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The translation of Diels 1906 *Plant Life in Western Australia* – editor's note

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After some 100 years it has now been possible to publish for the first time a complete translation of Diel's seminal work on Western Australian biogeography (Diels 1906). The production of this translation has stretched over many decades and involved a number of people who recognized the need to provide an accessible version of the first major work on the ecology, vegetation and biogeography of Western Australian plants to an Australian audience.

Soon after his appointment as Head of the Department of Botany, University of Western Australia (now the School of Plant Biology within the Facility of Natural and Agricultural Sciences) in 1947, Dr B.J. Grieve located a partially completed draft translation of Diels' work which had been commenced by Professor and Mrs W. Dakin after their arrival in the Biology Department of the University in 1914. Unfortunately, after they returned to England in 1920, the work largely lapsed. Some minor additions appears to have been undertaken on this manuscript by Dr D. Herbert and C.A. Gardner with copies dated 1927 lodged in library of the Western Australian Herbarium (Diels *et al.* 1927).

Appreciating the value of Diels' work for teaching and research purposes, Grieve completed a definitive translation which included updated taxonomy and ecological data. The typed manuscript, complete with illustrations from the original text, then served as a valuable source book in the Botany Department.

In due course, the desirability of obtaining permission to publish the translation arose and the matter was discussed with the University of Western Australia Press. Repeated attempts were then made to trace and contact the original publishing firm, W. Engelmann of Leipzig, or its possible successors in West Germany, but without success, and there the matter was forced to rest.

However, in 1981, Dr B.B. Lamont, who had independently commenced a translation of a chapter in the book relating to his researches, was, after much searching and correspondence, successful in contacting the new firm which had taken over the copyright for the book and he obtained formal permission to proceed with the translation. Learning of the existence of the Botany Department complete translation, Lamont agreed to collaborate with Grieve, and later with the invaluable assistance of E.O. Hellmuth in jointly editing the work. In the same year Carr (1981) independently published a translation of a small section of Diel's work.

In an effort illustrate the vegetation changes since Diels' time, as many as possible of the original photographic sites that could be identified were visited and new photographs made by Lamont (Lamont & Grieve1984). For purposes of comparison, these were placed in an appendix alongside the original plates. The publication of this work was unfortunately halted when funding could not be raised to publish the book and the project lapsed for quite some while.

The advent of widespread accessibility to digital media made it feasible in the early 21st century to publish this document in an electronic form with the kind permission of J. Cramer in Gebrüder Borntraeger Verlagsbuchhandlung. To that end Grieve's manuscript was edited and original figures and photographic plates scanned to complete this task.

Unfortunately Grieve's updated taxonomy and ecological data incorporated in his translation has seriously dated over the intervening 20 years. Therefore the original taxonomy and data published by Diels has been used in this translation. To assist the reader in understanding taxonomic changes an appendix of name changes current to 2002 has been added. Points of clarification are added to the text enclosed in [square brackets], but these have kept to a minimum. Translations of the captions of the tables and figures can be found in appendices.

With regard to the title of Diels' work, a direct translation from the German would be "The Plant World of Western Australia". We have chosen to translate this as "The Plant Life of Western Australia" to highlight the strong connection between the seminal work of Diels at the start of the 20th century with the other major work on Western Australian biogeography of the same name produced by Dr John Beard in the last decade of that millennium (Beard 1990). Beard has recently produced several papers highlighting the contribution of Diels during the centenary of his visit (Beard 2001a, 2001b).

Dr Beard and Dr Kilian (B) have also recently published further information on Diels and Pritzel's travels in eastern Australia in 1902 and are hoping be able to further expand this work in the future (Beard & Kilian 2003).

The electronic version of this translation had a limited release in June 2003. This current opportunity to provide a limited number of printed copies of Diels' work and an updated electronic version has been taken to provide easy access to this first major work on plant biogeography in Western Australia.

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Die

Vegetation der Erde.

Sammlung
Pflanzengeographischer Monographien

herausgegeben von

A. Engler und **O. Drude**

ord. Professor der Botanik und Direktor des botan. Gartens in Berlin

ord. Professor der Botanik und Direktor des botan. Gartens in Dresden.

VII.

Die Pflanzenwelt von West-Australien südlich des Wendekreises.

Mit einer Einleitung über die Pflanzenwelt Gesamt-Australiens in Grundzügen.

Ergebnisse
einer im Auftrag der Humboldt-Stiftung der Kgl. Preussischen Akademie der Wissenschaften 1900-1902 unternommenen Reise.

Von

Dr. L. Diels.

Leipzig
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Privatdozent an der Universität Berlin,
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VII

The Plant Life of Western Australia south of the tropics

With an Introductory Part dealing with the salient features of the vegetation of the whole of Australia

The results of an expedition carried out during 1900-1902 under the auspices of the Humboldt Foundation Royal Prussian Academy of Science

by

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A translation by

Emeritus Professor B.J. GRIEVE, Professor B.B. LAMONT
and Dr E.O. HELLMUTH

Edited Dr N. Gibson

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Special thanks are due to: K. Holland who typed the whole of the original manuscript as completed by BJ Grieve in 1950 and the revisions of 1990/91; the School of Plant Biology, University of Western Australia for the curation of Prof. Grieve's manuscript and notes over many years; L. Cobb and the Wildflower Society of Western Australia for facilitating access to these materials which has allowed the publication of this long delayed work.

Perth 2007

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AUTHOR'S PREFACE

Knowledge of the plant life of Western Australia was very limited at the time of my visit. While the floral elements were well known, no studies had been made on their inter-relationships in the field. Again, although their external affinities had been noted by Hooker, little was known about the conditions that determined the inner relationships of the endemic flora. These aspects were considered as being fundamentally important. Because of the variation in form of its vegetation and the fact that this variation occurred in a winter rainfall area of the earth (where the vegetation is more closely defined and shows a more regular gradation than in any other part) it appeared that it might provide solutions to many questions of general interest. Also the country's unrivalled richness in species could be expected to prove rewarding to those who studied its vegetation.

For these reasons I proposed a study visit there and in 1900 submitted my plan to the governors of the Humboldt-Foundation for Biological Research and Travel. The account of the vegetation formations of Western Australia and the investigation of the conditions influencing the development of the wide range of species existing in the flora were considered to be the most important matters to be investigated.

The governors of the Humboldt-Foundation approved my plan and I was able to travel to Australia and engage on a two-year research programme. Fourteen months were allocated for studies in Western Australia.

The taxonomic results which formed the first part of my researches have already been published in collaboration with Dr E. Pritzel (L. Diels and E. Pritzel, Fragmenta Phytographiae Australiae occidentalis. In Englers Botan. Jahrbüchern XXXV [1904, 1905]). The second part, which deals with the plant geography and botany of the area, represents the fulfillment of the main objective of my expedition.

I am most grateful to those who financed my research work. The Royal Prussian Academy in Berlin and the governors of the Humboldt-Foundation have, through the funds provided by the latter, enabled me not only to travel extensively in the area which formed the main subject of my researches, but also to become more familiar with the problems facing me by providing me with the opportunity to visit the Cape region [South Africa] and eastern Australia. I wish to thank the authorities for their munificence and in particular the President of the Governors, Medical Privy Councillor, Professor Waldeyer, for his constant sympathetic support.

I am deeply indebted also to the Government of Western Australia, which greatly assisted me. I wish particularly to express my most sincere gratitude to the Rt. Hon. Sir John Forrest, P.C., G.C.M.G., at that time Premier of the State, for his active interest which contributed significantly to making my visit so successful.

I was accompanied by Dr E. Pritzel during the tour and I wish also to thank him for his great help during our travels. He placed at my disposal all the photographs he took during the trip, and also assisted in proof-reading the manuscript.

Finally, I must thank Privy Councillor Professor Engler, my esteemed teacher, for advice during the preparation of this volume. It was, for instance, at his suggestion that the introductory section dealing with the vegetation of the whole of Australia was presented. This was designed to serve as a setting for the picture of the botany of the more restricted area of Western Australia and to help to highlight the features that give that region its greatest individuality.

BERLIN, May 1906 L. DIELS

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INTRODUCTION

The characteristic features of the vegetation of Australia

I. General Physiography

At present the animals and plants of Australia are isolated from the rest of the world, except by way of the Torres Straits to New Guinea and southeast Asia. Even here adverse climatic conditions restrict or make it impossible for migration. Over a long period this isolation has meant that even what was common to the floras of the southern Asiatic Archipelago and Australia has become restricted to small areas. This resulted in an ever increasing divergence. As a consequence, Australia is a true island continent, with its own peculiar flora and fauna.

As in southern Africa, Australia is largely an extensive plateau, although at a lower elevation. As in Africa too, the plateau increases gradually in height towards the east, culminating in a high ridge from which the land then drops steeply to a narrow coastal plain crossed by short rivers. On the west coast the plateau is only 300-500 m in height but there is usually an abrupt descent to the narrow coastal region. The plateau drops towards the center, and the major rivers flow into this depression. Fed from the high eastern margin of the plateau, these rivers run through low rainfall areas to the sea.

While the tropical northern region is characterized by a wet summer and dry winter, the actual amount of rain is determined by additional factors. On the mountainous east coast the rainfall is high, while it diminishes with surprising rapidity towards the interior. Thus in New South Wales, the yearly rainfall at the edge of the plateau and the adjacent coast often reaches over 100 cm. In Queensland, the effect of coastal elevation on rainfall is even more marked. The most highly developed rainforests on the continent occur where the eastern slopes of the ranges reach their summit in Bellenden-Ker (the wettest region in Australia with over 250 cm per year.). The decrease in rainfall from the coast towards the interior is also striking. Todd in 1879 showed that summer rains occurred as far south as 28°S along the north-east coast. However, by 16° 15' S these summer rains were of little value. Rainfall is also very erratic by this latitude: in certain years heavy thunderstorms and floods extend over almost the whole of the interior. In others, the rain may extend only a few hundred kilometres inland so that the whole area south of the Tropic of Capricorn becomes subject to drought. We now know that this lack of reliability in the rainfall also applies to the north-west of Australia. The amount of reliable summer rain also diminishes from east to west with the fall in elevation of the plateau. Again, as one proceeds southwards along the west coast, summer rain gradually decreases, the minimum being recorded in the vicinity of the North-West Cape.

The winter rains are very similar in total. At the higher latitudes it is abundant as, for example, at South-west Cape [Cape Leeuwin], where the rainfall exceeds 100 cm per year. Again, in Tasmania, on the western slopes of its cloud-covered mountains, several localities receive over 250 cm of rain per year. In addition to this, the rainfall is spread over most months of the year so that the summer/ winter periodicity mentioned for other parts earlier, does not apply. The central region of the south coast, particularly the coastal region of the Bight, receives very little winter rain. Otherwise the coastal regions in general receive adequate rain. The interior, however, is subject to the same uncertainty of adequate rain as mentioned for the zone of summer rains. Notwithstanding the above, essentially rainless regions, such as those represented by the deserts of the northern hemisphere, or the western areas of southern Africa and South America, are almost completely lacking in Australia. The whole area of the central plateau is, nevertheless, subject to problems associated with its water supply. Periods when raging floods occur alternate with year-long droughts. This unpredictable curse seriously restricts agriculture which, to a great extent at the present time, provides the Australian States with their staple industry.

The temperature component acts in an equally extreme and unpredictable way. The first impression is that the mean temperature is not in general very high for the latitude. But the range of values reached in the interior is considerable. This is particularly true for the variation in daily temperature. This variation is due largely to the great heat exchange made possible by the clear skies of the interior. The maximum temperature for the year varies between 40°C and 48°C. To find comparable conditions elsewhere, one must refer to the hottest deserts of the old world, such as those of the Sudan, Arabia and the Punjab. At the same time, daily variations in temperature are among the largest on earth (particularly at these latitudes). An average daily variation of 20°C is common in central Australia.

II. Formations

The huge tableland of the Australian continent is, for the most part, covered with very mesomorphic or xeromorphic plant forms, with savanna with stiff-leaved and prickly shrubs, or with desert-adapted species. The greatest range of vegetation formations extends towards the interior from the northern and eastern edges of the plateau as broad zones, and from the south-west corner only as a narrow zone. These include savanna woodlands, low forests, and even rainforests. There are, however, extensive areas where this vegetationally well developed margin is lacking. For example, along the north-west coast and the shores of the Great [Australian] Bight in the south, the sparse vegetation characteristic of the interior extends unaltered to the coast.

1. TROPICAL RAINFOREST

Because of the unreliability of rainfall in the interior and its marked periodicity in most coastal regions, Australia would not appear to be a suitable region for the development of true rainforest. However, a few scattered areas do occur along the east coast where the greater elevation ameliorates the otherwise harsh climate of this part of the earth. In such areas a local reduction in periodicity associated with heavier rainfall in the drier half of the year occurs. At these places rainforests develop. Although they occur only as isolated patches in the Australian vegetation, they include many interesting forms. In spite of their relatively small extent and scattered occurrence, they are of great relevance to the genesis of the Australian flora.

With regard to the general floristic pattern, these rainforests are quite distinct. At least this is true in the tropics, and it probably applies also as far as about 30°S. Enclosed everywhere by eucalypt woodland, the rainforests remain unmixed, and show a purely Malaysian affinity. Both formations meet abruptly. They are sharply marked off from each other, and through the light-timbered eucalypt parkland one may suddenly see, towering up like an abrupt wall, the dark-foliaged trees of the rainforest.

In the true rainforest, rainfall is the controlling factor in the maintenance of these floristically rich formations, the level and movement of groundwater playing no direct role. Australia does not possess many such rainforest patches. Their total area is negligible. All lie close to the east coast. Coming down from Cape York Peninsular the first rainforest area is met to the north of Cape Tribulation (16°S). Here Mount Finnigan is thickly covered to its cloud-topped crest with rainforest. It is rich in epiphytes, the whole being "hopelessly tangled", as Semon puts it. However, it is only south of Trinity Bay, where the mountains of Bellenden-Ker and Bartle Frere rise to over 1600 m that really imposing rainforest appears. This is the most extensive, the most beautiful and without doubt, the best example of Australian rainforest. It ends, however, on the other side of Rockingham Bay. Near Ingham (18° 30'S), where the elevation of the plateau decreases and the rainfall drops markedly, the rainforest almost disappears. It does, however, extend further south, although its occurrence is strictly limited and patchy. Not until one travels south of 25° on the Upper Burnett, and again to the north of Brisbane, does the rainforest again become apparent. It makes its final appearance in the Mount Lindsay region. The Richmond River area is extremely rich in "brushes" as the rainforests are called by the settlers. The "Big Scrub" which extends from the upper reaches of this river to the Macpherson Range has been described in detail by A. Campbell (in Victorian Natural. XVII (1900) 84). We learn from this how completely the tropical character of the forest has been retained to this point. Further south, however, the characteristic elements become less and less evident. The rainfall appears no longer to be adequate to sustain rainforest. It retreats into the lowlands until finally its characteristic and peculiar features are largely lost. The savanna forest becomes dominant, and the remnants of the former rainforest are restricted to the shelter of gullies and depressions. It is only much further south in the moist and rugged mountain districts of Gippsland and in the temperate Tasmanian climate that something of a renewal of the rainforest occurs. It is, however, different in that the plants tolerant of higher temperatures have to a large extent been thinned out, while those characteristic of more temperate regions have increased. In short, we have a new type of temperate rainforest which is related only by certain genetic links with the tropical rainforests of the north.

The most extensive rainforest area extends as we have already indicated, over north-east Queensland, from Cooktown to Ingham, between 16° and 18° 30'S. Areas such as Daintree River, Mulgrave River, Cairns, Russell River and Rockingham Bay are among those most frequently mentioned in the literature as being representative of this 'scrub' region. The edge of the plateau rises to about 350 m. It is bounded on the east by the mountain systems of Bellenden-Ker, Bartle Frere and others. This area has the highest rainfall for the whole of Australia. Up to 500 cm has been recorded at Johnstone River, and it is possible that still higher figures may yet be recorded. The run-off feeds many streams which flow all the year round. Of these, the Barron River (and its impressive waterfall, situated where the river descends from the plateau to the lowlands) is probably the most famous.

Even in this favourable terrain the occurrence of rainforest is often confined to limited areas on mountain slopes, to low ground, river-banks and river gorges. Where it is best developed, however, it stretches almost uninterruptedly from the coast over mountain and valley for 50-60 km inland to the heights of the plateau.

The character of the forest on low-lying areas differs somewhat from that at higher altitudes. In the former the growth is much more lush. The damp humid depressions on the lower courses of the rivers and creeks favour the development of dense undergrowth and lianes in the depths of the forest. The occurrence of numerous tall trees (on which plank-buttresses and cauliflory occur in great variety) are also a feature. These in particular are still imperfectly known and need further study. In the undergrowth, the slender stemmed palm *Archontophoenix Alexandrae is* of common occurrence. Among the lianes various species of *Calamus* (Palm.) are prominent, together with a climbing bamboo *(Bambusa Moreheadiana* Bailey*),* which as yet has not been found in flower. In areas where the vegetation is less dense *Pothos longipes* (Arac.) and species of *Piper* cover the trunks. The great leaf masses of *Epipremnum mirabile* (Arac.) are frequently seen. Species of *Musa (M. Banksii* and *M. Hillii),* and a tall *Elettaria* (*E. Scottiana* - Zingiber.) complete the true Malaysian aspect of the forest.

By contrast the rainforest at the higher altitudes (between 400-500 m) at the edge of the plateau shows many different features. On the whole, it is somewhat less dense, the undergrowth in particular being less well developed. It appears to have been modified to the so-called "open" type of rainforest which Kurz contrasted with the "closed" type in Pegu [Calcutta]. Members of the Scitamineae, climbing plants belonging to the Araceae, and *Bambusa Moreheadiana* occur only rarely. Climbing palms represented by *Calamus moti* and *C. australis* are, however, still present, although their stems fail to match the size and rate of growth of those specimens which were such a feature at lower altitudes. *Piper is* still common, but the most frequently occurring lianes belong to more cosmopolitan hardier types. Among these, many fine and graceful plants occur. *Clematis glycinoides, Jasminum Dallachii, Smilax australis* (Lil.)*, Tecoma australis* (Bignon.)*,* together with many members of the Vitaceae festoon trees, lightly linking them together or draping their tops. Among the epiphytes, ferns and orchids are quite strongly represented. *Asplenium Nidus* and *Platycerium* are among the most common. We have more detailed knowledge of the trees of this upper forest than of those of the lower parts, due largely to the investigations of the younger Bailey. A beautiful tree, *Tarrietia argyrodendron* (Strecul.) is commonly present. It is easily recognized in the depths of the forest by its plank buttresses and by the silvery and shiny undersurface of the leaves. Among the most important elements of these virgin forests we may list the following: *Elaeocarpus grandis* (Elaeocarp.), several species of *Ficus*, *Flindersia* and *Cedrela* (Meliac.), many beautiful Proteaceous plants such as *Stenocarpus* and *Embothrium,* the huge *Agathis Palmerstonii* (Pinac.), a *Podocarpus* (*P. amarus*, which is also found in Java), together with several members of the Lauraceae and *Aleurites moluccana* (Euphorb.).

Many of the plants show promise of becoming valuable timber trees for Queensland. Even now, sawmills may be seen in operation, indicating that the excellent nature of the timber of these highland forests has been recognized. The timber here is considered to be of better quality than that of the lowlands. This is believed to be due to the moderate temperatures occurring in these regions and to the light but more or less continuous rainfall which favourably influences growth.

Unfortunately, I have only seen the southern rainforest between Wide Bay and Moreton Bay in the dry season. They are rich dense forests about 30 km from east to west and quite like those of the tropics, although the Aracacea and Scitamineae play a smaller part and only *Aplinia coerulea* (Zingib.) is still common. *Calamus* and chocking figs together with the large and small palms, still play an important part. However, these rainforests owe their particular character to the mixture of the Australian *Araucaria* (*A. Bidwillii* and *A. Cunninghamii*) whose unmistakable crests stand out above the richly tinted foliage of the dicotyledonous trees. The earth is ornamented with ground ferns, otherwise it is poorly clothed in plant growth. B. W. Spencer visited Mount Cooran in the same region during a better season of the year and described the epiphytic orchids as very stricking, especially *Cymbidium canaliculatum* which attracts attention by the size and abundence of the hanging yellowish brown flowers.[1] In the more southerly Richmond forest (cf. Campbell's aforementioned description, p. 4) the "roof-garden" is decorated also with *Dendrobium (D. speciosum* and *D. Hillii)*. Yet in these high latitude (ca. 27° S) epiphytes are found frequently on rocks, for example the western slopes of Mount Cooran are completely covered with *Asplenium Nidus* and *Platycerium*, and also a *Dendrobium* with delicate white flowers which stand out pleasingly from the red of *Kennedya rubicunda* (Legum.) (Spencer *loc cit.*).

The rainforest areas are separated by regions whose rainfall is insufficent for such formations, and yet there is enough water present in the damp valleys and basins to support communities of gallery forests made up of many rainforest elements. The various gradations of this development are well known in Africa and South America. In this part of Australia the absence of large rivers does not permit the development of gallery forests of any size, but there are all grades from the moderately sized to the last trace of the Malayan vegetation in the narrow hollows which are found so often in southern New South Wales. In eastern Queensland the bottom of the valleys are occupied by the dark rainforest whilst on the higher ground the eucalypt savanna predominates. Toward the south there is a diminution in the diversity and thickness of these formations. The two dissimilar palms *Archontophoenix Cunninghamii* and *Livistona australis*, with *Alsophila australis* (Cyatheac.) and the showy agave-like *Doryanthes excelsa* (Amaryll.) still decorate the short rocky valleys running toward the ocean in the Illawarra district (34° 30?S) and in similar local favourable sanctuaries. Finally the trees disappear completely and only shrubs and lianas remain as indications of the Malayan character. This development comes to a certain conclusion in the west at the edge of the New England plateau and in the south in the cooler parts of New South Wales where thickets of lianas are found (in the water channels of the *Eucalyptus* forests) just as in the warmer zones they indicate the last traces of rainforest. Thus, not far from Broken Bay, I saw a thick undergrowth consisting of *Panax cephalobotrys* (Araliac.), *Synoum glandulosum* (Meliac.), *Cissus Bau-*

1 Victorian Natural. IX 16.

diniana (Vit.)*, Marsdenia flavescens* (Asclepiad.)*, Discoria transvera* (Disocor.) completely filling a narrow moist gully, but the trees which cast light shadow were eucalypts and on the slopes there was only savanna woodland.

2. SUB-TROPICAL RAINFOREST

Further south in Australia climatic conditions change again, the winter rains becoming more regular and abundant. As a result, many of the taxa with Malaysian characters once again become important. Because of this, right down to the extreme southern part of the continent and even beyond to Tasmania (which biogeographically is part of Australia), the vegetation in sheltered places is sub-tropical in character. One may speak of it as subtropical rainforest. It is much poorer in species than the tropical rainforest, and because of the pervasive presence of species of *Eucalyptus* it has quite a different aspect. The flora of this region, particularly that of east Gippsland, has been studied by F. von Müller[1]. He describes the situation as follows:

> "Rather suddenly, tropical species such as *Nephelium* (Sapind.), *Acronychia* (Rut.), *Ficus, Passiflora, Tylophora* (Asclep.), *Marsdenia* (Asclep.) and *Livistona* (Palm.) appear to the east of Cape Otway."

He indicates how this south-eastern corner of Australia is shielded from the cold Antarctic winds (to which the Cape Otway district is exposed) by Tasmania with its high mountains, while it is warmed by the current from the Pacific. The possible effect of drying winds from the inland north-west are also minimized by the presence of buffering mountain ranges. A more detailed description of the vegetation of this climatically mild region has been given by W. B. Spencer and C. French (Victorian Natural. VI). Dense plant growths occur in the narrow valleys and depressions. The huge *Eucalyptus amygdalina* and *Eugenia Smithii* (Myrt.)*,* together with the tall *Olearia argophylla, Pittosporum bicolor* (Pittospor.) and *Elaeocarpus cyaneus* (Elaeocarp.)*,* make up the most important components of these woodlands. In addition, large specimens (over 30 m high) of the fine "Cabbage Palm", *Livistona australis,* are present even though this is the southern-most limit of the range of such palms in Australia. *Smilax australis* (Lil.) and *Clematis aristata* (Ranunc.) also occur while luxuriant growths cover the ground amid the tangle of fallen branches and rotting vegetation which make these forests so difficult to traverse. *Polypodium, Blechnum, Gleichenia, Pteridium* and *Asplenium* are represented, and also several species of *Hymenophyllum,* which cover the stems of the tree-ferns. These tree-ferns (of which *Dicksonia antarctica* and the large *Todea barbara* are the most common) are the pride of the Gippsland forests.

These forests also extend considerably further westward, although their sub-tropical nature rapidly deteriorates. Near Wilson's Promontory, for instance, one can still find tree-ferns present in each narrow valley, while an epiphytic member of the Gesneriaceae *(Fieldia australis)* still grows on their stems. In Tasmania we find the last of the epiphytic orchids *(Sarchochilus parviflorus)* attached to dead branches of *Aster argophyllus* (at almost 42^{o}S). In the mountains of western Victoria, the tree-ferns *Dicksonia, Cyathea* and *Alsophila,* at present form the famous fern-tree gullies. It is only in the most southern corner of South Australia - the so-called "Garden of the Colony", in the Mount Gambier district (about 140°E) - where the climate is equable, misty and somewhat humid in contrast to that further west, that we find the last of the tree-ferns. *Todea,* however, still occurs a little further to the west in the gorges of the Mount Lofty ranges.

South of Gippsland we find a continuation of the sub-tropical rainforest in Tasmania but the lianes and the higher epiphytes have almost entirely disappeared. In their place for the first time we find cryptogamic growths strongly represented. The heavy rainfall and the uniformly moist conditions (particularly in the hilly regions), together with the

1 A lecture on the Flora of Australia. School of Mines and Industry. Ballarat 1882

ameliorating effects of the sea upon the temperature, encourage a richness of vegetation in many parts of the island which is rarely met with on the mainland. Here we see impressive stands of *Eucalyptus globulus* and underneath them the forest floor is thickly covered with ferns and mosses. Through the finely divided and transparent meshwork of the tree-ferns one may gaze up at the majestic crowns of the eucalypts whose dark green foliage forms such an effective contrast to the delicate undergrowth. A well developed cryptogamic flora is present. Filmy ferns adorn the tree-fern stems while mosses and liverworts, together with a great variety of delicate plants, grow in rank abundance. The picture is almost reminiscent of that presented by the damp mountain forests of New Zealand.

From the point of view of the flora, the sub-tropical rainforests of Australia cannot be regarded as impoverished derivatives of the tropical forests. Rather, they possess much that is peculiar to them as, for example, the fine "Sassafras" tree *(Atherosperma moschatum* Monim.). In addition to this, the presence of antarctic forms gives them a character of their own. In some ways they form a link with Alpine vegetation. Amongst them are species of *Nothofagus* and shrubby members of the Compositae. *Eucalyptus,* however, remains the dominant genus in these woodland. Consequently, there exists in the south a peculiar combination of the Malaysian rainforest and the Australian eucalypt forest. This contrasts with the north where the two formations are sharply separated. It appears advisable here to refer briefly to the genus *Eucalyptus* which dominates the Australian vegetation to an extent not achieved by any other genus in any other part of the world. The genus belongs to the Myrtaceae, arising from a branch which is typically represented in eastern Malaysia, although its exact place of origin is not known. At the present state of knowledge, *Eucalyptus* forms a natural genus whose character is not easily mistaken, and whose distribution is also in many ways similar to that of the marsupials. Like this group too, its members have developed almost entirely in Australia. They have become adapted to almost all possible conditions. Thus one meets them as tall trees in the forests of the moist coastal regions, as characteristic plants of the park-like savannas, and as gregarious constituents of the dense bush of the hot, dry interior. They occur as low gnarled bushes [mallees] on the windy hill-tops as well as on the desolate exposed sandplains of the interior. Although they show great variability in appearance, in overall growth, and in the colour and abundance of flowers, the most constant feature is the more or less vertical orientation of the leaves. The species also are all evergreen. It is because of this evergreen appearance that the Australian landscape appears so drab.

Due to this adaptability of the genus *Eucalyptus* all attempts so far to organize the species on a truly scientific basis have more or less failed. The mutual interchange between the environment and the specific elements of the flora is achieved in a novel manner, and no analogies exist elsewhere on earth. The genetic constitution of *Eucalyptus* is the ultimate cause of this. In no other part of the world can one demonstrate so clearly that in order to understand the situation the specific nature of the flora must be considered independently of plant geography.

3. SCLEROPHYLL FORESTS and WOODLAND

The temperate rainforests of the antarctic portions of South America are dominated by *Nothofagus* (Fagac.). The climate of the neighboring drier regions has caused it to adopt a regular leaf-fall. This has not occurred in the case of the genus *Eucalyptus.* In areas where the rainfall decreases, becoming moderate in amount, and shows increasing unreliability, we still find forests which are difficult to compare with anything of the kind elsewhere. These are forests in which the *Eucalyptus* trees are almost entirely dominant. Only a few other plants reach tree-like dimensions, as for example, *Casuarina* and some members of the family Proteaceae, in particular *Banksia.* The eucalypts tend to be closely spaced but the well-known vertical orientation of the leaves gives one an impression quite different from that given by other leafy woodland. The only analogy that one could make would perhaps be that with a thinly grown coniferous wood. The undergrowth is important and interesting. It is a dense mixture of low shrubs and of bushes with hard evergreen foliage and often brightly coloured flowers. Herbaceous perennials are rare and annuals seldom common. Grasses are poorly developed, their place being taken by members of the Cyperaceae and Restionaceae. Ferns are few in number and of relatively little importance. The most common one would be *Pteridium aquilinum.* Tree-ferns are completely lacking.

This sclerophyllous formation shows its best development in the high rainfall area of south-west Australia between 30° and 35°S. The forests of *Eucalyptus marginata, E. diversicolor* and *E. redunca,* constitute the best example of this sclerophyll formation. It will be described in detail later. The rich undergrowth of these south-western forests forms an important component of the vegetation scene. The undergrowth extends beyond the boundaries of the forest area, changing gradually through xeromorphic modifications into the sandplain communities.

In south-eastern Australia *Eucalyptus* woodlands with hard-leaved undergrowth also occur. The formation is also found there in districts with a moderately high rainfall (50-100 cm per year), but with a markedly dry period in summer.

In South Australia these conditions are only found east of Spencer's Gulf and there only in the southern portion of the mountain country. Even here sclerophyllous woodland is incompletely developed and, as Schombergk has already shown, it is broken up by savanna-like formations. Several species of *Eucalyptus* (e.g., *E. paniculata, E. viminalis* and *E. rostrata)* predominate and in the undergrowth we meet species of *Correa* (Rut.), *Grevillea* (Prot.), *Hakea* (Prot.), *Isopogon* (Prot.), *Exocarpos* (Santal.), *Acacia* (Legum.), *Banksia* (Prot.), *Cassia* (Legum.), *Calythrix* (Myrt.), *Pomaderris* (Rhamn.), *Leucopogon* (Epacr.), *Leptospermum* (Myrt.), *Daviesia* (Legum.), *Dillwynia* (Legum.), *Eutaxia* (Legum.), *Platylobium* (Legum.), and *Pultenaea* (Legum.). They comprise a series of genera which are representative of this formation in south-west Australia. The frequent occurrence of several species of *Xanthorrhoea,* which are common to the two areas, although they are not exclusively found there, is also important. The strongest development of these woodlands occurs in the deep valleys where the streams flow all the year round so that the plants remain fresh and green. It has already been mentioned that *Todea africana* (a most delicate fern) occurs there. Schomburgk has also given a list of other decorative ferns which inhabit these gullies. Violets *(Viola betonicifolia* and *V. hederacea)* may be found growing on the margins of the streams following good rains. The blue-flowered *Chamaescilla* and the white-flowered *Burchardia* (Lilac.) are present on the slopes while, higher up, *Pteridium* is often present.

It is not until we travel east of the dry Murray region in Victoria that we re-encounter this formation. It keeps essentially to the mountains, only descending to the lowlands as one passes eastwards and the rainfall increases. Finally, towards the north as we reach New South Wales and the winter rains cease, it is once again confined to the mountain areas. In all these regions it seems to develop well on sandstone soils. From the Grampians in the west of Victoria to the northerly parts of the Blue Mountains, it is on sandstone that the richest undergrowth in the *Eucalyptus* woodlands occurs. C. French (Victor. Natur. III (1886) p 147 and on) reports the following as playing a prominent part in the make-up of this undergrowth in the Grampians; members of the Epacridaceae, together with *Lhotskya* (Myrt.), *Conospermum* (Prot.), *Grevillea ilicifolia* and *G. dimorpha* (Prot.), *Correa,* and *Eriostemon* (Rut.) and *Hibbertia virgata* Dillen.). In favorable areas in the vicinity of Melbourne a similar type of vegetation is met with at lower elevations. The same applies also in eastern Victoria, Tasmania and the more southerly parts of New South Wales. Further north this formation, which is evidently dependent upon the winter rains, is confined to high ground and finally disappears altogether. It is well developed on the Blue Mountains on the edge of the tableland at about 200 m, where the undergrowth is particularly dense consisting of bushes from 1-2 m in height. Thickets of *Pteridium,* species of *Acacia,* members of the Proteaceae, *Pimelea* (Thymelaeac.), *Xantorrhoea* (Lil.), *Hibbertia* (Dillen.) and species of Epacridaceae occur. Grasses and herbs are, however, lacking. In certain places there is a marked resemblance to parts of the

Jarrah country of Western Australia. One may note that it is in just such places that the very definite occurrence on sandy soils of the representatives of the true Australian (autochthonous) flora becomes apparent. In New South Wales, the sandstones end in the Clyde and Braidwood district. It is here that one finds a large number of species which are at the southern limit of their distribution (see Maiden, in Proceed. Linn. Soc. New South Wales 2 ser. IV (Sydney 1890) 107-112).

With regard to the sclerophyll *Eucalyptus* forest, we may note that like rainforest it occupies only a small area but has a wide range across the continent, some 3000 km from Cape York to Tasmania and from the Swan River to the Blue Mountains.

4. SAVANNA WOODLAND

Savanna woodland occupies extensive parts of the marginal areas of the Australian tableland. While only weakly developed in the west, savanna woodlands are a major features of the eastern landscapes. In many cases they extend into coastal regions. In the southern part of Australia, the savanna woodland reaches its strongest development where soil conditions are favorable and the rainfall varies between 60 - 35 cm per year. Towards the north, however, in the regions of summer rainfall, it only persists where the rainfall is considerably higher.

In Western Australia, the savanna woodland appears to be confined to a comparatively small area. It may be present to some extent in the neighborhood of the Tropic where, unfortunately, little investigation has been made. In the south-west, however, it is only present along a very narrow zone. The dominant tree genera are, as usual, *Eucalyptus, Casuarina,* and *Acacia.* In the western savanna woodland *Eucalyptus loxophleba, E. occidentalis* and *Acacia acuminata* are particularly important.

Extensive areas of savanna woodland occur in the coastal areas of South Australia, and detailed descriptions of these have been published. Behr (in Linnaea XX), for instance, described it as meadow-like grassland. It is characterized by the presence of large eucalypt trees which are sparsely scattered throughout the area, producing a park-like effect. On poorer soils *Casuarina* occurs, its brownish-grey crowns contrasting strikingly with the green of the grass. As a rule they are rarely taller than 10 m and are dwarfed by the tall *Eucalyptus* trees. *Acacia* species, e.g. *A. retinodes* and *A. pycnantha,* are also found here. The latter rarely grows more than 2 m high, but it has a decidedly tree-like habit of growth and is easily recognised by its umbrella-like crown. It often forms small woody enclaves within the formation. It is an exact analogue of the western *Acacia acuminata.* Shrubby undergrowth is rare and in typical savanah woodland the only commonly occurring species is *Bursaria spinosa.* This is a privet-like member of the family Pittosporaceae which is widespread over almost the whole of Australia. On the other hand, there is a thicker growth of herbaceous plants and, although other herbs are very well represented, grasses predominate. In favourable localities, members of the Liliiflorae and two other bulbous plants are abundant, but the annual composites dominate the scene. A small number of introduced plants are present in addition to the foregoing. It is only in the grassy formations in Australia that large numbers of alien plants have established themselves. Most have come from Europe, but a few have been introduced from South Africa. Only one or two, however, have become widespread. Amongst these are *Medicago denticulata, Xanthium spinosum* and *Cryptostemma calendulacea* (Compos.), which many Australians mistakenly call the Dandelion). This is often extremely prevalent and gregarious on fallow land. In the cooler moister regions of the south-east *Rubus fruticosus* and *Ulex europaeus* occur. Wild roses of European origin are also found, particularly in Tasmania. In the tropical and sub-tropical regions the cactus *Opuntia* is present. These introduced plants, however, rarely pose any serious threat to the hardy native flora.

The strong development of undergrowth in savanna woodlands reflects, better than that of any other formation, the marked periodicity which prevails over wide areas of Australia. The first botanists in South Australia described in detail the different phases. Just before the beginning of the wet season everything appears dry and dead with the exception of a few branches of *Eucalyptus* which may be in flower. Within a few days everything is changed by the rain. The annual grasses grow rapidly and form a fresh green carpet rather like that of a European meadow. The first flowers to appear are *Drosera Whittakeri* and *Oxalis corniculata.* They are the forerunners of the army of wildflowers which develop within a few weeks. They are followed by *Ranunculus lappaceus, Hypoxis glabella* (Amaryll.), *Stackhousia* (Stackhousia.) and many others, until the end of August when the number diminishes. Flowers of orchids and lilies next appear in great profusion. Each week brings new forms. The bright red *Kennedya prostrata* (Legum.) and the gay colours of *Swainsona* (Legum.) are splendid decorative features. Finally the sward "becomes a rich meadow ground in which related species develop in great variety'. These form 'as with us the last act of the beautiful drama" (Behr *loc. cit.* 550). "The ground which only a short time ago was rich and green, then comes to resemble a ripe but very thinly sown cornfield and the number of plants in flower diminishes daily. This continues until finally the only vegetation left appears restricted to the unusual species found in dried up creeks and small streams. The onset of this dry period is somewhat variable. However, it never sets in before the end of November and sometimes rather later, usually by the beginning of February" (Behr in Linnaea XX 551). However, by then the undergrowth appears completely dried up, with the exception of the almost succulent *Lobelia gibbosa.* At this time also many eucalypts develop their flowers. "*Acacia retinodes* also bursts into blossom at this time, while the bright-red flower tassels of *Loranthus* hang from the eucalypts, casuarinas, and acacias".

In Victoria, New South Wales and Queensland, the savanna woodlands occur in a broad zone often several kilometres wide, running parallel to the coast. It has been described for New South Wales under the name of "Argyle vegetation" by Lhotsky (in Hookers London Journ. of Bot. II (1843) 135). This is a most important region from the point of view of agriculture and in many places the native vegetation has been largely cleared. When it does remain in its natural condition, the same picture is presented again and again. It shows the uniformly and sparsely scattered eucalypts together with the mixture of species of *Casuarina* and *Acacia* with their mistletoe parasite *Loranthus.* The frequent presence of umbrella-like tree crowns and the ground covered with sparse underbrush is also a feature. According to the time of year, the grasses and herbs may appear fresh and green, or dried up and brown. Depending also upon the nature of the season they may be well developed and tall or sparse and depauperate. Through the blooming and fading of the flowers, and the colour play of the composites at the close of the favourable season, the overall impression given by savanna woodland with its characteristic plants is the same from west to east and from south to north.

The number of species of *Eucalyptus* which are found in the forests of the east is very high. Many of them are fine trees valuable for timber. They vary greatly in height, in growth form, in mode of branching, and in type of bark, as well as showing considerable differences in their flowers and fruit. Their habitats are sometimes extensive, sometimes very localized. In some places they are sharply segregated, in other areas their habitats adjoin and overlap with broad transition zones. The early colonists described them as gums, stringybarks, ironbarks, boxes and bloodwoods. But these terms are somewhat vague and are of little use to the taxonomic botanist. Even an experienced taxonomist finds it difficult to master the genus *Eucalyptus.* Only a few species can be easily recognised from a distance by some striking character as, for example, the delicate-leaved *E. crebra* in New South Wales, *E. melliodora* with its bright yellow bark, and similarly *E. platyphylla* which with its white trunks is first encountered near the tropics. It re-occurs on dry sandy country in the tropical parts of Queensland often as the dominant tree. In addition to the eucalypts, species of *Tristania* (*T. conferta* and *T. suaveolens*) are present. They are closely related to *Eucalyptus,* and this is clearly indicated by their appearance. For the physiognomist, they have much the same significance as the true *Eucalyptus* species.

In dry areas this *Eucalyptus* forest is only enriched to any marked extent by the presence of the coniferous genus *Frenela* [*Callitris*][1]. This cupressoid, which from a distance resembles a poorly developed pine tree, forms an important element of the savanna woodland both in Queensland and New South Wales. From the interior of New South Wales southwards to Victoria a very broad zone of vegetation is present which is actually characterized by the mixture of *Eucalyptus* species and *Frenela* (*F. verrucosa* and *F. calcarata*).

The transition from savanna woodland to other formations is similar everywhere.

What is of particular interest, however, is its strong development in places where adequate water is available. Behr has already aptly described the use made of shallow valleys and creeks in the savanna woodlands. Majestic eucalypts with trunks over 1 m in diameter have their roots in the damp earth. A border of imposing shrubs accompanies them, e.g. *Viminaria* (Legum.), *Leptospermum* (Myrt.), *Melaleuca* (Myrt.) and *Myoporum* (Myporo), just as willows accompany the poplar and the ash tree. At the bottom of valleys, woody plants are naturally lacking, but when the surface water disappears, the ground becomes covered with a soft green carpet consisting of numerous herbs. They belong mostly to cosmopolitan genera, but many of the species are strictly Australian. This green band, shaded by tall trees on the banks, remains fresh long into the dry season when everything on the slopes above is withered and bleached to the colour of dry straw.

On the other hand, the gradual deterioration of the *Eucalyptus*-enriched savanna woodland is a feature which, at least in eastern Australia, also presents something typical. Jung (Petermanns Geogr. Mitt. XXIII (1877) 352) described how it takes place on the west slopes of the Flinders Range (South Australia). Where the rivers emerge from the hills: "Their beds widen out between the banks to a width of 2-300 feet the banks being covered with trees and shrubs. Towards Lake Torrens the vegetation becomes sparser with acacias gradually replacing the eucalypts, while sand instead of gravel appears in the river beds; these channels branch and finally the stream bed disappears altogether." The vigorous growth of vegetation along the stream bed and the thick layer of gravel and stone which fills the bed is quite characteristic of the creeks of the Mount Lofty and Flinders Range area. "Only where the eucalyptus vegetation peters out do we find that the stony nature of the district also disappears. Then stunted species of *Casuarina* make their appearance, followed by species of *Acacia*, and both finally make way for salsolaceous plants."

In the north-east, in Queensland, savanna woodland presents a striking feature in the extremely sharp boundary with the rainforest. Attention has already been drawn to this fact already. Its appearance is completely different from that of the rainforest. *Eucalyptus* species (together with *Tristania* or *Syncarpia*) form well-defined stands of tall trees. Only a few other woody plants are of any consequence, e.g. the delicately branched casuarinas (*C. Cunninghamiana* in particular), some *Acacia* species and *Banksia integrifolia*. The ground is richly covered with grasses and *Pteridium* also plays an important role. Shrubby undergrowth is very sparse, while the unmistakeable forms of *Cycas* are characteristic figures in the landscape. Some lianes and epiphytes have invaded the formation in the forest area where most rainfall occurs. They festoon the rough surface of *Cycas* in particular. Of the ferns, *Drynaria quercifolia* (even some with quite large stems) is present here and also mosses and orchids, e.g. *Oberonia palmicola*. Eucalypt trunks on the contrary support few guests. Occasionally in the region of the Barron River, I did see slender shoots of *Vitis trifolia* growing on their bark; but this was the only liane in these woodlands.

5. RIPARIAN WOODLANDS

It has already been mentioned that, near the east coast, a part of the riparian woodland is represented by complexes of the more resistant elements of the true rainforest. Beyond these areas and in the region of the pure savanna woodland one finds communities of river-banks which are in many ways characteristic. F. von Müller, while

1 see Maiden, The Forests of New South Wales. Agricult. Gazette of N. S. Wales 1901

on Gregory's expedition, found the following species to be common along the northern rivers: *Terminalia chuncoa* (Combret.), *Jambosa eucalyptoides* (Myrt.), *Morinda Leichhardtii* (Rub.), *Inga moniliferum* (Legum.), *Agati* (Legum.), *Polygonum Cunninghamii* (Polygon.), *Pandanus, Melaleuca* and *Eucalyptus rostrata.* These trees shade grassy valley slopes with an undergrowth consisting of a mixture of savanna and pan-tropical types. As the rainfall diminishes towards the south and west there is a gradual impoverishment of these riparian woodlands. The palm *Livistona alfredi* extends westwards to 117°E longitude. *Pandanus* does not seem to go beyond 125°E longitude. Finally, only a very small group remains. However, *Eucalyptus rostrata* and *Melaleuca leucadendron* continue to survive in the driest regions and adorn the creek banks with their fine crowns. *E. rostrata,* however, extends also beyond the tropics and in fact reaches the south coast. No other single species of the tropical riparian forests and woodlands extends that far.

6. COASTAL WOODLANDS and SCRUBS

Mangroves which occur along the tropical coast of Australia are somewhat depauperate relatives of the Malaysian forms, and neither floristically nor biologically have they developed any special features of their own. Its most resistant and extensive element is *Avicennia officinalis.* This Mangrove appears to occur around practically the whole coast of Australia, although here and there it is rare. In Tasmania for instance, it does not occur at all.

Immediately behind the mangrove swamps in many of the drier regions, one encounters the inland communities. On the north-east coast, however, a special coastal woodland formation can be distinguished. Also on the southern coast, dune and marsh communities are present.

The north-eastern and north-western coastal woodland occurs characteristically in the region of plentiful summer rain, and consequently extends from the Kimberley region eastward as far as Moreton Bay. *Melaleuca leucadendron,* unmistakable with its tall stem and its white bark splitting off in flakes, plays the most important role in this region. In the cool season of the year the scent of its greenish-white flowers fills the air. Further inland, *Tristania* (Myrt.) and species of *Acacia* become common and almost all are imposing trees. Most species of *Acacia* here possess remarkable broad phyllodes. In moist places in the tropics *Wormia alata* (Dillen.) is an important element, as is also *Clerodendron* (Verben.), and a number of leguminous lianes. The whole scene is characterized more by the strong development of these few forms rather than by the presence of a large number of different species. *Pandanus,* palms and *Cycas* become more abundant as one moves further away from the coast. *Alpinia coerulea* (Zingib.), *Amorphophallus* (Arac.) and *Tacca* (Tacc.) fill the shady places. *Pothos* (Arac.) climbs on their stems and great tufts of *Drynaria* (Polypod.) hang down. On the lakes, the water is covered by *Nymphaea gigantea* and *Nelumbium speciosum.* In short, a large number of those species which are of wide distribution in the world's vegetation are present. As one passes further into the interior the number of the above species gradually diminishes. This process continues until we reach the transition zone to the real savanna or to the sharp line where the rainforest suddenly begins. It may be noted, however, that projecting arms of the latter extend along the water-courses deep into the strand woodland.

In the southern coastal commuities, the presence of tall trees is the exception rather than the rule. However, *Eucalyptus gomphocephala,* an imposing tree which occurs in south-western Australia, between the Swan River and Cape Naturaliste, grows in abundance near the coast. Some species of *Melaleuca* (called paperbarks because of their white bark which sheds in flakes) occur as trees of gnarled form. It may be noted that they also appear in moist places in the interior. But the bulk of the coastal vegetation of the temperate parts of Australia consists of shrubs. According to their taxonomic character, they always bear a distinct relationship to the grasslands of the interior. As a result we get the remarkable fact that in south-western Australia the coastal bush differs sharply from the communities immediately bounding it on the interior, and appears as a border of strange forms. Phyllode-bearing species of *Acacia* are present everywhere as an important genus, while *Alyxia buxifolia* (Apocyn.), *Myoporum* spp. (Myopo.), *Pittosporum phillyreifolium* (Pittspor.), *Fusanus acuminatus* (Santal.), and *Leucopogon australis* (Epacrid.) play a more or less important role. Where the sand becomes looser the number of shrubs diminishes considerably and herb-like dune plants such as *Apium* (Umbell.), *Mesembryanthemum* (Aizoac.), *Spinifex* (Gram.), *Lepidosperma* (Cyper.) and other related plants, together with several species of *Atriplex, Rhagodia* (Chenopod.) and *Zygophyllum,* appear. In addition, certain local elements, most of which may be regarded as extensions of the inland vegetation, occur. The flora of the muddy ground is more uniform in the south than the psammophilous dune vegetation. The most important elements of the scanty plant growth are *Salicornia, Atriplex, Chenopodium, Rhagodia* and *Apium.*

7. SAVANNA

Towards the interior the savanna woodland gradually changes to savanna over wide areas of Australia. By degrees the trees are found occurring further and further apart; they also show a decrease in height and vigour. This decline is particularly true of the eucalypts. The acacias compete more and more strongly with them until finally the savanna formation - the real "grassland" of Australian authors - develops its characteristic form.

It was most fortunate that Schomburgk described the scenery of this interesting formation in the east. The grassland, according to him, forms the principal part of South Australia. It consists of endless undulating plains (stretching from the coast towards the north and east). The coastal area, once covered by savanna woodland, is today the granary of the country, while the grassy plains of the interior constitute the pastoral areas. Their extent seems immeasurable and they finally blend with the horizon, becoming like the deserts, monotonous and lonely. In the deep interior there are only a few fertile regions of moderate extent. For the rest, bare sandstone tops and dune-like sandhills alternate with gravelly and arid plains. Only where the salty soil is covered with scattered wind-polished stones does a very sparse vegetation, consisting of succulent members of the family Chenopodiaceae *(Kochia, Atriplex* and *Salicornia),* together with hardy grass tufts, manage to survive. Usually, however, one sees on the grassy plains low shrubs and small strongly branched trees. These may be solitary or arranged in clumps which stand out like islands emerging from the sea. They consist chiefly of *Casuarina* spp. (e.g. *C. stricta, C. glauca, C. distyla),* eucalypts *(E. odorata, E. drumosa, E. virgata)* and *Acacia pycnantha.*

According to R. Schomburgk, "The grassland, in fact the whole appearance of the plains, bears a striking resemblance to the savannas of British Guiana. Naturally there are great floristic differences between the two, but these savannas usually present the same undulating ground, the scattered much branched trees, the oases, and the rivers lined with a green belt. The grasses and herbs which cover the areas during the dry season show the same sunburnt yellow character. With the onset of the rainy season, there is the same magical re-appearance of the green colour."

In Western Australia, Schomburgk's descriptions would apply only in a few cases, specifically to a few districts near the tropics. Elsewhere, the western half of the continent presents only the most depauperate picture. Because of the unreliability of the rainfall (15-25 cm per year.), it resembles desert rather than savanna. Species of *Acacia,* with their stiff, narrow oblong phyllodes and greyish-green colours, tend to dominate this area. We may mention, for example, *Acacia aneura* (called 'Mulga' by the early settlers). The grass growth, however, is scanty. The everlastings persist all the year round and over wide areas the salt-bush, with its glaucous or grey coloured fleshy stems, is the dominant vegetation form.

The situation in the eastern half of the continent is quite different. Here, in normal years, the summer rains extend far into the south, creating those broad grassland zones which play such an important part in the cattle industry. These grasslands develop gradually from savanna woodland. On the other hand, they also change very gradually into almost grassless deserts as the rainfall diminishes.

Well towards the south, in the high plains at the foot of the Australian Alps, a savanna-like vegetation is present which is known locally as the “Mineroo-vegetation”. In winter the plants are covered here and there by snow, but by November they have become green and form fine herbland until April.

The savannas in the region of the Darling, insofar as this river belongs to New South Wales, are, according to Maiden[1], characterized by “Low-growing species of *Eucalyptus, Casuarina, Acacia,* useful pasture shrubs and saltbush”. These are in effect the same features as are present in South Australia. Further north the savannas extend to the coast at the Gulf of Carpentaria. They show a great diversity of form, but always retain the same fundamental characteristics. In fact, as Warburg states, it is the only formation of Australia which extends unaltered beyond the Torres Straits to New Guinea. Here, in the Fly River Basin, it becomes widespread.

The number of individual grass species which occur in these savannas is not as yet definitely known. Bailey mentions that on the “Downs” in the interior of Queensland the number of grass species is high and that for the most part they have high nutrient value. Species which are particularly highly regarded by the cattle farmers include *Andropogon sericeus* (Blue grass), *Astrebla pectinata* (Mitchell grass), and several species of *Panicum, Danthonia* and *Sporobolus.*

Because of the lack of reliability of summer rainfall in this part of the world, an unfavorable physiological peculiarity has been impressed upon the savannas of almost the whole of Australia. A rapid progression through the developmental processes occurs. This is in marked contrast to the savannas of Guiana and, more particularly, to the pampas of the Argentine. In Australia, where in one year a tall grass field waves, concealing horse and rider, in another year a poor growth occurs, the grasses being scarcely a foot high. This lack of reliability in one of the most vital climatic components, resulting as it does in long and frequently recurring droughts, has made the settlement and development of Australia exceedingly difficult and dangerous.

8. SHRUBLANDS

Over much of Australia, open grass plains are absent, their place being taken by shrublands which are very strongly developed. These constitute the so-called Australian “scrub”. The scrub is the most characteristic form of vegetation in this part of the world, just as the savanna is in Africa. A large number of different types are to be found which we may list as follows:

a. Mallee scrub

On the southern margin of the tableland a quite dense assemblage of shrubby eucalypts is present. It appears to consist of a mixture of several *Eucalyptus* species with an admixture of other genera. These communities are characterized by the presence of strongly branched shrubs with dull green leaves and a general impression of barrenness. Called ‘mallee scrub’ by the early settlers, this formation extends from the Stirling Range in the west to the Murray River in the east. It comprises landscapes of depressing aridity which are often termed ‘desert’ in the literature and on the maps. But they are, in fact, deserts of a most peculiar character. The mallee scrub of South Australia has often been described, and the accounts of Schomburgk and Behr are generally known. These descriptions, for the most part, also apply to Western Australia. The scrub is an ‘ocean of shrubs’ extending further than the eye can reach and scarcely penetrable. Landmarks are lacking except where the harsh outline of some rugged hill rises above the dreary mass. In spite of the first impression of monotonous uniformity, however, the bush presents quite a diverse structure when more closely examined.

In one place the formation will be an almost pure and unmixed stand, in another

1 The Forests of New South Wales. Agricult. Gaz. of N. S. Wales 1901

a mixture of the most different elements; in some one finds shrubs all about the same height, while in other parts some members actually reach the dimensions of tall trees.

Pure stands of Eucalyptus communities are frequently encountered in the Murray Basin area. Here, *E. dumosa, E. uncinata, E. bicolor* and *E. incrassata* participate in the formation of a closely interwoven bush. This is the extensive shrub-labyrinth whose appearance Schomburgk termed “oppressively” uniform. ‘The relatively low and similar height of the plants and the dull blue colour of the foliage form a picture which from a distance looks like the surface of the sea, extending to the horizon.’ Frequently, however, the mallee scrub is found to be richer in species. Together with *Eucalyptus* species, one may find *Casuarina, Melaleuca* (Myrt.), *Exocarpos* (Santal.), *Dodonaea* (Sapind.) and *Frenela* (Pinac.) present in the formation, as well as an abundance of smaller bushes representing many different Australian genera. These are for the most part similar in form and appearance, yet specifically different according to the locality and type of soil. The genera represented are richer in species than those of the savanna formation and the whole is dominated by xeromorphic species. Behr describes how: “heath-like or vertically oriented leaves are crowded in a moss-like interlacing kind of growth into rounded shrubs. Alternatively, they sparsely cover the bareness of the long shoots which project from the forbidding scraggy shrubs. The dominant colour of this foliage is a dull blue green. However, in this respect nature allows some variety. *Rhagodia* (Chenopod.), for instance, bears whitish foliage, while other shrubs have brownish red leaves. Strangest of all because it appears so incongruous among such surroundings is the bright green of *Cassia* (Legum.) and of *Santalum*. Compound leaves are rare but, apart from that, one finds the greatest variation in shape, from ovate through lanceolate to spiny leaves. One notes also that leaf arrangement varies from the closest degree of crowding through all possible gradations to leafless branches. At the same time it is apparent that plants which belong to very different families are present. However, they are so alike in habit that it is only when in flower or fruit that one can make reliable determinations.”

It is on the boundaries of the mallee scrub area that the richest developments of the formation occur. Such a favorable zone is present in the Southwest Province where it is particularly broad. At 129°E, the “giant mallees” rise to heights of 15-18 m, but as one proceeds further west, such tall forms become more and more common until in the Coolgardie Goldfields area, 122°E, they appear in woodland-like communities. A detailed description of these is given in a later section of this work. Under such circumstances, transitions to savanna woodland occur.

Over the whole extent of the mallee scrub area the undergrowth is more or less similar in nature. Some strongly xeromorphic grasses *(Stipa, Neurachne* and *Anthistiria)* grow in scattered tufts on the infertile soil. Herbs appear more plentifully only when the winter rains have been more than adequate, then everlastings, brighten the otherwise drab picture. Very important, in particular, are the mealy-white or almost metallic-looking succulent members of the Chenopodiaceae, which are resistant to the dryness and heat.

From the point of view of seasonal development, the scrub outwardly presents a very different picture from the grassland. This feature is clearly described by Behr who points out the small degree of change which takes place in the scrub with the advent of the dry season: “Little can fade where little sprouts, and each month sees the same dense, desert-like assemblage of rigid, sapless and mostly similar appearing species. Nevertheless, in the somewhat moister areas, flowers are rarely completely absent. With more abundant rain, herbs and some grasses develop, although they soon disappear. The flowering period of the shrubs and trees is, however, of longer duration than on the grassland, and it continues, although with diminished vigor, right up to the beginning of the next rainy season. It almost appears as if the flora of this region was quite independent of all climatic conditions. It has something demoniac about it. Undeterred by the hostile outer world it produces its own floral decoration.” Up to the present these areas have largely been left undisturbed by man. The scrub “offers little resistance to the settler but gives him at the same time little hope."[1]

Corresponding formations are sometimes present in the regions of tropical summer rainfall, although their components differ considerably in their taxonomic character from their southern counterparts. In his paper on the botany of the Gregory expedition to North Australia, F. von Müller gives an imposing list of plants which form the vegetation of these "sandstone tables" occurring to the west of the Gulf of Carpentaria. The list shows the presence of a peculiar mixture of tropical elements with many that we must consider as typically Australian. Thus, with species of *Terminalia* (Combert.), *Psoralea* (Legum.), *Strychnos* (Logan.), *Spathodea* (Bignon.) and *Bauhinia* (Legum.), there occur small eucalypts with brightly coloured flowers, and also species of *Boronia* (Rut.), *Jacksonia* (Legum.), *Verticordia* (Myrt.), *Goodenia* (Gooden.), *Persoonia* (Prot.), and *Grevillea* (Prot.). This is a very important flora, and further biological studies of it are urgently needed. That there are many points of agreement with the mallee types of the south can scarcely be doubted. It is also interesting that they seem to be similarly conditioned insofar as that in both places we have evidence of a sandy substratum.

b. Sublittoral sclerophyll shrubland

In the moister regions characterized by regular and plentiful winter rains, the mallee scrub as such comes to an end. To a certain extent it passes into other formations. Either the eucalypts become so dominant that *Eucalyptus* woodland with shrubby undergrowth is developed or eucalypts play a very small part and thick shrubby growths are formed which can be compared with the "Maquis" of the Mediterranean, or better still, with the stiff leaved scrub of the Cape. This formation shows its best development in the coastal regions of south-west Australia, between the Murchison River and Esperance Bay. It is rich in species and adds considerably to the number of species in the flora of Western Australia. The formation consists chiefly of shrubs of all heights down to heath-like dwarf bushes. In the rainy season a few perennial herbs and bulbous plants (Liliaceae, Orchidaceae and *Drosera)* together with some annuals also occur. These, however, are not nearly as numerous or important as the similar forms in the Cape or Mediterranean countries.

The south-eastern part of Australia also possesses such shrub-associations. The same preference for sandy soil is shown in both the mountainous areas and the coastal woodlands. They have frequently been described from the region around Sydney. The old name of Botany Bay actually refers to the particular richness in flowers and form of the plants in this area. The Sydney region, in fact, provides a particularly good example of the formation in eastern Australia. Topp (in Victor. Natur. V. 63), in a short but interesting article, has shown how, in terms of its floral biology, it appears more important than the corresponding sections further south, i.e. the Melbourne area. Near Sydney, according to this author, the red epacrids occur more frequently than the white and in particular the long-tubed species are more dominant. The same thing applies in the family Rutaceae. "While (in southern Victoria) only white or greenish yellow *Correa* spp. occur, red and blue species are common near Sydney." Members of the Proteaceae show much the same picture: the grevilleas of New South Wales are more brightly coloured than the more southern species, while the attractive *Lambertia formosa* (Prot.), with its long red tubular flowers, does not extend south to Victoria at all.

c. Sand heaths

It has already been shown that the undergrowth of the sclerophyllous *Eucalyptus* forest or woodland is taxonomically and biologically equivalent to the above formation and in a modified form is continued by it. This applies to the sand heaths of the whole of southern Australia, They are either directly connected with the undergrowth of the woodlands or originate through reduction of the sublittoral shrublands.

These heaths of the infertile sandy country (termed 'sandplains' by the early settlers who detested them) were first described in South Australia, and quite naturally as a sub-

1 Jung in Peterm. Mitt. XXIII (1877) 353.

division of the mallee scrub. “The plants in these regions,” says Behr, “‘while growing to less than the height of a man and differing very little in habit from those of other scrub regions, nevertheless always provided me with new species.” This brief characterization is apt and it holds good also for the south-west of Australia. The sand heaths occupy areas on the surface of the gently undulating tableland leveled by erosion. They often show a very clear line of demarcation from savanna woodlands and grass steppes which occupy the loamy soil of depressions in the same region. The deep-seated differences between the taxonomy and biology of these two Australian types of vegetation are, as a consequence, strikingly brought out. The remarkable duality of the whole plant world of the Australian winter rain area is clearly highlighted. The differences between them were perceived by the earliest South Australian botanists when they compared grassland and scrub areas.

d. Mulga scrub

Shrubby associations, which are closely bound genetically with the savanna woodlands, cover wide areas of the interior of Australia. In the west they occur slightly north of 30°S, while in the east they are found further south. *Eucalyptus* tends to take a back seat here, whilst species of *Acacia* dominate the scene. The early settlers referred to these *Acacia* communities as the “Mulga scrub”. We have already discussed its essential peculiarities and have also seen how, as conditions worsen in low rainfall areas, the Mulga scrub shows a gradual transition to desert-like stunted forms.

e. Brigalow scrub

The northern half of Australia shows many peculiarities in its shrub communities, and although the descriptions of explorers are somewhat incomplete, some features are now clear.

The Brigalow scrub must be regarded as a characteristic formation. It extends from the eastern edge of the plateau in Queensland to the region of the Victoria River in northern Australia and is bounded towards the interior by deserts. It is a formation of shrubs or small trees often closely mixed and of the most diverse relationship. *Eucalyptus* species are present, but although impressive in size, they play an inconspicuous role. By contrast, species of *Acacia* are of considerable importance. Amongst these, *Acacia harpophylla,* with its bluish-green leaves, is common, giving a remarkable pale and gloomy colour to the landscape. The Brigalow trees are, for the most part, gnarled and irregularly branched. The foliage of all the members of the community show xeromorphic modifications. Low undergrowth remains sparse, and grasses are almost completely lacking. Massive dead tree trunks and decaying wood cover the ground in abundance. Altogether the impression given by the Brigalow is bleak and depressing.

In addition to the above, the most important constituents are *Alphitonia excelsa* (Rhamn.), *Flindersia maculosa* (Rut.), *Eremophila longifolia* and *E. Mitchellii* (Myopo.), *Atalaya hemiglauca* (Sapind.), several *Capparis* species, *Heterodendrum oleifolium* (Sapind.), *Cassia* (Legum.), *Ehretia saligna* (Borrag.), *Bauhinia* (Legum.), *Carissa ovata* (Apocyn.) and *Delabechea rupestris* (Stercul.). Among the dense shrubs one may also see again the bottle-like trunks of *Brachychiton rupestris* and others. In the undergrowth, pan-tropical genera such as *Sida* (Malv.), *Polymeria* (Convol.), *Evolvulus* (Convol.) and *Vittadinia* (Compos.) are the main representatives.

Tenison Woods (Proc. Linn. Soc. N.S. Wales VII (1882-83) 579) concludes his description of this community in tropical Australia as follows: “By the term “Brigalow scrub” one understand a scrub composed almost purely of *Acacia harpophylla*, or of thickets of mixed character in which particular trees and shrubs are present in varying proportions.”

The Brigalow scrub is a pre-eminently xeromorphic woody assemblage. More xeromorphic than the savanna woodland, it bears the same relationship to it as the savanna woodland in its turn bears to the rainforest. The Goondiwindi district, for example, in southern Queensland is described as follows in the Official Year Book for 1901 (p. 164): “The whole district is covered with woody growth; from open forests (i.e. savanna woodland) - usually on river banks and creeks - down to thick scrubs which are situated away from the watercourses. These are Brigalow scrubs of *Acacia harpophylla, Casuarina, Geijera* (Rut.), etc. They are usually found on the watersheds, but long tongues project into the forest land and often reach as far as the watercourses in this way. At the same time there are also clear open places in this scrub where it is replaced by forest”.

9. DESERTS

Because of their links with less arid areas through a series of plants showing decreasing xeromorphy, Australian deserts do not show any effects of isolation on the vegetation. In consequence, there are no features of special interest. What is found in these deserts is a depauperate residuum of the vegetation of the surrounding areas. The definition of the desert, according to Australian explorers, is quite comprehensive. Large expanses where surface water is lacking are classed as desert, although covered to a certain extent by sparse vegetation or sometimes even by true woodland. As students of plant geography we cannot agree with this conception of a desert. Only regions where the rainfall is very small - less than 20 cm per year - show such a sparseness of vegetation that we can speak of them as deserts. Even here, however, the frequently emphasized unreliability of the weather does not always permit a rigid definition.

Actually, there are no really extensive areas in Australia which are completely lacking in vegetation. The edaphically peculiar salt pans are the largest. The vegetation may become very scanty, but it is still characterized by a certain diversity. In particular, its nature varies with differences in soil character. On loamy soils, succulent-leaved members of the Chenopodiaceae are most typical. In fact, near salt depressions, such as around Lake Torrens for example, they constitute the dominant vegetation. On the other hand, they are sometimes also present in the drier savanna country and are not completely lacking from the mallee scrub. Stiff-leaved woody or shrubby species of *Acacia* are also usually present with the salt-bush. The genus *Acacia* is the most important woody one of the loam deserts.

Sandy deserts are even more barren than loam deserts. Large sand-dune areas in the interior are in fact often completely barren of vegetation of any kind. As a rule, however, sandy desert country is scantily covered by dark crowned species of *Frenela* [*Callitris*], and by the leafless branch networks of species of *Casuarina* and *Exocarpos.* Poorly developed specimens of *Eucalyptus,* stunted forms of *Fusanus* [*Santalum*], and the peculiar cones of *Codonocarpus cotinifolius* (Phytolacc.). In their vicinity, one almost always finds the true sign of the Australian desert - the so-called “spinifex”. This term is applied to clumps of the most stiff and highly xeromorphic members of the Graminaceae. In fact, they do not belong to the genus *Spinifex* at all, but are species of *Triodia.* The presence of these close bands and mats of pale-coloured spiny-foliaged grasses characterize the most dreary widespread stretches of the interior of Australia. Thus, for example, referring to the region 25°S and 122°E, Forrest (in his Journal of 1874) remarks: “The view from here stretches away to the horizon, but as far as the eye can see from NW to SW nothing is visible but an ocean of spinifex. There is no sign of water or of any other change in the character of the country.” The main centre of the true spinifex desert (see map) lies in the low rainfall area between 120° and 130°E. The distribution of spinifex is, of course, much more extensive than this and in fact in the west it covers almost the whole width of the continent.

In the basin of the Finke River System, which occurs almost in the heart of the Australian desert region, the mountains create more favorable conditions. A broad oasis occurs where the heavier summer rains have led to the development of a kind of savanna with grassland and attractive everlastings. In the river valleys even tree growth may occur. *Eucalyptus rostrata* attains a height of 30 m, and one may see specimens of *Grevillea striata* (Prot.) over 20 m high. *Frenela verrucosa* (Pinac.) covers the slopes of the gorge-like valleys. At the point where the Finke River breaks through the Krichauff Range, one finds *Livistona Mariae* (Palm.) growing in the river bed [Palm Valley]. It represents a very isolated outlier of the palm regions. The dark leaves of the 20 m tall fan palm contrasts effectively with the bright green of the eucalypts.

Schematic Explanation of the Vegetation map of Australia

Vegetation types on the map naturally represented only the approximate circumscription the patterning.

Name	Upper storey	Lower storey	Ground layer
Tropical rainforest	Mixed trees, many species	Many shrubs	No grass
Temperate rainforest	Eucalypts dominant, few other trees	Even more shrubs	Some grass, many ferns
Sclerophyll forest / woodland	Eucalypts dominant, few other trees	Many small shrubs	No grass
Savanna forest / woodland	*Eucalyptus* or *Acacia* dominant	Few or no shrubs	Much grass
Savanna	Few low trees or shrubs		Much grass
Mulga Scrub	Few low trees or shrubs (*Acacia* dominant)		Little grass
Brigalow, mallee scrub or sand heath	Many low trees or shrubs (*Acacia* or *Eucalyptus* dominant)		No grass
Desert	Scattered shrubs, *Acacia* or *Casuarina* dominant		*Triodia*, otherwise no grass

III. Regions

Variations in distribution of the vegetation according to altitude is restricted to eastern Australia. On even the highest peaks in south-western Australia (Stirling Range, 1100 m), the shrub growth present is only very slightly modified by elevation. Because of the higher humidity of the summits, however, the vegetation is thicker and there are some differences in species composition from that at lower levels.

The same holds true for the more northerly situated mountains of the south-eastern part of the continent, e.g. the Blue Mountains, where a characteristic shrub community forms the undergrowth at higher elevations.

By contrast, a distinct change in vegetation with elevation occurs in tropical Australia on the Bellenden-Ker Mountains in north-eastern Queensland.[1]

BELLENDEN-KER RANGE

At a height of about l000 m the luxuriant rainforest of the lowlands begins to show a decrease in vigour and gradually becomes somewhat depauperate. At this point, groups of low palms (e.g. *Bacularia Palmeriana* and *Calyptrocalyx australasicus)* and tree ferns *(Alsophila Rebeccae)* begin to appear. However, it is only at a short distance below the summit, at an elevation of about 1500 m, that a distinct change becomes apparent in the vegetation. *Dracophyllum Sayeri* (Epacrid.) now appears, 1.5-4 m in height, with wide horizontal, somewhat tortuous branches and reflexed leaves. It is the dominant feature of the stunted thickets which cover the rocks up to the summit at 1625 m. These thick-

1 The first account concerning this region was given by Sayer. More details on the flora and fauna of the Bellenden-Ker Range are found in the Report of the Government Scientific Expedition to Bellenden-Ker Range upon the Flora and Fauna of that Part of the Colony by Meston, Brisbane 1889. The botanist E. M. Bailey took part in this expedition and made a fine collection of plants (*loc. cit.* 30-80). In company with Dr Pritzel, I visited the range in June 1902.

ets consist of robust shrubs 1.5-3 m high, with darkgreen leathery leaves. They include *Orites fragrans* (Prot.), *Drimys* (Magnol.), *Hibbertia scandens* (Dill.), an upright, intricately branched form, *Myrtus metrosideros* (Myrt.), *Leptospermum wooroonooran* Bailey (Myrt.), *Rhododendron Lochae* F.v.M. (Eric.), *Trochocarpa laurina* (Epacrid.), *Halfordia* (Rut.), and *Alyxia ruscifolia* (Apocyn.).

The densely branched network of shrubs is even more closely knitted together by the tangled mass of mosses and lichens which live on the bark. In this moist atmosphere they grow so well that at first one overlooks the abundance of epiphytic ferns and small orchids *(Dendrobium, Oberonia, Liparis* and *Bulbophyllum).*

This unusual community on these isolated mountain tops, with its mixture of Malaysian, Melanesian and Australian species, bears a striking resemblance to the flora at high elevations in the Malay Peninsula from Java to New Guinea. Thus the flora of this part of Queensland retains its Malaysian features even on the highest peaks.

SOUTHEASTERN MOUNTAINS

The effect of elevation on distribution of the vegetation is more pronounced in the higher ranges of south-eastern Australia. These high ranges unite Tasmania geologically with the continent. On the mainland they stretch from Mount William to the southern border of N.S.W. In these regions, as temperature falls with elevation, it results in a gradual phasing out of the subtropical elements of the flora. Many Australian groups also become rare or disappear altogether. The effect occurs because the winter is too severe and the summer not warm enough. During winter, heavy snowfalls frequently occur in the higher parts of the woodland region and we may see the unusual spectacle of evergreen foliage contrasting with the glistening white of snow. The fronds of the tree-ferns bend down under the mass of snow, while the delicate pinnate leaves of the acacias are concealed beneath it. The twigs of *Eucalyptus* may even break under its weight.

The limit of tree growth and the start of the subalpine or alpine regions[1] occurs at 1950 m on Mount Kosciusko, at about 1600 m in southern Victoria and at 1100 m in southern Tasmania. Elevations above this are treeless, even though the growing season may last five months (November to March).

An indication that the limit of tree growth is being approached, particularly in Tasmania, is given by the occurrence of dense stands of woody composites (e.g. *Senecio centropappus* F.v.M.) 3-4 m high. At the same elevation, an undergrowth of dwarf eucalypts marks the limit of tree growth. In Tasmania this is represented by *Eucalyptus Gunnii* [*E. verncosa*], in Victoria by *E. Gunnii* [misdetermined = *E. glaucescens*] and *E. coriacea* [*E. pauciflora*], and on Mount Kosciusko by *E. coriacea* only. The plants eventually become so crowded together that they form an almost impenetrable thicket with a dense uniform canopy. It is interesting to note that even here the genus *Eucalyptus* maintains its dominant role in Australian vegetation. This contrasts with the situation in antarctic South America where *Nothofagus* is dominant.

In the alpine region of the continent, ericoid or xeromorphic-leaved bushes are usually common. Species belong mainly to the families Proteaceae, Myrtaceae, Compositae and Epacridaceae. They are characterized by low stunted stems, dense arrangement of branches, thick foliage and abundant flowers. They usually form very open stands which tend to shelter behind rock outcrops and are often interspersed with large areas where only perennial herbs are present. Many of them, such as the fine-leaved *Leptospermum* (Myrt.) or the silky *Pimelea* (Thymel.), grow close to the rocks. In this environment the *Pimelea* strongly resembles *Daphne striata* of the Tyrol Alps. As well as members of these genera, others include *Grevillea* (Prot.), *Orites* (Prot.), *Leptospermum* (Myrt.), *Kunzea* (Myrt.), *Richea* (Epacr.), *Epacris* (Epacr.) and *Leucopogon* (Epacr.). In addition, many low shrubs mostly belonging to typical Australian genera, e.g. *Hibbertia* (Dillen.), *Bossiaea* (Legum.), *Pultenaea* (Legum.), *Eriostemon* (Rut.), *Boronia* (Rut.), *Pimelea* (Thymel.), *Prostanthera* (Lab.), *Stackhousia* (Stackhous.) and *Gaultheria* (Eric.) occur here. By contrast,

1 The best on mountain flora is J.H. Maidens Second Contribution toward a Flora of Mount Kosciusko. Departm. of Agricult. Sydney, Misc. Public. n. 331 (1899).

the part played by *Acacia* in the mountain environment is not significant. On Mount Kosciusko, Maiden was unable to find any above the 1600 m contour.

In the gaps between the bushes many different herbaceous species occur. These are largely confined to mountainous areas. The imposing *Ranunculus anemoneus* with large white crowns and *R. Gunnianus* with deep yellow flowers, grow in depressions fed by melting snow, while *Caltha introloba* (Ranunc.) covers moist areas with a glistening green sward. Other examples of alpine plants are the mat-forming *Veronica densiflora,* the imposing composite *Celmisia longifolia* (Compos.) and *Euphrasia Brownii* (Scrophul.). This species of *Euphrasia* reminds one of *Pedicularis.*

Maiden's (*loc. cit.* 20) paper dealing with the Mount Kosciusko area gives a short account of the overall effect produced by these mat-forming species: "Naturally the green of the grasses provides the basic colour but numerous white patches of *Epacris* sp. and *Phebalium ovatifolium* (Rut.) occur, together with the yellow-flowered *Oxylobium alpestre* (Legum.). Scattered through the grassy areas are the yellow-flowered *Ranunculus anemoneus*, a violet-flowered *Brachycome* (Compos.), with the massed white clumps of *Olearia stellulata* (Compos.) and *Celmisia longifolia* (Compos.). Interspersed between these is the charming *Aciphylla glacialis* (Umbell.). Finally, growing as small, dense, cushions, we may note the elegant *Stackhousia pulvinaris* (Stackhous.), *Raoulia catipes* (Compos.), *Epilobium confertifolium* (Oenother.) and many others."

As we move further south in Australia, the mountain flora rapidly becomes more abundant. Mount William in the Grampians is an isolated western outpost of the Australian Alps. In spite of its height of 1166 m, only *Celmisia longifolia* and two or three other species of alpine or subalpine plants, apart from the endemics *Eucalyptus alpina* and *Pultenaea rosea,* grow there. On the Australian Alps proper, the number of species present increases considerably and on Mount Kosciusko (2227 m high), 105 species have been collected above the tree line. But here, as well as on other mountains of the continent, the number of endemic species is very small. F. von Müller, the first botanist to investigate these wilderness areas 50 years ago [ca. 1850], could only find 15 species which were peculiar to the continent. Tasmania, however, posseses a large number of endemic alpine species and this island is the true home of the Australian mountain flora. Although its alpine flora surpasses that of the mainland, its lowland flora is, however, more closely related to and dependent upon the mainland flora. F. von Müller estimated that of the 130 endemic vascular plants of Tasmania, 80 were alpine. It is noteworthy that almost all the endemic genera are alpine. Some of them, such as *Bellendena* (Prot.), whose charming white inflorescences are to be seen everywhere on the slopes of Mount Wellington, play a prominent part in the physiognomy of the Tasmanian Alpine flora. More important still are the low conifers which form the most remarkable feature of the Australian high mountain flora. They belong to the genera *Pherosphaera* [*Microstrobus*], *Microcachrys* and *Arthrotaxis.* The distribution of these essentially endemic plants is very restricted. With few exceptions, they only occur in the moist mountains of western Tasmania. They are common there, however, and in places often gregarious. This at least is the view of Tenison Wood, who states that on some mountains there are impenetrable thickets of *Arthrotaxis cupressoides.* Species of *Pherosphaera* and *Microcachrys,* on the other hand, have a somewhat scattered distribution, more like that of the family Epacridaceae, with which they are often found associated.

The subdivisions of the alpine vegetation of Australia are most clearly seen in Tasmania. Rock outcrops and boulders appear to form the substrate. The communities are never closed; bare ground being always present between the scattered shrubs, perennial herbs and moss cushions. Also many streams and drainage channels are present. Moss moors form in the shallow depressions or on the flat summits of these rain-swept, cloud topped mountains. These are the only moss moors in Australia. They rarely form closed communities over large areas, but instead usually consist of a number of small areas interrupted by debris or rock outcrops.

Species of *Sphagnum* are an essential feature of this flora. They are not, in my opinion, as dominant as those of analogous moors in the northern hemisphere. They also show some ecological differences from the northern hemisphere species. They do not occur as cover plants over wide areas but form small mats, rarely covering more than a few square metres. Cushion or turf-forming plants frequently occur interspersed with these mats. There are also many places where other plants act as turf-formers. Among these are some species of *Carex. Schizaea fistulosa* also occurs here and there, but the most important is *Gleichenia alpina.* This pygmy species was discovered by R. Brown on Mount Wellington where in waterlogged areas it forms extensive closed stands. In contrast to the pale *Sphagnum,* this moor plant is dark and glossy in appearance. Its stalks are dark grey and the frond is covered with reddish-brown scales.

Among the flowering plants of the Tasmanian moor, the monocotyledons appear to be the most important. It is interesting to note, however, that it is not the representatives of the families Cyperaceae and Juncaceae which are dominant but rather those of the families Restionaceae and Centrolepidaceae. In the Cyperaceae, *Oreobolus pumilio* is noteworthy because it forms a transition between the cushion and mat plants of the moor.

These plants have an important part to play in the Austral-Tasmanian Sphagnetum, just as they do in New Zealand and the Chilean moor regions. Members of the families Compositae (*Abrotanella, Pterygopappus*) and Stylidiaceae are (*Phyllachne*, *Donatia)* also prominent. Some members of the Compositae are so similar in appearance that one may easily be mistaken for the other, e.g. *Abrotanella* and *Pterygopappus* [while both cushion plants it is unlikely that they would be mistaken]. *Phyllachne* and *Donatia* also show an extraordinary resemblance. Together with *Azorella* and *Silene acaulis,* all these plants are grouped together as cushion plants.

As well as the species of *Sphagnum,* the gregarious members of the Restionaceae and the cushion plants, a very unusual species, *Astelia alpina,* is found. Its occurrence here is remarkable as otherwise the genus is almost absent from Australia. It occurs in New Caledonia and New Zealand with a fairly large number of species which are mainly epiphytic in their growth habit. But *Astelia alpina is* a true moor plant which often dominates extensive areas. Its leaves are dull olive green and their sheathing bases are covered underneath with long white silky hairs. In the Australian Alps this species is found occurring at the margins of the permanent snow cover.

Distributed almost at random among the moss cushions we find *Caltha introloba* (Ranunc.) and *Drosera Arcturi.* These two species, which floristically resemble many other species on these moors, are of great importance.

Physiognomically, only the shrubs give character to the moors. Members of the Epacridaceae are particularly important. In this respect they resemble the Ericaceae of Europe. One often sees them in the middle of a group of plants surrounded by *Sphagnum* which forms hummocks around the central shrubs. Among the conifers, *Pherosphaera, Podocarpus* and *Microcachrys* must also be mentioned. *Microcachrys is* the most unusual of these with its horizontally growing main stem and prostrate branches. As a rule, a thick mat of dark-coloured needles forms over the boggy ground or the boulder-strewn waterlogged hummocks.

The floral biology of the Australian alpine flora is similar to that of New Zealand. Pale-coloured flowers predominate. According to Maiden out of 75 species which occur at the summit of Mount Kosciosko, 36 are white-flowered, 13 yellow and 13 either green or indeterminate. Blue- and red-flowered species are rare.

IV. Floristics

1. ELEMENTS OF THE AUSTRALIAN FLORA

Analysis of the Australian flora, the foundations for which were laid by Sir J. Hooker and F. v. Müller, shows that it consists of three main elements, to be termed the Antarctic, Malaysian and Australian.

a. Antarctic element

Of the three floral elements, the Antarctic is the most limited in distribution. It is restricted to the south-east corner of the country, and even here it is only well developed in the mountain regions. In such areas, however, it is a major component, particularly in the alpine areas, and provides the link between the Australian mountain flora and the alpine vegetation of New Zealand. Its general geographical characteristics have already been discussed by Hooker (1859) and referred to by later plant geographers, especially Engler (in Versuch d. Entwickelungsgeschichte II 95-103), who analysed this element in considerable detail.

One point which emerges from the discussions is the difficulty of formulating a concise definition of the term 'Antarctic'. It has been extended incorrectly to include groups which belong to the southern hemisphere but are not Antarctic.

The following Australian genera may be regarded as typically Antarctic: *Oreobolus* (Cyper.), *Astelia* (Lil.), *Libertia* (Irid.), *Nothofagus* (Fagac.), *Colobanthus* (Caryophyll.), *Caltha* (Ranun.), *Drosera* § Psychophila , *Aristotelia* (Elaeocarp.), *Azorella* (Umbell.), *Oreomyrrhis* (Umbell.), *Drapetes* (Thymel.), *Geum* § Sieversia (Ros.), *Ourisia* (Scrophul.), *Euphrasia* (Scrophul.), *Gentiana, Forstera* (Stylid.), *Donatia* (Stylid.), *Phyllachne* (Stylid.), and *Abrotanella* (Compos.). Some have been mentioned earlier as moor plants. *Nothofagus* requires closer analysis. In Tasmania, the evergreen *Nothofagus Cunninghamii* frequently occurs up to subalpine levels in the mountains. In Victoria, it only occurs near the sources of the Yarra, Latrobe and Goulbourn rivers and on Bawbaw. Here it descends to the tree-fern gullies. This species has not been found further north than Victoria. About 8° further north, however, in New South Wales, another species, *Nothofagus Moorei,* occurs. An impressive stand of this species may be seen on the ranges at the edges of the plateau where the Bellingen and MacLeay Rivers arise.

The Antarctic components of the flora appear to be essentially confined to the mountains of south-east Australia. However, it would be incorrect to include all the mountain plants as Antarctic, as many are not essentially Australian. Species of *Veronica, Anemone crassifolia,* and *Alchemilla* are members of families with distant but unknown origins.

b. Malaysian element

The Malaysian element – refered to by many authors as "Indian" - covers greater areas of the Australian flora than the Antarctic element. It is also taxonomically more diverse and shows greater versatility in its adaptations.

The greatest number of species appears to occur in the rainforests of north-eastern Australia. The floristic character of the Australian rainforest is without doubt predominantly Malaysian. Naturally, very close links occur with Papua. How far the agreement extends is not at present known, since the floras of Queensland and New Guinea have not been sufficiently studied. It is quite possible that Warburg's statement: "The forests of Queensland are not a remnant and still less a replica of those of New Guinea; in spite of its relative poorness in species it possesses a very large number of endemics" may prove to be substantially correct.

Engler (Entwickelungsgesch. II 45) provided an interesting list which confirmed the high degree of endemism of the Malaysian groups in northern and eastern Australia. For example, endemism of the palms in northern Australia is 66%, and in eastern Australia, 76%. In the Annonaceae, the respective levels are 100% and 92%, in the Sapindaceae 40% and 72%. In eastern Australia 75% of the Passifloraceae are endemic.

In addition, a large number of Australian forest genera are not present in New Guinea[1]. Nevertheless, despite the quite specific differences listed by Warburg, the high degree of agreement between the two forest floras is perhaps not fully appreciated. He does state, however, that Malaysian species are not 'quite so sporadic' in the rainforests of Queensland. Many species are common to the two floras, e.g. *Aleurites moluccana* (Euphorb.), *Cananga odorata* (Anon.), *Elaeagnus latifolia* (Elaeagn.) and *Podocarpus amarus* (Taxac.). Others, however, are slightly modified under Queensland conditions. Their overall character, however, remains essentially Malaysian. There is also the possibility that really isolated Queensland taxa, such as *Blepharocarya* (Anacard.) or *Davidsonia* (Cunon.), may yet be found in New Guinea, just as *Eupomatia* (Anon.) has now been found there.

The close relationship which exists between the Malaysian, Papua and eastern Australian rainforests indicates that these floras have a common origin. However, this does not imply that there has been a recent migration of the rainforest flora from the north. On the contrary, I consider this to be quite out of the question. The rainforest flora of eastern Australia is very old. Its distribution indicates that it represents only the remnants of a widespread past. It is important to note that each segment possesses its own characteristic array of taxa. The northern, and most extensive, part not only has the largest number but also, as might be expected, the most striking of these taxa. Even in the small districts north of Moreton Bay, species characteristic of the area are present. In the larger forest complex extending from the Macpherson Range to the Richmond River, endemic genera include *Piptocalyx* (Monim.), *Daphnandra* (Monim.), *Doryphora* (Monim.) and *Hicksbeachia* (Prot.).

The smaller southern rainforest complexes bear the same relationship to the main northern centres as Natal does to the tropical African forest regions. One must not, however, limit their characteristics by assuming that the tropical families have, as it were, delivered a variety of adaptive capabilities to the species of the sub-tropical regions. These latter, in fact, show little ecological or floristic difference. It is the typical diversity of form of the tropical rainforest species which confers the characteristic endemism on these outlier species of the higher latitudes. As well as the rainforest types, northern Australia possesses numerous mesophytic to xeromorphic species which in the widest sense are Malaysian components. This includes not only the species found in the river-bank forests, but also many components of the savanna and shrublands. The Brigalow scrub abounds in them. A strong development of these xeromorphically-modified components is also found in the drier regions towards the western coast and further south beyond the tropics. The proportion of endemics here is less than in the eastern woodlands. Nevertheless, it is still strong enough to show that northern Australia has not received its flora second-hand and unaltered from its ancestors, but has diversified into new forms.

Taking into account the great variety in the flora of the Malaysian area, it is not surprising that on Australian soil this Malaysian element again lacks complete homogeneity. Further investigation of components of the flora shows that they fall into two sub-groups, one widely distributed in the south-east Asian vegetation, the other largely restricted to Papua, Melanesia and perhaps New Zealand.

The first of these - which we may call the Malaysian section - is represented in Australia by a large number of families. These include: Aracaceae, Taccaceae, Scitamineae, Orchidaceae, Piperaceae, Moraceae, Urticaceae, Nymphaceae, Aristolochaceae, Annonaceae, Lauraceae, Myristicaceae, Menispermaceae, Capparaceae, Nepenthaceae, many Leguminosae, Connariaceae, Rutaceae, Simaroubaceae, Euphorbiaceae, Meliaceae, Malpighiaceae, Flacourtiaceae, Ochnaceae, Dilleniaceae, Guttiferae, Vitaceae, Combretaceae, Ericaceae, Myrsinaceae, Sapotaceae., Styracaceae, Ebenaceae, Contorae, Rubiaceae, Sambucaceae and Cucurbitaceae. The relatively small number of endemics in this section is of interest. Among the 37 families listed above, there are only about 30 endemic genera. The total number of endemic species, however, is quite considerable.

1 Warburg lists about 33 such endemic genera but this number could probably be doubled. One must take into account, however, the fact that most of these are known from Australian sources and that material from Malaysia with which it could be compared may not yet be available.

The main area where these Malaysian species occur is in the moister, low-lying country, although they also occur to a slighter extent in the drier areas.

The second subgroup, which is more limited geographically in its distribution, is known as the Melanesian section. The fact that much of New Guinea remains unexplored makes it difficult to accurately describe its nature and extent. However, it has already been shown that it is of considerable importance, not only in indicating links between Australia, New Caledonia, New Zealand and South America, but also in relation to the plant geography of Australia. The following groups may be considered representative of the Melanesian section: *Araucaria,* part of the Palmae, *Balanops*, Proteaceae - Grevilleoideae, Monimiaceae, Saxifragaceae, Cunoniaceae, *Pittosporum,* Sapindaceae - Cupanieae, Violaceae and Bignoniaceae.

Typical geographical distributions of this section may be illustrated using the family Monimiaceae[1]. As shown in the following table, 9 genera of the family occur in Australia, but their distribution in the other more eastern regions listed is quite limited.

	Papua-Asia	Australia	New Caledonia	Fiji and Polynesia	New Zealand
Hedycarya	—	1	2	2	1
Levieria	3	1	—	—	—
Piptocalyx		* 1	—	vw	—
Tetrasynandra	vw	*3	—	–	—
Wilkiea	vw	*2	—	—	–
Palmeria	1	2	—	—	—
Daphnandra	—	2	vw	—	—
Atherosperma	—	2	—	—	—
Doryphora	—	*1	—	—	—

The links with Papua and the other island areas are also found in other groups of the Melanesian section, although to a varying degree. Furthermore, links with South America are often evident. These links are, however, mostly more tenuous in families other than the Monimiaceae.

With regard to the degree of endemism, there is a very significant difference between the Melanesian and the Malaysian sections. In the 11 families and genera listed as Melanesian there are no less than 35 endemic genera and the species of these are almost all endemic. The number endemic genera on a family basis is thus over three times greater in the Melanesian than in the Malaysian section.

As a generalisation, the Melanesian species are distributed mainly in the sub-tropical regions and tend not to be present in the drier districts. They are often present in the southern outposts of the rainforest. In the north they tend to occur in the higher parts of the ranges towards the edge of the plateau, although they are not entirely lacking from the low-lying country.

The Melanesian section appears to be the older component of the flora. Its existence in Australia probably extends back to the time when the land mass extended eastward from the present continent between the parallels of 15° and 30°S latitude.

The assumption that such land masses existed in those latitudes is supported by various authors who have provided indirect evidence from data on distribution of plants and land animals. The only question which remains unanswered is the extent and shape of the old mainland. The extent of its former boundary is indicated by the location of the present-day islands. There is some evidence favouring the idea that two large peninsulas extended southwards from Papua into higher latitudes, one connecting with eastern Australia and the other with Melanesia. Without doubt, the configuration of these old land

1 J. Perkins and E. Gilg, Monimiaceae. In “Pflanzenrich” IV. 101 (1901)

complexes underwent many changes but their influence reached as far as Samoa and New Zealand. It provided the nucleus of the Melanesian section of the Australian flora.

c. Australian element

The Australian element includes the majority of plant species in Australia. Its components are either restricted to Australia with no close relatives outside the continent, or they possess a few wandering representatives which are closely connected with the main stock in Australia. While a clear boundary for this element is not yet possible, the following taxa comprise the most important of the Australian components of the flora. There are a few more groups of secondary importance.

Cyperac. –Rhynchosporeae
Cyperac. –Gahnieae
Centrolepidaceae
Restonaceae
Lilliaceae – Johnsonieae
Lilliaceae –Dasypogoneae
Lilliaceae –Lomandreae
Lilliaceae –Calectasieae
Lilliaceae –Anguillarieae pr. p.
Lilliaceae –Anthericineae

Amaryllidaceae –Haemodoreae
Amaryllidaceae –Conostylideae
Iridaceae –Patersonia
Philydraceae
Orchidaceae –Thelymitrinae
Orchidaceae –Diuridinae
Orchidaceae –Pterostylidinae
Orchidaceae –Caladeniinae

Casuarinaceae

E *Santalaceae*
Proteaceae
E *Amarantaceae-Achyranthinae* pr. p.
E *Chenopodiaceae – Camphorosmeae* pr. p.
E *Phytolaccaceae*
Lauraceae –Cassytheae
Droseraceae –Drosera Sub.-gen *Ergaleium*
Pittosporaceae
Leguminosae –Podalyrieae
Leguminosae -Genisteae
Leguminosae –Acacia
Rutaceae –Boronieae
Polygalaceae –Comesperma
Tremandraceae
Euphorbiaceae –Stenolobeae
E *Sapindaceae –Dodonaea*
Stackhousiaceae
Rhamnaceae –Rhamneae

Sterculiaceae – Bütterieae
Sterculiaceae –Lasiopetaleae
Myrtaceae –Chamaelaucieae
Myrtaceae –Leptospermeae
Halorrhagaceae
Thymelaeaceae –Pimele
Umbelliferae -Hydrocotyleae
Epacridaceae
Loganiaceae

E *Verbenac. -Lachnostachydinae*
E *Verbenac. -Chloanthinae*

Labitae -Prostantheroideae
E *Myoporaceae*
Goodinaceae
Stylidiaceae
Rubiaceae -Opercularia
Compositae -Asterinae
E *Compositae -Gnaphaliinae*
E *Compositae –Angianthinae*

The Australian element comprises about 300 endemic genera at present. It shows little affinity with the Antarctic element but a more marked relationship with the Malaysian element. Since this Australian element is strongly developed in Western Australia, we leave a more detailed account to a later section of this book.

The distribution of the Australian element in Australia is tied to the physical geography of the country. The contrast between the western and eastern parts of Australia pointed out by Hooker (Introduct. Essay) is due essentially to the absence of the Antarctic element and the almost complete absence of the Malaysian element in south-western Australia. A second and more important feature relates to the remarkable division of the Australian element into two groups. This duality was first noted and stressed by Tate who developed the terminology used below. He pointed out that one part of the Australian element was restricted to the more coastal areas, being strongly developed in the true winter rain regions of south-western Australia, and called it the “Autochthonous flora”. The other part showed its best development in the inland or more central parts of the continent which were either summer rainfall areas or showed a general unreliability in rainfall. Tate called this the “Eremaean flora”. The more important components of this second category are indicated in the table by the letter **E**. In addition, there are a few groups which are quite uniformly distributed over the whole of Australia, especially the important genus *Acacia.*

The area of the Autochthonous section is divisible into two widely-separated regions. The south-western area, because of its large number of species, is the best developed. This rich area occurs between the coast and a line drawn between Shark Bay and Cape Arid. The high degree of endemism which characterizes south-western Australia has been known since Robert Brown’s time, but it has almost always been overrated. When, for example, Hooker (*loc. cit.* p. 28) states that the difference between south-eastern and south-western Australia is greater than that between Australia and the rest of the earth, he is going too far. His conclusions are based on incorrect deductions from inadequate data. A close investigation of the difference between the two sides of the continent shows that the families characteristic of the west show little difference from those of the east. In fact, apart from the Conostylideae, there are no differences even at the tribe level. It may further be noted, as emphasized by Engler, that the endemic genera of eastern Australia are recruited from 48 families, while those of the western area come from only 33 families. Many show just as strong a development in south-eastern Australia as in south-western Australia. Others show a much stronger degree of endemism in the south-western than in the south-eastern area. This varies from twice the number of species in some families to about 4 times the number in the Stylidiaceae and up to 10 times the number in the Chamaelaucieae (Myrt.) and Proteaceae. All this indicates that progressive endemism has established itself particularly effectively in the south-west. This is the reason for the higher number of species here as compared with south-eastern Australia, as Hooker so clearly demonstrated. It is this high level of endemism which is responsible for the species richness of Western Australia which has made its flora so world famous. Several factors have interacted in bringing about this richness in species - the absence of the Antarctic and Malaysian elements and the varied and at the same time intergrading of its climatic zones which would tend to favour the formation of complex adaptations. Hooker has already pointed out the great interest in this area and we will examine the matter in more detail in the final section of this work.

The Eremaean section forms a broad area in the centre of Australia, where the landscapes are very similar. As a consequence of this, eremaean forms tend to show considerable uniformity. From the boundaries of the narrow Southwest Province to the Darling and Murray Rivers, the same flora predominates. Its eastern and western boundaries come into contact with the Autochthonous element, but the two sections show very little mixing. What mixing does occur is less evident in Western Australia than in the east. On the other hand, a relatively broad zone exists in the west where the two sections show segregation due to the operation of edaphic factors. The Autochthonous component predominates on sandy soils, while the Eremaean element favours the clay-loam soils. While the Autochthonous flora rarely intermixes with other elements, the Eremaean tolerates the presence in its communities of quite a large number of xeromorphic species of Malaysian origin, e.g. members of the family Malvaceae, and species of *Cassia* and *Solanum.* As a result, the Malaysian and Eremaean elements are often found closely intermingled, particularly in the northern parts.

2. REGIONAL DISTRIBUTION OF THE AUSTRALIAN FLORA

From the point of view of biogeography, the plant formations and floral elements of Australia cannot be divided into just eastern and western halves. On the other hand, divisions may be carried to excess, as done by Drude, who defined 11 vegetation regions. This appears to me to obscure the main divisions.

I consider three provinces of very unequal extent as representing the primary divisions of the Australian flora, namely: the Eastern Australian, the Eremaean, and the Southwest Australian Provinces.

a. Eastern Australia

Eastern Australia is the most clearly defined province of the three. It contains most formations and all the floral elements are represented. The Malaysian flora present shows great ecological diversity. The Australian element is well represented but its polymorphic potential is only really shown in some families. Finally, the Antarctic element only occurs in this province where it is restricted almost entirely to the mountains of the south-east.

The following subdivisions of the Eastern Australian Province may be distinguished- northern Australia in the restricted sense, Queensland and the South-East.

1. In northern Australia, the Malaysian element is present with xeromorphic types often predominating. The Australian element shows its strongest development in the genus *Acacia* and several representatives of the Eremaean Province are also present. On

the other hand, the Autochthonian element is rather poorly developed. The Antarctic element is absent.

Northern Australia is the land of the savanna woodland. This formation is open and rarely shows rank growth. The river valleys with heavy permeable soils, however, are occupied by rich forests where *Pandanus* and palms grow. In Arnhem Land, Tate estimated that the flora of the lowlands comprised about 1,221 species with 64% endemic, while the tableland only possessed 614 with about 80% endemic. Dense rainforests are not present in this area and the region is therefore richer in pan-tropical forms than in true tropical groups.

2. In Queensland, there is a great contrast between the vegetation of the coast and the interior. On the coast, the mesophytic forms of the Malaysian element occur sporadically but nevertheless are of considerable importance. The Melanesian species also are conspicuous. In the interior, the xeromorphic forms of this element predominate, but many eremaean types also play a part. Among the Autochthonian flora, only a few genera, such as *Eucalyptus,* show a reasonable degree of development. The Antarctic element is absent. The savanna woodland also covers wide areas here. The inland development of this formation differs markedly from the infertile Brigalow scrub and from the open savannas - the undulating “Downs”, where the summer rains produce excellent pastures on fertile soils. The plateau rises markedly to the east. In the coastal ranges with high rainfall, true tropical rainforests develop. The rainforests are dependent to a large extent on the presence of a favourable environment, and so in some areas savanna woodland is in close competition with it.

3. The line of separation of the South-eastern subprovince from the Queensland subprovince lies at about at 30°S latitude. From there it extends to the extreme south, including Tasmania. This botanical district is easily distinguished from the two northern subdivisions by the reduction in number of the Malaysian species which is apparent in both the coastal and inland areas. This is balanced by a comparable rise in the Australian element. The Antarctic element is present in the mountains, being most strongly represented at the higher elevations. Tate originally coined the term “Euronotic element” for the south-eastern flora. While this name may have some local application, it is of little use in considering wider relationships.

In the drier zones of the South-eastern subprovince, attractive *Eucalyptus* woodlands of varying character develop. The undergrowth is either grassy or shrubby. In moister habitats (Gippsland, Tasmania), the undergrowth may be interspersed with tropical climbers as well as showing a strong development of ferns. These areas belong to the subtropical rainforest zone. The high mountains on the mainland and in Tasmania do not show typical mat-growths but carry a mixed collection of alpine pasture and high moor species.

b. Eremaean

The Eremaean shows a remarkable degree of uniformity. That strange assortment of Australian plants which we know as the Eremaean element is predominant in this large area. However, many Malaysian species are also present. In the marginal areas of the southern half, isolated outliers of the Autochthonian element occur and these break down the uniform character of the vegetation to some extent. In addition, isolated occurrences of Autochthonian species occur far inland on the mountains of central Australia, e.g. *Actinotus Schwarzii* (Umbell.) on the Macdonnel Range.

Edaphic factors are responsible for the most important variations in the vegetation of this very extensive area. The inland parts consist of vast sandy deserts with scant vegetation. Here, *Triodia* (Gramin.) and scattered specimens of *Casuarina, Fusanus* [*Santalum*](Sant.) and *Frenola* [*Callitris*](Pinac.) give the general tone. On loamy soil, *Acacia* shrubs predominate. Members of the Myoporaceae and succulent representatives of the Chenopodiaceae also occur, together with perennial herbs and annuals, according to the incidence of rain. Finally, in the more southern part of the Eremaean Province, where winter rains predominate, the dry land is covered by mallee scrub for hundreds of kilometres. A more detailed description of the western Eremaean Province, which also applies to the eastern part, will be found in Part IV of this work.

c. Southwest Australia

Southwest Australia is by far the smallest of the three provinces. At the same time, it is the most sharply delimited. No representatives of either the Malaysian or the Antarctic elements are present, but numerous groups of the Australian branch of the flora have reached a high degree of development. It is the home of the Autochtonian flora. Large areas are completely dominated by it, and it can compete on more-or-less equal terms with the eremaean species. A more detailed examination of these topics forms the subject matter of the following chapters.

PART I

History and literature of the botanical investigation of extra-tropical Western Australia

CHAPTER 1 HISTORY

EARLY DISCOVERIES

The early voyages of exploration which first brought Western Australia to the attention of the western world were of little value insofar as the botany of the area was concerned. None of the many Dutch navigators of the seventeenth and eighteenth centuries who must surely have visited the west coast of Australia on many occasions seems to have shown any interest in the flora of the new country.

It was left to the British Captain Dampier to bring back the first information regarding the vegetation of Western Australia. Some of the 40 species which he collected came from the tropical regions of Western Australia, especially from the Archipelago which bears his name. The rest came from the Shark Bay area, which his expedition visited briefly in 1699. This collection was worked up by Woodward and some of the results published in the account of Dampier's travels and in Plukenet's *Amaltheum Botanicum* (1705). The collection is held in the herbarium of the University of Oxford today. Reference was made to it by Lawson during the British Association Meeting at Bradford in 1873.

The second collection of plants from Western Australia was made by Archibald Menzies, also British, who was the naturalist on Vancouver's expedition. Vancouver discovered King George Sound in 1791, and gave an excellent description of this impressive area. It was from here that Menzies collected a number of plants which unfortunately remained unknown to the scientific world for some years until Robert Brown's publication.

THE FRENCH

The unfortunate delay referred to above was responsible for the loss of priority to names of species in Menzies' collection. Only a year later (1792) Labillardière visited Western Australia. His botanical collections which were much more numerous than those of Menzies, were described between 1804 - 1806 in *Novae Hollandiae Plantarum Specimen* (2 volumes). This was the first important contribution to the botanical literature of Western Australia.

Labillardière was the naturalist with the expedition of D'Entrecasteaux, who sailed along the southern coasts of Western Australia towards the end of 1792 in the corvettes *La Recherche* and *L'Espérance.* He proceeded along the south coast without landing, until in early December the ships were forced by bad weather to run for shelter. They anchored in the neighbourhood of Esperance Bay[1] on 13 December and remained there until 20 December 1792. The scientists on board made good use of their time there. Labillardière gave a detailed account of his work in the area in the *Relation du Voyage.* At first he collected on a small island which was situated facing the bay. He noted the characteristic form of the granite and at the west end of the island, the occurrence of coastal limestone which he correctly considered to be a remnant of a former general deposit covering the island. One of the first plants he saw (*loc. cit.* p. 395) was "a *Leptospermum* which was remarkable for its silvery leaves and dazzling red flowers" (*Kunzea sericea* (Labill.) Turcz., Myrt.). Next collected were banksias, *Lobelia* and other less conspicuous plants. On page 401 there is a description of *Eucalyptus cornuta* and on page 403, *Chorizema ilicifolium* (Legum.) which "was found with many other plants in a marly soil". Finally, *Spinifex hirsutus* (Gramin.), *Anigozanthos rufus* (Amaryll.), *Banksia repens* (Prot.) *Dryandra nivea* (Prot.) and several myrtaceous species were discovered on the mainland.

The careful publication, clear descriptions and fine illustrations ensured the value of Labillardière's collection, although it only resulted from the work of a single week.

Labillardière was followed by Leschenault, who took part in the expedition of the

1 Labillardière specifies the place accurately in his itinerary tables as Baie de Legrande, 33° 55' 16"S, 119° 32' 1

Géographe and *Naturaliste* under Baudin and Peron. This expedition holds a special place among the voyages of discovery to Western Australia. A chronicle of the voyage, *Voyage de découvertes aux Terres Australes,* was published by Freycinet in 1824**.** The mainland was sighted on 27 May 1801, and by 31 May botanical investigations were being made on the coast in the neighbourhood of Cape Naturaliste.

Melaleuca Preissiana (Myrt.) was reported as a striking tree on alluvial soils; the first description of it is given in Vol. 1, p. 181, of Freycinet. It was recorded with some surprise that this apparently nutrient-impoverished region exhibited a "variété prodigieuse des arbers et des arbrisseaux". The most important species collected are listed in Leschenault's summary (*loc. cit.* IV, pp. 338-339). These include *Salicornia* found on marshy ground - together with species of *Banksia, Calothamnus* (Myrt.)*, Macrozamia* (Cycad.)*, Anthocercis* (Scroph.) and *Lasiopetalum* (Stercul.) on sandy soil further inland.

In the latter half of June, the *Géographe* sailed northwards to Shark Bay where botanical investigations were begun, in particular on Bernier Island. In Vol. 1, p. 245, are mentioned a *Ficus,* 2 or 3 *Acacia* spp., "a small *Melaleuca"* and several species of *Atriplex* and *Triodia* (Gram.). A low-growing *Acacia* with horizontal branches and a *Cyperus* 2 – 3 ft. high with more-or-less-globular flowering heads the size of a man's fist (probably *Spinifex longifolius* R. Br. (Gram.)),, occurred on the dunes. In Vol. IV, p. 337, a more detailed list is given, although only genera are named. These collections were of particular interest, as Bernier Island has not been re-investigated botanically since, and no exact determinations of Leschenault's specimens have yet been made. Leschenault deserves further credit for his observations on the effects of the prevailing winds on vegetation. This work also arose out of his study of the vegetation of Bernier Island (*loc. cit.* Vol. I, p. 248).

Incidentally, the coast of Shark Bay was visited once again by the French - by the expedition of the *L'Uranie* and *La Physicienne,* under Freycinet's command. Gaudichaud, who was botanist to the expedition, collected a considerable number of specimens at Shark Bay but only a few new species were described (in "Voyage autour du Monde sur l'Uranie et la Physicienne" 1817-1820. Botany by C. Gaudichaud. Plates by A. Poiret. Paris 1826).

While botanists on the *Géographe* were working in the vicinity of Shark Bay, those on its sister ship, the *Naturaliste,* were exploring the Swan River district in June 1801. Rottnest Island was traversed (*loc. cit.* I, p. 365), followed by part of the Swan River. The coastal limestone of the river banks was noted and *Eucalyptus "resinifera" (= E. gomphocephala)* reported as a particularly stately tree (see I, p. 353). The Darling Range was seen in the distance, but the party did not succeed in penetrating that far into the country.

Almost two years later, following the conclusion of their explorations in eastern Australia, the expedition returned to the shores of Western Australia. The boats remained anchored in King George Sound from 15 February to I March 1803. In these two weeks Guichenot and Leschenault made very large collections (*loc. cit.* IV. 340) of novel taxa whose genera fill several pages of the account of the expedition (*loc. cit.* IV 341-343).

Leschenault's collection, however, was never thoroughly processed, and he only receives a mention in monographs as a botanical collector. Thus the returns for his labours were relatively small. However, it should be noted that he saw more of the Western Australian vegetation than any earlier investigator and even more than Robert Brown did. It is therefore particularly unfortunate that the passing on of his knowledge to his contemporaries was limited to a short summary in the last chapter of Freycinet's work (*loc. cit.* IV 327 and on), under the title "Notice sur la végétation de la Nouvelle Hollande et de la Terre De Diéemen". He emphasised the xeromorphic character of the vegetation and suggested it was a reaction to the dryness of the climate. The poor development of cryptograms and the harshness of leaves of the indigenous Gramineae were also mentioned.

ROBERT BROWN AND HIS CONTEMPORARIES

At about the same time as the explorations under Baudin and Peron were proceeding, the expedition of the *Investigator* under Captain Flinders reached Australia. Among the scientists present was Robert Brown and it was through him that our knowledge of the Australian flora was greatly expanded. Also present were F. Bauer, a botanical artist, and the horticulturalist, P. Good, who acted as conservator.

Flinders followed the course of his predecessor, Vancouver, and approached the Australian coast from the south-west. On 8 December 1801 he landed in King George Sound. The stay here lasted until 30 December, and in these three weeks R. Brown laid the foundations of his huge Australian collection. The extraordinarily rich flora of this region is clearly represented in these collections even though they were made in mid-summer when only a limited number were in flower. R. Brown's explorations were evidently very thorough, for his herbarium contained species (e.g. *Thysanotus pauciflorus* R. Br. (Lil.)) which were only recollected during our expedition exactly one hundred years later.

After leaving King George Sound, Flinders sailed eastward and cast anchor at only one other spot on the West Australian coast where his scientific colleagues wished to collect. This was at Lucky Bay. Various islands in the Recherche Archipelago were also visited and collections were made on Goose and Middle Islands. The ship stayed in the area from 10 to 18 January 1802 and several field trips were organized. Robert Brown, for example, travelled westwards as far as Cape Le Grand. The collections he made provided very important material, some of which is still unique. Despite the fact that the adjoining region had been investigated by Labillardière in 1792, by Maxwell at a later date, and that we collected at Esperance Bay, there still remain some species which have not been collected since Robert Brown discovered them.

Allan Cunningham also botanised in Western Australia. The visits of this enterprising and successful explorer of Australia, particularly with regard to the rich flora of the southwest, were however only very short. As a member of an expedition under Captain King, he collected on two occasions, from 21 January to 1 February 1819, and from 24 December 1821 to 8 January 1822. He made quite extensive collections at King George Sound. At the end of January he also spent two to three hours on Dirk Hartog Island. Although he was never involved in investigating any new territory, his descriptions of his excursions are so clear that his collecting notes are of considerable value. They are recorded in his paper "A few general remarks on the vegetation of certain coasts of Terra Australis, and more especially of its north-western shores". This appeared as an appendix to the report of Capt. King " Narrative of a Survey of the Inter-tropical and Western Coasts of Australia." More information is given in the biography of R. Heward in Hookers Journ. of Bot. IV (London 1842) 231 and on.

The region around King George Sound was also the base for the explorations of W. Baxter, who collected for Henchman between the years 1823 and 1825, as well as later in 1829. From King George Sound, Baxter appears to have traveled as far as the foothills of the Stirling Range to the north, and as far east as Lucky Bay and Cape Arid. These trips do not seem to have produced much that was new to science. I have no detailed knowledge of his fieldwork in this area.

We have much more information about the explorations of Capt. J. Stirling which took place in 1827 in the region of the Swan River. The naturalist on the expedition was Ch. Fraser, the colonial botanist of New South Wales. He was the first, since Leschenault's brief visits, to study in some detail the flora of the Swan River and to bring back pressed specimens. His observations have been set out in "Remarks on the Botany of the Banks of the Swan River, Isle of Bauche, Baie Geographe, and Cape Naturaliste" (in Hookers Botan. Micellany I (1830) 221-236). From this account it appears that the expedition, after overcoming many difficulties (which had defeated the French explorers in 1801), followed the Swan River to the foothills of the Darling Range which forms the edge of the plateau. Fraser apparently ascended the extreme western slopes of the scarp. His report, which had very important effects politically, is also interesting from the point of view of the history of botanical investigations in Western Australia. It contains vivid descriptions of the coastal limestone zone, mentions *Agonis flexuosa* (Myrt.), emphasises the importance of *Xanthorhoea Preissiana* (Lil.) and *Macrozamia* (Cycad.) in the landscape, and lists the most common species of *Eucalyptus.* The value of these observations was unfortunately somewhat reduced by misdeterminations arising out of confusion with related New South Wales species. His account finished with notes on the vegetation of Garden Island (Isle of Bauche) and in the region of Geographe Bay. Fraser's paper also examined the possibilities for settlement around the Swan River, and he reported so favourably that it no doubt led to the annexation of the region by the British Crown. The descriptions of the vegetation of the Swan River as tropical in character, stand in striking contrast to the rather depressing account of the same region in Freycinet's work. However, in the latter case, it should be noted that the author was a Frenchman unfamiliar with Australia, while Fraser was at home on Australian soil. Fraser's visit took place in March at the end of summer when few flowers were in bloom and consequently a most unfavourable time for floristic studies. This is responsible for the fact that his collection contains relatively few species which could be identified. His travels therefore did not greatly expand our knowledge of the flora of the region. The same applies to the travels made by Collie, who, in 1832, botanised in the coastal districts of the south-west.

Finally we may mention that the collections of Fraser proved of some historical value in that they formed the subject of a small article by Robert Brown published in 1832, entitled "General View of the Botany of the Swan River" (Journ. Roy. Geogr. Soc. London I. 17-21). In this paper the relationship between the flora of the south coast (from King George Sound to Lucky Bay) and that of the Swan River country is considered, and a further advance was made in our knowledge of the extent of the Southwest Province.

BARON VON HÜGEL

Following the visits of Leschenault and Robert Brown, very little progress was made in knowledge of the Western Australian flora during the first thirty years of the nineteenth century. A more rapid advance was made possible by the declaration of the Swan River area as a British Colony in 1829 and the beginning of land settlement.

Because of the interest of the British in plants and flowers, the beautiful wildflowers of their new home created a keen interest among the settlers. Specimens and seeds of the most striking plants began to be sent back. As a result, there was a large increase in cultivation of the novel species from the Swan River. They began to take their place in conservatories together with those already grown from New South Wales.

Western Australian species began to be mentioned more often in horticultural journals, and here and there new species were described. However, before reports on the above material sent to England appeared, the records of a voyage made by Karl Baron von Hugel to Western Australia at the end of 1833 were published. He landed at the mouth of the Swan River on 17 November 1833 and studied the islands near the entrance to the river, collected in the neighbourhood of Perth and managed to penetrate inland as far as Darlington on the Darling scarp. He remained in the Swan River area until 19 December and then continued by sea to King George Sound, where he remained from 1-12 January 1833. His excursions there were not confined to the immediate vicinity of the Sound but covered the general Albany area, including the lower reaches of the King and Kalgan Rivers. G. Bentham, E. Fenzl, H. Schott and, in particular, St. Endlicher participated in processing the collections, and the results were published in 1837 under the title "Enumeratio Plantarum quas in Novae Hollandiae ora austro-occidentali ad fluvium cygnorum et in sinu regis Georgii collegit Carolus liber Baro de Hügel. Vindobonae (83 pgs.)". Unfortunately, only a part of the collection was described in this paper. Important families such as the Myrtaceae and Proteaceae were omitted. In spite of this, however, the Enumeratio listed a large number of new species, mainly from the Swan River area, about whose flora next to nothing had previously been published. Because of the work of earlier botanists in the King George Sound region, his collections from that area did not add much that was new.

PREISS

In 1838, Dr Ludwig Preiss visited the colony in order to study its natural history. He devoted most of his time to the investigation of the flora with the intention of establishing a representative collection. His undertaking was the first carefully planned exploration of the flora of Western Australia.

Almost the whole of his first year was devoted to collecting in the immediate neighbourhood of the Swan River and the coastal area near Fremantle. In company with Drummond, he also collected on Rottnest Island. From Perth, he collected eastwards as far as the foothills of the Darling Range. It was not, however, until September of the following year that he extended his collecting to the top of the Darling scarp and beyond to the woodlands on both sides of the main road as far as York. In November and December he visited the district round Geographe Bay, travelling as far south as the point where Busselton stands today. In the following year he again crossed the Darling Range, going as far as the Avon Valley. From here he organised an important trip north into the Victoria District which he penetrated as far as the Quangan Plains. This visit took place at the most unfavourable time of the year as far as flowering was concerned, so that only a small fraction of the rich flora of these regions was collected. Despite this, Preiss made many valuable discoveries there.

During the early winter period of 1840 Preiss does not appear to have collected very much, but in August he organized an expedition south for about six months. From September 1840 to February 1841 he made his headquarters at Albany. He collected very thoroughly in this already well known area, and also made trips into botanically unexplored districts. One of these followed the newly opened mail route to the north-west from Albany as far as the Gordon River. In November 1840 he travelled to Cape Riche where he found a particularly large number of new species. By the end of the summer in March 1841 he arrived back at the Swan River. He again collected here for some months in order to complete his herbarium, especially the Cryptograms. In 1842, Preiss returned to Germany.

The collection of Dr L. Preiss, which comprised some 2,718 specimens, was by far the largest which had been made in Western Australia up to that time. It has only been exceeded since by the collections of Drummond and Diels. However, the thoroughness with which Preiss annotated and presented the collection makes it much more important. In fact, in terms of its understanding of the requirements of science, it was years ahead of its time. It was the first collection from Western Australia to become available in several leading European herbaria. It was also the first in which accurate and careful details were present on the labels giving the locality and time of the year the specimens were collected. It also provided valuable information concerning the colour of the flowers and the habitat of the plants. Finally, it was the first collection in which the plants were carefully studied and named in a relatively short time. To Chr. Lehmann and his co-workers (Endlicher, Nees von Esenback, G. Kunze, A. Braun, Hampe, E. Fries, O.W. Sonder, Meissner, Bunge, Bartling, Schauer, De Vries, Reissek, Miquel and Steudel) is due the credit of completing this task within a period of five years. The book was entitled "Plantae Preissianae" and published in 2 volumes, 1844 - 1847. It provided clear evidence of the success and value of Preiss's expedition. One of the most important advances which arose out of Preiss's collections was that it focused attention on certain families (e.g. the Myrtaceae) which up to that time had received less attention from English authors. Regions which Preiss was the first to explore, such as the hinterland of the Avon district, the Upper Gordon River system and the environs of Cape Riche, were particularly rich in new genera and species.

The later success of "Plantae Preissianae" has to some extent been less than its actual worth. The collection was less well known in England than on the Continent and as a consequence of this the views of those who worked on *Plantae Preissianae* were neither sufficiently made use of, nor indeed properly accredited, by the author of *Flora Australiensis* [Bentham]. The detailed notes on the geographical distribution and biology of the types given in *Plantae Preissianae* at first received little attention. It is for this reason that we wish to emphasize the great value of the work of Preiss and of the co-workers who studied his collections.

JAMES DRUMMOND AND HIS CONTEMPORARIES

The interest by the first European settlers of Western Australia in the botanical exploration of their country has already been mentioned. The flora which surrounded them was exciting both in form and colour. In many homes and farms, small herbaria were started. Orchids and everlastings, in particular, were collected, just as is the case today. Apart from this, a more serious interest in the flora was evident during the early years of the young settlement. Thus, from 1830 until her death in 1843, the wife of Capt. [Georgina] Molloy, who had settled on the Vasse River, was busily engaged in the collection of plants from the district around her home. Her collections, prepared with meticulous care and carefully annotated, are still of great value to several herbaria to which, upon Lindley's recommendation, she forwarded specimens. She is often mentioned in the *Flora Australiensis.*

The name of Drummond is connected with the foundation of the Western Australian colony, and this gentleman exceeded all his forerunners as a botanical collector and investigator of Western Australia. In fact, no-one since his time has gained such an intimate knowledge of the vegetation of this region.

Drummond was in charge of the Botanical Gardens at Cork, Ireland, before emigrating to the Swan River Colony, and so was well fitted to take up botanical work. His brother, Thomas, had also become well known through a botanical expedition he had made in North America. James Drummond was therefore in a sense predestined for the role which awaited him in his new home. He landed on the infertile coast of the almost unknown country as one of the first emigrants in 1829, and helped to found the Swan River settlement. He was involved in all the struggles which the pioneers of this young country had to face in order to overcome their difficulties. But despite the arduous work and the bitter frustrations experienced, he managed to continue with his favourite hobby. With rare devotion and enthusiasm he kept it up right to the end. Soon he was not only better acquainted with the vegetation of the south-west than anyone before or after him but also with the plants of the dry inland eremaean country. Even today, elderly people who had met him describe his deep involvement in his botanical work. When riding, he would carefully carry a plant for days at a time in the field to ensure that it got back in good condition to his base-camp. They also spoke of his ability to give a name to any plant he was given, no matter how inconspicuous, and to indicate its use.

It is very difficult to follow Drummond's travels in detail. His enormous collections were not labelled and his numbering system was somewhat unreliable. Moreover, the various notes often did not correspond with the specimen numbers[1]. During the process of sorting and distributing the dried specimens, mistakes also arose. There were also certain difficulties which could not very well be avoided since communications between Western Australia and the outside world at that time were subject to all sorts of delays. In short, in many cases one cannot really be sure where Drummond's plants were actually collected.

Drummond published only a few small articles. However, the more important parts of many letters and diaries which he sent to Sir W. Hooker, and which are still preserved in the Kew Herbarium, were published in *Hooker's Journal of Botany,* Vol. 2 (1840), the *London Journal of Botany,* Vol. 2 (1843) and the *Journal of Botany and Kew Miscellany* (usually known as the *Kew Journal*) I (1849), 4 (1852), and 5 (1853). These provide the only sources whereby some of the data of his field trips can be traced.

At the time when the correspondence commenced (1839), Drummond had settled at Toodyay on the Avon. He had evidently already travelled extensively in the Colony and had at least thoroughly explored the more distant surroundings of the Avon River as far as the Quangan. Besides this, he often visited the Swan River area and adjacent

1 On the confusion of Drummonds collections in Kew and London see Spencer Moores comparison noted in Journ. of Botan. XL (1902) p. 29, 30.

regions along the coast so that he must have been well acquainted with the whole stretch of floristically diverse country between the Avon and the Swan.

The first published letter (Journ. of Botan. II (1840) p. 343 on) describes the flora of the coastal limestone zone and the changing nature of the vegetation as the base of the Darling scarp is approached, together with the vegetation of the plateau as seen on the road towards the Avon.

The next article is concerned with the inland flora of the Avon system and the plants which grow in the "Salt River" area. It also refers to the sandplains which extend far to the east.

In September 1839, Drummond and the visiting German botanist, Preiss, travelled to Rottnest Island. The short sketch of the vegetation of this island gives many interesting details.

In October 1840, he undertook an expedition to King George Sound at the same time as Preiss was collecting in the area. The note about the journey gives little in the way of detail and there is much to indicate that Drummond did not collect very thoroughly in the area of King George Sound.

In 1842, at the beginning of a very wet winter, he traveled down the west coast to the Vasse River and beyond in order to inspect a species of *Dasypogon* (Lil.) which was endemic there. He gave it the name *D. Hookeri.* The letter describing the Vasse River journey is published as a detailed note (London Journ. of Bot. II (1843) 167 on). It is important scientifically as it includes a description of the above-mentioned remarkable species and also personally in that it mentions that he was a guest in Molloy's home.

We have little information about his travels in the following years. But around 1847 a bold project to travel southwards from the Swan River to the south coast in the vicinity of Lucky Bay had to be abandoned owing to illness. Drummond had scarcely begun his long trip (he had travelled about 150 km from the Swan River) when he began to suffer from an inflammation of the eyes which necessitated his return.

In 1848 (Kew Journ. of Bot. I (1849) 247-249) Drummond travelled to Cape Riche on the south coast where he stayed at Moir's farm and made it his headquarters for a number of very important investigations. His letters speak of excursions to the Perongerup Hills [Porongurup Range] and Stirling Range. No mention is made in the article of any trip in an easterly direction, although Mr Moir informed me that Drummond, at that time accompanied by Maxwell (who later collected on his own), explored the country eastward, including Bremer Bay, West Mount Barren and Middle Mount Barren and beyond, until they reached the hills near Mount Drummond (named after him) which mark the eastern limit of his travels. It is a pity that we have no direct information from Drummond himself regarding this trip.

About the middle of 1850 Drummond set out on his most successful collecting expedition and for the first time collected in the north of the Southwest Province. He followed the Avon as far as the Moore River, stopping for a short time at Dandaragan, after which he turned towards the coast along the Hill River. Mount Lesueur provided valuable material and from there his course was northerly. The zone of coastal limestone was followed, and both the Irwin and the Greenough Rivers were crossed and he finally reached the Murchison River at the Geraldine Mines.

Owing to the hostility of the Aborigines, the expedition was in constant danger and had many obstacles to overcome. The expedition continued for eighteen months, the party returning home at the end of 1851. Because of the dangerous circumstances, the collections were not very large but they were strikingly rich in new species and exceeded all the earlier ones in beauty. "They are indeed rather a selection than a collection", writes W. Hooker. In Drummond's notes on his discoveries (Kew Journ. of Bot. V (1853) 115 on) some of the enthusiasm which his unexpected successes had aroused is evident. The description of the newly-found plants is more compelling than usual. Anyone who has visited the districts from which they came, can today write after each description the correct name of each species, so carefully were they described. The floristic richness of the regions between the Moore and Murchison Rivers, particularly in the families Leguminosae, Myrtaceae and Proteaceae, is clearly apparent.

After the big undertaking of 1850-1851, news from Drummond became scarce. In the Kew Journ. of Bot. V (1853) 312 and on, it appears that some trips were made eastward from the Moore River towards Wangan [Wongan] Hills. This is a region where no-one has botanised since Drummond's time, and so it is all the more regrettable that his communications were so brief.

Among the botanists who have helped to open up Western Australia, Drummond was the first and only "colonial". Over the last fifty years his example and achievements have stood alone and he remains a model for the future.

By a curious chance of fate, the two most thorough botanical investigations of Western Australia during the last century coincided, so that Preiss and Drummond were able to meet and spend time together in active work. This co-operation was all the more successful since both men embodied opposite traits. Preiss as a cultured scientist of old Europe always endeavoured to bring order out of the chaos arising from purely superficial knowledge but was seldom aroused to explore new country. Each plant in his collection was very carefully labelled, giving the locality and other data in a way which no-one had previously tried to do in Western Australia. Drummond, on the other hand, was a bushman, always in the saddle, and most happy when riding along uncharted tracks. He was always on the lookout for something new and was quick to observe differences in characters. He was a great collector but not one who liked keeping a carefully written account or to spend time in arranging his specimens in order.

The vast number of rare and unusual plants, including all the species which have never been re-collected since his time, must make up for the meagre information which his travels provided for the subject of plant geography. However, provided one knows the country, it is possible to distill a great deal of information regarding the habitats and distributions of species from his letters.

These letters as stated above are to be found in Hookers Journals. Some additional letters were published in the Perth-based newspaper, "The Enquirer" (1843). These letters contain a great deal of valuable information concerning the habit and life forms of plants typical of the area. In addition, more general comments were included regarding, for instance, the colour variation of the flowers in certain genera and species, local variants and the effect of soil type. Everything of possible interest to the farmer is emphasized, and reference is also made to species valued as sources of food or medicine by the Aborigines - information which unfortunately we can no longer obtain.

As far as their value to science is concerned, Drummond's collections (the largest ever made from Western Australia) did not have the fate they deserved. All appeared to go well at first, but the collector had soon to suffer the disappointment of seeing type descriptions published in "Plantae Preissianae" of much that he had sent years before to Europe. Lacking any formal arrangements, the description and publication of his material took place at different centres[1] until it was finally completely broken up. It was only when Bentham worked on the relatively complete collections at Kew for his "Flora Australiensis" that some degree of order was reached. Even with this, however, the work was incomplete and to this day there are specimens from Drummond in the Kew Herbarium which have never been described or at least remain insufficiently studied.

Only two works among the numerous scattered publications referring to Drummond's material require mention here, since they are relevant for our study of the development of knowledge of the Western Australian flora. The first is Lindley's "Sketch of the Vegetation of the Swan River Colony", and the second, Bentham's "Flora Australiensis".

Lindley's "Sketch of the Vegetation of the Swan River Colony" appeared in 1839 in London, as an "Appendix to the first 23 volumes of Edwards Botanical Register" together with a general index of this periodical.

The description of the vegetation could not be very detailed at this early date, and consequently the value of Lindley's work for plant geography is limited. Rather, its value lay in the 283 new and important species, the descriptions of which were included in the

1 Particularly valuable contributions supplied Meissner and Turczaninow (see Literature)

text. In addition, brief comments were added relating to their systematic position, horticultural potential and aesthetic appeal. The genus *Eremaea* (Myrt.), the much discussed *Byblis gigantea* and many other species were described here for the first time. The work was illustrated with nine colour plates.

The material on which the descriptions for these numerous new species was based, came from Drummond's first collections. It was unfortunate that after such an enthusiastic start the study of Drummond's material was allowed to lapse. Only in Benthams "Florae Australiensis" were all the various pieces of Drummonds life work brought together.

Bentham's great work, "Flora Australiensis", which commenced publication in 1863 and was finished in 1878, contained the first and so far the only systematic description of the Western Australian flora. This work, together with the labours of earlier and later botanists, has at long last given Drummond's contributions their proper place in history.

Bentham's work, "Flora Australiensis" has received the approval of those best in a position to criticise and value it. But only those who have used it month after month in the field, identifying species which the author never saw in the living condition, can appreciate properly the magnitude of the undertaking. It is doubtful if any other flora has been so successfully described and keyed out on herbarium studies alone. As far as the Western Australian sections are concerned, there are very few families which in the light of modern investigation require major changes. In my opinion, only the Stylidiaceae requires treatment, but Bentham himself appreciated this and emphasised this fact. I have already remarked that the results of "Plantae Preissianae" did not in fact receive adequate attention in "Flora Australiensis", but this was probably due to the lack of Preiss's material in English herbaria.

The main defect of "Flora Australiensis" (and this applies generally to British colonial floras) is the neglect of locality names and notes. Western Australia has suffered especially, in this respect. Too often the locality of Drummond's specimens is given simply as 'Swan River'. This could mean the vicinity of that river, but could also refer to the whole settlement - thus including entirely different floristic areas. This may result in serious errors. On the other hand, the very precise annotations in "Plantae Preissianae" appear to be arbitrarily handled and by grouping with other citations often become quite incorrect. If one adds to this the confusion arising out of the inadequate labelling by collectors such as Oldfield, and the uncertainty as to the correctness of the information in Robert Brown's collections, one comes to the conclusion that the "Flora Australiensis" must be used with great caution as far as information regarding the details of the plant geography of Western Australia is concerned.

Despite this, one need scarcely mention how much Western Australian plant geography owes to Benthams "Flora Australiensis", and how it remains the taxonomic foundation upon which geographical work can safely be built.

Having looked at how Drummond's collections were of major importance in the publication of the pioneering "Flora Australiensis", we must now turn back in order to refer to a contemporary of Drummond's, who was only involved in botanical collection as a sideline.

J. S. Roe became famous as an explorer of regions which even today are little opened up. He was the first chief of the Western Australian Lands Department. After several surveying trips in the Southwest Province he set off eastwards from the Avon River in 1836 and reached the Eremaean zone, with its loamy claypans and salt pans, in the far inland areas of Western Australia. His explorations took him as far east as the Lake Brown area. In 1848-49 he carried out a more extensive exploration from the Avon to the south coast. This journey (which Drummond earlier had attempted but abandoned because of ill health) made Roe's name famous among the pioneers of Australian exploration. He set out in September from York on the Avon, reaching the Pallinup River in October and then turned eastwards towards the Bremer Range. However, owing to lack of water and the dense vegetation, Roe had to abandon his objective of penetrating further inland. Following a route rather closer to the coast, he then travelled due east until he reached the Russell Range where, at its south-eastern extremity, water and grass were obtainable. On his return journey, keeping close to the coast, he investigated the valleys of this region and reached King George Sound at the end of January 1849.

A small number of plants collected on these journeys reached Endlicher in Vienna and were described by him. A few others are in the collection of Sir W. Hooker in the Kew Herbarium. Part of the collection of specimens is housed in the Western Australian Museum, Perth, but I was unable to locate the collection so I cannot report anything about its size, etc.

Roe published a note concerning his second journey in Hooker's Kew Journ. VI and VII (1854, 1855). This paper is noteworthy from the point of view of plant geography since the greater part of the district traversed is still botanically *terra incognita.*

In the second half of Drummond's period of activity Dr W. H. Harvey visited Western Australia. This famous phycologist stayed here for several months in 1854, essentially to investigate the fine algal flora of the coasts of King George Sound and the Swan River region. A few short letters regarding his sojourn were published in Hookers Kew Journal VI (1854) and VII (1855). Some flowering plants collected from Cape Riche and on an overland trip between King George Sound and the Swan River are listed and were cited in Bentham's "Flora Australiensis".

Following the period of exploration and collection by Drummond and Roe, the next phase of botanical investigation in Western Australia was initiated by Ferdinand von Müller.

FERDINAND VON MÜLLER AND HIS CORRESPONDENTS

Ferdinand von Müller visited south-western Australia twice, but on both occasions stayed for only a few weeks. His knowledge of the state of botany in this country, however, enabled him to make the greatest possible use of his time. He chose King George Sound as the starting point for his first field trips in 1867. He knew that in this area the different zones of the flora were more closely crowded than was apparent in any other part of the State. He studied the woodlands and swamp communities around Albany and Wilsons Inlet. At the Perongerups, where scarcely anyone had collected since Drummond's time, he saw one of the best examples of forest development in south-western Australia. Later on, he made his headquarters near Kendinup in order to have easier access for collecting in the rich region of the Stirling Range. He climbed the highest peaks of this range and also investigated the extensive sandplains to the north of the range where the character of the south-eastern sand heaths is strongly evident.

His second visit to Western Australia in 1877 was undertaken under the auspices of the Western Australian Government. The first part of his stay seems to have been devoted to the investigation of the more northern areas whose floristic richness was known from Drummond's descriptions. F. v. Müller had become familiar with some of these through his study of Oldfield's collections. The Arrowsmith, Irwin and Greenough rivers were crossed along the old road which passed over the sand heaths. He travelled from Champion Bay beyond Northampton to the Murchison River. From there he journeyed across the apparently endless, barren waterless plains further northward to Shark Bay. Here the extreme northern limit of the Southwest Botanical Province was reached at Freycinet Harbour. He then returned to the Swan River. This journey was followed by a short trip across the Darling Range to the Avon Valley and finally a further small excursion to the south. He stopped at the Preston River area for some time and then visited the most beautiful parts of the south coast in the Shannon River area. Some new species were discovered which rank amongst the most important mesophytic plants of the flora.

The other districts visited by F. v. Müller also provided additional new information which helped him to complete descriptions already available. The overall number, however, was not very large. The importance of his journeys is more related to the fact that they made him acquainted with the habitats and life forms of the flora where there is a higher proportion of endemic species than in any other part of the continent. It enabled him to appreciate the beauty of form and flower which he was to describe so enthusiastically later. His sensitive nature was moved by the aesthetic qualities of the flora and the range of its species aroused feelings of devotion. An eyewitness gave me an account of how, on one occasion when on an isolated heath, he came across a stand of *Verticordia oculata* (Myrt.) and stood quite entranced. He could barely drag himself away from the wonderful floral display. Later he referred to this species as the "princess of the Australian flora". All this was a tremendous experience for him, and it is moving to read the words at the end of his last short description of the Western Australian vegetation.

It is well known that F. v. Müller was able to infect others with his own enthusiasm for botany. In this there lies another effect of great importance which his journeys to Western Australia had upon the botanical investigation of this country. Wherever he went he taught people to appreciate and observe the wonders of nature. Many needed only a little encouragement to commence useful scientific studies, while others collected purely out of friendship or high regard for von Müller. Many sent him the results of their excursions through the bush. He came to be regarded in Western Australia, as the botanical authority in Australia. Even today the memory of the 'Baron' lives on in the whole province. This is particularly true of isolated farm houses where he had once been a guest for perhaps only one or two hours.

F. v. Müller was untiring in his efforts to place even the smallest discovery in its correct taxonomic position and consequently, he ranks very highly among the investigators of the Western Australian flora. The herbarium which he established in Melbourne contained no Western Australian plants at all when he commenced work. Now it is perhaps the richest in the world in representatives of this flora. In the first volume of his Fragmenta he published an account of some new species, most arising from the collections of Maxwell, whom he had sent to the south-eastern part of the Province, and some from those of Oldfield who collected in the north-west of the Southwest Province, particularly near the mouth of the Murchison River. Both these collections provided much material for taxonomic work. The results were published in the "Fragmenta" pending their incorporation in Bentham's treatise. Nevertheless, during the period of production of the "Flora Australiensis" the number of F. v. Müller's Western Australian correspondents increased to such an extent that the later volumes of the "Fragmenta" and even his last publications contained new species from this region. Unfortunately, F. v. Müller was unable to complete the study of a large number of the specimens forwarded after 1880 and they still lie undetermined in the National Herbarium of Melbourne.

In addition to the articles published in "Fragmenta", F. v. Müller also published an impressive series of papers which deal with certain districts in Western Australia. Some of these deal with the tropical portion of the country with which we are not concerned. Of more relevance is his list of "Gascoyne River Flora" (The Plants indigenous around Shark Bay and its vicinity. Perth 1883), which deals with the collections of J. Forrest and the results of his own journey to the Shark Bay area. This catalogue is also of considerable interest to plant geographers as it showed that species with features characteristic of the south-west did not extend beyond Shark Bay.

Taxonomic papers also resulted from his work on the collections of E. Giles, who became famous for his pioneer travels into the interior of Australia. In terms of worthwhile botanical results, his expedition of 1875 was the most important. In August, Giles and his companions crossed the boundary from South to Western Australia. They kept to an almost east-west course and after one stretch of almost 500 km without water, they reached Queen Victoria Spring almost exhausted. A large number of interesting species was collected here. After a short rest the journey was continued, extensive collections being made at Ularring and Mount Churchman. Perth was reached in November. The next year, Giles started off on the return journey, commencing from the upper reaches of the Murchison River. He passed the sources of the Ashburton and then travelled eastwards between 25 and 24°S, slightly south of Lake Amadeus.

Useful notes on the vegetation of the region traversed by the expedition are given in Giles journal ("Australia twice traversed", London 1899). The list of species collected was recorded by F. v. Müller in "Journal of Botany" XV (1877) pg 269 on. Many species were shown to have a wider westward distribution than had been expected. As a consequence, this work has considerable value for plant geographers.

For the same reason, one of the last works of F. v. Müller is important for its analysis of the Eremaean flora. This was his joint work with Prof. Tate on the species collected by Helms on the Elder Expedition. A complete record of this important collection has been produced (in Transcations of the Royal Society of South Australia XVI 333-383). Unfortunately the work is less thorough than is usual with the investigations of F. v. Müller and there are several misdeterminations.

With regard to the plant geography of Western Australia and the analysis of the economic problems presented by its vegetation, no work is of greater value than F. v. Müller's "Report on the Forest Resources of Western Australia", London 1879. The important trees of the country, mostly *Eucalyptus,* were described for the first time, finely illustrated and organized in terms of their habit and commercial value. The publication of this work marked a big advance over the rather vague descriptions and quite inadequate account of their distribution given in "Flora Australiensis". This report of F. v. Müller's laid the foundation for all later reports on the forests of Western Australia. For the first time, too, boundaries for the different plant-geographical zones of the south-west were proposed.

Finally, reference must be made to the monographs in which F. v. Müller described certain important groups of the Australian flora -*Eucalyptus, Acacia,* the Myoporaceae and the Chenopodiaceae. These are essential for the study of the Western Australian vegetation. A wealth of material, collected by the early pioneers in the course of hazardous journeys, is described for the first time. They are especially valuable because of the important information they provide regarding the flora of the interior.

It would occupy too much space to go any deeper into the details of F. v. Müller's work, and we must refer the reader to the long list of publications which very clearly shows the extent of his activity with regard to the western half of Australia. In fact, he was almost as familiar with the flora of this part of the continent as he was with that of Victoria itself. Consequently, he was proud to be asked to write a chapter on the vegetation of Western Australia for the [1894/5] "Western Australian Year Book". The result was a warmly written eulogistic essay, the value of which was enhanced by the inclusion of a detailed list of the components of the Western Australian flora, the first that we possess. He believed himself to be an authority on the botany of this isolated colony, and no-one ever disputed this claim.

F. v. Müller had a major influence on the botanical investigations of the last ten years of the nineteenth century in Australia. F. v. Müller had at his fingertips all areas of botanical development in Western Australia. Every activity concerning the flora benefited from his untiring readiness to help.

The list of names of those who co-operated with him in Western Australia is extensive. Around 1858 and 1859 there were Maxwell and Oldfield and from this date up to the time of his death the master was linked with many other correspondents. Information regarding many of these collectors is lacking and details of the time and places of the collections are often uncertain. It must suffice therefore, to mention only the general localities where they collected and to indicate the value of their collections in terms of botanical exploration of the west.

In the extreme southerly part of the Southwest Botanical Province comparatively little collecting was carried out. Miss Irvine collected around Geographe Bay and Mrs MacHard in almost the same locality. Neither found much that was new to science, but the carefully prepared specimens enriched the Melbourne Herbarium. The collections of Mr Muir of Deeside and Lake Muir, together with several specimens sent by James Forrest from the woodland regions along the Blackwood River, are of interest. The small, but fine, collections of Mr Webb from Mount Lindsay (between Denmark and Hay Rivers) are of rather greater value. The latter contain several species only known previously from Drummond's collections.

The remaining collections owe their origin to the gradual eastward movement of settlement. Drummond's field trips had already indicated the presence of a rich flora in the transition zone between the coastal vegetation in the south and the Eremaea. F. v. Müller, working through Maxwell, organized a fairly thorough exploration of this region. However, there are still wide stretches further inland where even today very little is known. Mr Hassell later discovered a few novelties in the region of the sources of the Pallinup and Gairdner Rivers. Mr Muir travelled further north collecting, while Mr Cronin carried out explorations from the vicinity of Wagin Lake eastwards towards Lake Lefroy and collected a few specimens.

A larger band of collectors was active in the transition zone between the Avon River and the true Eremaea, just to the north of 32°S. This is the region where settlement has extended eastwards from the rich farm districts of the Avon. Drummond had collected a good deal there but the district was so rich in species that he had far from exhausted the flora. Many of the species found by him in this transition zone have never been recollected again. On the other hand, many new species unknown to him have since turned up. Several women took part in collecting in this district, especially Miss Eaton (of Youndegin), Miss Sewell, Mrs Heal and Miss Adams. Their combined collections were quite extensive and would provide more information if they were thoroughly worked on.

Eastwards are the regions now opened up by the goldfields railway. These areas had only been reached by one or two collectors up to the end of the 1880s. It was only following the establishment of the goldfields at Southern Cross that gradually further outposts of civilization were established. From these goldmine camps new settlements developed and many new botanical discoveries were made. Cronin's excursion from Wagin Lake to Lake Lefroy has already been mentioned. Merrall sent collections from Parker's Range, south-east of Southern Cross, which contained such interesting material that a further exploration of these hills seems highly desirable. Sayer forwarded a number of specimens from near Southern Cross. Unfortunately, the number of these was much less than one might have expected from an experienced collector. He had, in fact, collected for F. v. Müller in North Queensland and was the discoverer of the important mountain flora of the Bellenden-Ker Range.

The flora of the goldfield areas of Coolgardie and Kalgoorlie, which were only discovered shortly before F. v. Müller's death, are mostly only represented in the Melbourne Herbarium by the earlier collections of Giles and Young, and of those made at a later date by Helms. On the other hand, important contributions came from the adjacent districts to the south-east which stretch to the south coast. Some species from this district originated from the overland expedition of Sir John Forrest, from Western Australia to Adelaide via Eucla in 1870. At a later date, valuable collections were sent by Dempster from sites between Esperance and Frasers Range and beyond. Study of these collections is not yet complete. Even the furthest outposts of settlement on the south coast are well represented by material in the Melbourne Herbarium. Among these are Israelite Bay, through the contributions of the Brooks family, and Eucla, through a series of correspondents among whom the names of Brooks, Batt, Webb and Mrs Richards may be mentioned. These collections showed that the Southwest Province extended only a little to the east of Israelite Bay at 124°E, and then was abruptly replaced by the Eremaean flora typical of the northern margins of the Great Bight.

The other extremity of the Southwest Province at the lower Murchison River had already been investigated by Drummond. At the end of the 1850s, Walcott and Aug. Oldfield made valuable additions to our knowledge which was incorporated in early volumes of F. v. Müller's "Fragmenta", and to a further extent in "Flora Australiensis". To mention only one item, it was Oldfield who collected a most peculiar Capparacean species, *Emblingia calceoliflora.* This is one of the most isolated of the Western Australian endemic species. After Oldfield's time, collections were made in the Murchison River area by Sir John Forrest, while Mrs Guerin at Champion Bay [near Geraldton] made extensive collections. F. v. Müller's trip, mentioned earlier also covered this area. Material forwarded to F. v. Müller at a later date contained some specimens collected by Stuart Carey who discovered the peculiar genus *Pentaptilon* (Goodinaceae) between the Murchison River and Shark Bay.

The journeys and prospecting expeditions which penetrated into the Eremaea from the Champion Bay area provided many new discoveries. The traffic increased as the excellent pasture lands of the upper Murchison became increasingly attractive to settlers. It increased markedly when gold was discovered at Lake Austin and at many other places scattered through the interior. This resulted in botanical discoveries from places where otherwise one would not have expected material for a long time. King was responsible for some of the first material from the Lake Austin district. The upper Murchison had already been investigated by Oldfield who traveled along the river up to about 450 km from the mouth, but unfortunately his botanical collections were confined to one or two species. The collections at Melbourne from this area were significantly increased by the work of Tyson and Crossland, although only a little has been published. J. Tyson's plants came from Mount Narryer close to the upper Murchison River at about 26° 30'S. Crossland travelled further north taking in the Mount Hale area and several places in the western area of the Peak Hill goldfield. These collections supplement those already mentioned, which came from the Gascoyne River system where the two Forrests, together with Pollack and later on King, collected material. F. v. Müller described these in his paper "Plants indigenous around Sharks Bay, etc." 1883.

SPENCER LE MOORE

Following completion of the "Flora Australiensis" (1878) and in the last years of Ferdinand von Müller's work (1890-1896), investigation of the flora of Western Australia appears to have almost reached a standstill. However, it was at this time that two great undertakings were being initiated in Europe in connection with the botanical exploration of this country. They were to be the first expeditions which would concern themselves exclusively with floristic investigations. These expeditions may well be the last in which botanists stationed in Europe would engage in active work in Australia, as this country had now formed its own botanical institutions which would increasingly undertake studies here.

The first of these expeditions was that undertaken by Spencer Le Marchant Moore. It centred on the exploration of the arid interior which had attracted considerable attention at the beginning of the 1890s owing to the gold discoveries in the districts of Southern Cross and Coolgardie. As set out in the report of this expedition (in Journal of the Linnean Society London, Botany XXXIV, 171-261), the party set out from Southern Cross at the end of December 1894 and travelled north-east over the sandy scrub-heath to Siberia Soak and Goongarrie, not far south of the present town of Menzies. As the party progressed, a major change in the vegetation became apparent. The *Eucalyptus* communities of the more southerly regions petered out and were replaced by a mixed shrub formation. The change was so marked that it had been noticed by the settlers. However, Moore was the first to recognise its importance for the plant geographer. He placed 30°S latitude as the boundary between the two floras which differed so markedly. From this boundary, Moore's journey led to the north-east from Goongarrie to Mount Margaret, from where most of his specimens came. A short trip to the north-west brought the party to the Bates Range north of Lake Darlôt about 27° 30'S.. In June 1905 [sic 1895], the return journey to Coolgardie was begun. The weather there had been so favourable that the "rain flora" was well developed and Moore was fortunate in obtaining a richer collection than would have been possible in many other years. His base camp was about 25 km to the south-west of the mining town [Coolgardie] and he remained there until October [1895].

Spencer Moore's collecting expedition was the longest which had been made to date for the specific purpose of studying the flora in the interior of Western Australia. Its value was heightened by the fact that the explorer himself studied and identified the plants in his collections of the "desert flora". Also he was not satisfied with just enumerating his species and describing the new ones, but went on to include an account of their biology.

It was the first time that this kind of approach had been used on the Western Australian flora. In addition, Moore used the opportunity to prepare a statistical analysis of the plant geography of the Western Australian flora using information from all available sources. Unfortunately, it proved to be of little use as it was much too schematic in approach.

DIELS AND PRITZEL

In 1900, I planned a botanical exploration of Western Australia with special reference to its plant geography. The major task was to study the plant formations, giving more attention than in the past to the structure of the vegetation in relation to climate and soils. In contrast to the journey of Spencer Le Moore, the aim of the expedition was to investigate the better-known regions using a more modern approach. The project was submitted to the trustees of the Humboldt-Foundation for Natural History and Travel for funding and was approved. The expedition was carried out during the years 1900-1902.

In company with Dr Ernst Pritzel, I traveled by way of South Africa. From August 1900 we studied the flora of the western Cape colony and the adjoining Karroo (around Calvinia) until the middle of October. Western Australia was reached on 30 October, and by the middle of November we were able to commence our studies. We soon found that the tremendous advances that the colony had made in the previous decade gave us many advantages over our forerunners. The rapid expansion of the railways since 1890 permitted a flexibility in travel which no-one had experienced before. Due to the generosity of the colonial government, we were able to make the widest use of this facility. In the relatively short period of 14 months we were thus able to cover a great deal of territory and to collect so many plants that we were almost independent of earlier collections.

We commenced our investigations in the neighbourhood of the capital, where Preiss had once collected. Later on, the woodland vegetation of the Darling Range, which was still in bloom towards the end of November, provided us with excellent collections.

As the winter rains of 1900 had penetrated far inland and had been unusually heavy, we decided to make a short trip to the Coolgardie district during late November-early December. However, the winter flora, with the exception of some composites, had already withered by the time we got there. The remains, however, showed what a profusion of flora the arid eremaean country could produce in a favourable year.

In December 1900, we made trips to the south-west to Geographe Bay, to areas near Perth and also to the Darling Range. During early January 1901, a visit to Champion Bay [Geraldton area] gave us an opportunity to learn something of the coastal flora to the north. On the way there, we were able to confirm the surprising species richness of the sand heaths north of the source of the Moore Rivers. Despite the fact that we were well into summer, these sand heaths were still bright with flowers.

After this, we journeyed south to the Collie River and investigated some of the surrounding forest areas, but the greater part of January was devoted to the flora of King George Sound. The presence of numerous species not found in the Swan River area and the unusual ecological conditions prevailing on the south coast provided excellent material for study. Stops along the Great Southern Railway also gave us the opportunity of collecting plants in Wandoo zone flowering during summer.

In February the rate of collecting diminished. We arranged excursions which were of value in studying the plant communities. These included trips to the lower Moore River, the Avon River as far as Newcastle [Toodyay], and in particular, to the extreme south-west in the neighbourhood of the Blackwood River.

In March, most of our investigations were carried out in the southern Jarrah regions. We visited the Vasse River and travelled from there to Karridale. A trip from the Blackwood River via Lake Muir to Hay River, with a short diversion to the south coast, took us through part of the southern forest area which had been least investigated. A second visit to King George Sound was made but extended only over a few days.

The last part of the dry summer season, during which the vegetation of the south-west remains dormant, appeared the most suitable time for a visit to the tropical regions of Western Australia. We therefore spent most of March and early April on a journey to the district around Nickol Bay. We made our base headquarters at Roebourne which proved very suitable for both long and short excursions.

By the time we returned, the rainy season had commenced and we made a collection of early winter-flowering plants around Perth and the Serpentine River. A short trip to Southern Cross showed that the plants of the interior were still in a dormant state, nothing being in flower with the exception of a composite shrub and a eucalypt. On the other hand, flowering had already begun on the sand heaths of the transition zone of the Southwest Province. An excursion to Tammin on 21 May showed us that many of the strange species there were already in flower. In the Darling Range, between the Avon River and the western slopes of the plateau, the number of shrubs in flower increased daily. Flowering in the south coast region, on the other hand, was still lagging as was clear from a visit at the end of May to King George Sound. On the way there we investigated the plant communities present on the plains and foothills around the Stirling Range. This was our first introduction to the unusual flora of the south-east.

With the beginning of July and the onset of winter conditions in the south, it seemed a suitable time to make a more thorough investigation of the warmer regions to the north. After several short excursions around the Swan River, we spent June and early July north of the Irwin River. The flora of the creeks, the inexhaustible supply of species on the sand heaths near the Irwin and Greenough Rivers and the bush thickets around Champion Bay gave us the most rewarding material during this period. From Champion Bay we visited a little-known region, the district around Cue not far from Lake Austin. This expedition of about 400 km crossed the boundary between the Southwest Province and the Eremaea. Although our stay there was short it gave us an understanding of the northern interior.

By the time we returned to the Swan River (10 July), many more species were in flower, especially on the slopes of the Darling Range. In mid-July we again travelled to the south coast, where many major species were in full bloom. We spent several days collecting in the neighbourhood of King George Sound and then moved eastwards to Cape Riche. This was a relatively short journey but important in providing information on the vegetation types of the Southwest Province.

We spent the early August at Carnarvon on Sharks Bay. This region had been little investigated so we were interested to see what role the south-western floral element played there. On the return journey we inspected the flora at Champion Bay again and found it at the peak of its flowering. Further south, flower development was proceeding rapidly. Every excursion in the neighbourhood of the Swan River showed this very clearly. A short trip to the southern Jarrah forests of the Blackwood River also provided much new material. The highlight of August was the journey from the Avon River at Newcastle [Toodyay] to the Moore River. This was carried out at the end of the month and almost the whole bush appeared in flower - the number of species of flowering shrubs appeared almost inexhaustible.

In September, our first trip was to Champion Bay, the Greenough River and the Irwin River at Mingenew. The second trip was to King George Sound and its environs and the plains to the west of the Stirling Range. In between times we also undertook short excursions around the Swan River.

The first three weeks in October were devoted to an expedition to the south-east along the road from King George Sound to the Phillips River, a region already visited by Drummond and Maxwell. Our course lay through the Stirling Range and gave us the opportunity to ascend two of the highest peaks, Tulbrunup and Mount Trio, and to examine their interesting flora.

Using the Goldfields Railway, we collected first at Tammin (east of York) and then in the neighbourhood of Southern Cross at the end of October. This was particularly rewarding with species from the sand heaths. Still more prolific in terms of species collected was an excursion undertaken during October-November. Menzies was the first town aimed at and a rich sand flora was discovered there. Later, we traveled to Coolgardie and from there through partly unexplored territory to Esperance Bay. This course led us from the eucalypt communities of the Eremaea to the eastern extremity of the Southwest Province, which at this point is only about 60 km in width.

In November we visited areas near the Swan River, King George Sound and the Denmark River to complete our information. Towards the middle of November we once again visited the sand heaths to the east of Southern Cross, with their extremely xeromorphic members peculiar to the south-west. Finally, we travelled for the last time to Champion Bay and crossed from there towards the Murchison River, over the undulating sandy country where many fascinating endemic species had been discovered and praised by Drummond.

A short excursion from Moore River westwards as far as the Dandaragan plateau completed our work. We left Western Australia at the end of December 1901 in order to travel to the eastern States and New Zealand.

Dr Pritzel was responsible for a collection of 1,016 specimens. Duplicates of these were sent to most of the major world herbaria. A detailed list of these has been published in Englers Botan. Jahrb. XXXV, 632-43. My collection, containing 4,700 specimens from Western Australia, is housed in the Royal Botanical Museum, Berlin. The results of the taxonomic study were published fairly quickly 1904 – 1905 (L. Diels and E. Pritzel Fragmenta Phytographiae Australiae occidentalis; in Englers Botan. Jahrb. XXXV, pp. 55-662, Fig. 1-70). The number of new species described and illustrated was 235. Details of habitat and distribution were included in order to provide an understanding of the biology of the species.

CURRENT ENDEAVORS

Owing to its arresting beauty, the vegetation of Western Australia arouses both interest and affection. From July to November there are "wildflower excursion trains" to key areas from the large towns, so that the public at large can see and pick wildflowers.

Serious study of the botany, however, has only recently begun. In 1897, the "Mueller Botanic Society" was founded. During the early years it served to draw popular attention to the native flora rather than to engage in scientific work. Lately, however, men educated in the natural sciences have taken up the administration of the society, setting it to work along lines which are likely to be profitable. Alex Purdie, who died in 1900, investigated the orchids of Western Australia and discovered a number of new species. The journal of the Society, in existence since that 1 July 1897, the "Journal and Proceedings of the Müller Society" has also published (No. 8 and following) interesting reports by W. V. Fitzgerald and Cecil R. P. Andrews. In Volume 2 (April, 1903), W. V. Fitzgerald published a short account of the trees in Western Australia, including those in the tropical parts of the State, largely compiled from data in "Flora Australiensis".

In 1904, the Mueller Botanic Society enlarged its scope and took the title "The West Australian Natural History Society". The first two issues of the Journal appeared in May 1904 and 1905, and contained valuable papers by W. V. Fitzgerald and C. Andrews. Both had collected specimens on field trips in 1903 and 1904. W. V. Fitzgerald collected along the Midland Railway and near Cue or Nannine in September, then again at various places along the Goldfields Railway in November. C. Andrews collected along the road from the Stirling Range to Esperance and from there northwards to Coolgardie and finally towards Cue. The success of these naturalists, as well as the discoveries of G. H. Thiselton-Dyer along the goldfields line (see literature under Hemsley), demonstrate what rewards await the newly formed society in the field of botany.

Examination of the results of all investigations of the vegetation of Western Australia (see Fig. 1), shows that there are still gaps in our knowledge of the flora of the State. Although the botany of the country between the Swan River and King George Sound is now well known, the remarkable finds of the last few years show that important discoveries remain to be made from areas already well collected. Large gaps are present from the other areas, and it should be noted that the collections that we do possess have been largely made along the same routes taken by Drummond. The full extent of the wilderness areas that lie between them has yet to be investigated. Likewise, the broad zone of sandy country which occurs almost everywhere between the forest formations and the Eremaea will doubtless provide a very large number of new species. In particular, we know very little about the zone to the east of the Great Southern Railway, between 32-34°S . In the northern districts, almost nothing is known of the country away from the main roads. Our knowledge of the Eremaea is similarly limited to a few routes. While over wide stretches the flora does not seem to be rich in species, the sand heaths which occur here and there should provide considerable additions. My observations on the road between Norseman and Esperance for instance encourage me to expect considerable additions also from the areas bounding the sub-coastal flora of the south-east.

Fig. 1. Stand der floristischen Erforschung von Südwest-Australien im Jahre 1905. Die abgestufte Schraffierung zeigt den Grad des Erforschtseins in vier Stufen.

In Western Australia I often heard statements that the flora of the country was almost completely known. F. v. Müller apparently was also of this opinion. This view, which is based entirely upon misleading information, cannot be upheld in any instance. Western Australia may not bring any more great surprises to the taxonomist, nor may novel genera be found. But the variability and polymorphic nature of its already known floral elements will be found in new guises and new combinations from time to time. Apart from the taxonomic work, very few of the tasks which the region offers for investigation have been attempted. In view of the circumstances, this is not surprising. Naturally, the laying of the taxonomic foundation ranks first among the tasks facing the first century of Australian botany. Although much has been done, the task is far from complete. Nevertheless, the way has been prepared for future botanical research.

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PART II

An Outline of the Physiography of Extra-tropical Western Australia

CHAPTER 1 GENERAL GEOGRAPHY

I. Physical Geography

For the purposes of our discussion, temperate Western Australia may be considered to extend from the Tropic of Capricorn southwards to the ocean. To the east it is arbitrarily bounded by the meridian of 128°E longitude.

Within these limits the Southwest Province is rather sharply marked off from the rest of the area by an oblique line running from Shark Bay to Russell Range.

The inland country extending to the east of the area forms, we consider, a part of Central Australia. This arid region, known as the Eremaea, extends over the greater part of the continent. It consists of a monotonous flat expanse of the Australian plateau at an elevation of 400-500 m. While it is more or less level over extensive areas, the surface frequently shows, however, a gently undulating appearance due to the occurrence of isolated hills or dune-like structures. All the features which give Central Australia its special character are present. These include extensive arid almost waterless areas, slightly depressed salt pans and steep bare hills rising out of the plain. The whole produces a timeless effect without any hint of change such as that we see expressed in the Eyre basin area which lies to the east of the Eremaea. Even the operation of present-day climatic forces appears to have little effect on the uniformity of its development.

On the western margin of the Eremaea, however, under the influence of a very marked change in climate, the everlasting monotony of the plateau begins to change. Two contrasting factors are involved in this. Firstly, towards the north the occurence of reliable and heavy summer rains begins to determine the nature of the country. The land-locked salt lakes gradually disappear, being replaced by valleys. The Ashburton, Gascoyne, Murchison and Greenough Rivers have cut relatively large valleys. They are in fact the largest in the whole of Western Australia. Essentially the rivers flow only during the wet period and intermittent flooding occurs. Because of this the operation of the forces of erosion is capricious and irregular.

As we move southwards the regular summer rains rapidly decrease, leading to a temporary deterioration in the situation along the western margin of the Eremaea. Thus, south of the Greenough River for instance, the valleys once again become considerably shorter and smaller. Soon, however, we pass into a region where heavy winter rains become effective. This is indicated by the changing configuration of the land which rapidly begins to show features characteristic of the greater part of the Southwest Province. The change is clearly apparent in the Moore River district where a deep valley has been eroded. The plateau characteristic of the interior no longer sinks gradually towards the coast but shows a sharp break. A steep escarpment is formed which is separated from the sea by a coastal plain of varying width. Further south, the rivers, under the influence of increasing annual rainfall, tend to flow all the year round and pleasant valley landscapes penetrate more deeply into the granite basement rocks of the country. The Blackwood River, in the region of highest rainfall, has the longest valley in the south. In contrast to the large northern rivers, it only stops flowing in exceptionally dry years. From this point eastwards to Tor Bay, the edge of the plateau is dissected by many short or long valleys. Usually the river valleys tend to run from north to south. The slope is gradual and so the streams mostly flow slowly along very winding courses. Still further east the river slopes become even more gradual and we get a return to the conditions observed between the Moore and Greenough Rivers in the more northerly part of the Southwest Province. The configuration of the country noted towards the north and which was due to the effect of tropical rains is, however, not repeated here. Instead, as we move eastward along the coast, the valleys gradually become smaller. Beyond Cape Arid they disappear altogether. On this eastern side of the Southwest Province the coastal area gradually begins to show again the monotonous character of the Eremaea. This rapidly intensifies so that soon the whole western shore of the Great [Australian] Bight appears Eremaean-like.

The coastline shows few estuaries and lacks the beautiful bays found in the tropical north-west. Some diversity, however, does occur along the more westerly parts of the granitic south coast. We may note, for example, the group of small islands which constitute the Recherche Archipelago and the beautiful region in the vicinity of King George Sound. Along the west coast there are two basins and the development of Shark Bay is quite interesting. All these areas are, however, of limited extent. In effect they prove the exception rather than the rule and only slightly lessen the impression of a long, uninterrupted and monotonously uniform coastline. As compared with the area of the interior, the length of the coast line of south-west Australia is extraordinarily short.

In many places a zone of recent limestone occurs along the coast. Its development is relatively weak but it can be reasonably assumed that it once extended over the whole length. It remains excellently preserved in places, although it may be covered over with sand. Good outcrops occur only in the neighbourhood of river mouths as, for example, the Osborne Cliffs on the Swan River and the banks of the Chapman River at Champion Bay. Elsewhere the limestone is hidden or has disappeared. Remnants of varying extent are present on the south coast but in general the rough seas there break directly onto the granite basement rocks. All that the voyager sees from Cape Leeuwin to the Great [Australian] Bight are gloomy-appearing cliffs.

Over the whole length of the coastline from Shark Bay to near Eucla only moderate tides occur. In fact, in some places there is no discernible tidal change. The small variations in sea level at the Swan River mouth, for instance, depend entirely upon the prevailing direction of the wind and the kind of sea that is running. It is only when one travels north beyond the Gascoyne River that the difference between ebb and flood tide becomes obvious. As one journeys still further north this difference increases and gradually tides of notable dimensions may be observed.

The topography of the land surface of the whole of temperate south-west Australia is predictable from the conditions of erosion mentioned above. The Stirling Range is the only mountain system present. It extends for 70 km and is located north of King George Sound. This peculiar formation consists of several largely independent peaks of uniform and almost pyramidal shape. Some of them reach a height of more or less 1100 m and are thus the highest elevations in the south-west. The rather sketchy accounts of these mountains in the literature must be read with great caution. Many are without doubt quite incorrect. The idea of them being volcanic, for example, as many people thought, is quite wrong.

The steep western margin of the Australian plateau, when viewed from the coastal plain, looks in places quite like a range of mountains. As a matter of fact, however, the margin of the plateau has been eroded to gently undulating hilly landscapes. Different names have been applied to it in different localities. The best known one is the 'Darling Range', east of Perth. The average height lies between 350 - 450 m. Few places rise above this, the highest point recorded being Mount Williams at 530 m[1].

II. Geology

In summary we may say that extra-tropical Western Australia consists of a massive complex of old country rock. Both in the Eremaea and in the Southwest Province, the Archaean rock is the foundation of all other deposits and sedimentary formations. It is most commonly exposed in the valleys, where it shows interesting rocky outcrops. In the south coastal area it outcrops almost everywhere in great rounded masses and its dull gloomy appearance dominates the scenery of this region. Inland, however, it is often exposed in low-lying areas where it forms smooth, bare, slightly convex bosses or tors. The water which runs off these collects round the edges at the base so that most of it is retained. These form the 'soaks' which have saved the lives of many pioneers and explor-

1 The height of this mountain is still indicated on many of the best maps as 3600 feet or 1122 m. From where these completely unfounded numbers come, I do not know. The current official government maps of the west Australian give the height correctly; indeed as early as the forties Drummond noted M William as being 1630 feet high.

ers in these desolate areas.

The extent of the sedimentary formations in south-west Australia is still unknown. This is in keeping with the overall paucity of any worthwhile geological information about the country as a whole. The brief notes in the otherwise excellent works on Australia contain many inaccuracies.

This state of affairs is most unfortunate, particularly with reference to the plant geography of the area. Lack of information on the geology and geological history makes it almost impossible to carry out any worthwhile vegetation analysis.

The botanist can only state that rocks of archaean age, poor in lime, form the greater part of the basement. An earlier Government Geologist, H. P. Woodward, distinguished six parallel zones of archaean rock running from north to south. The most western of these, formed of slate-like schistose material, is almost everywhere hidden and covered by sand plain. The second forms the edge of the mostly steeply-sloping plateau and consists of hard material, particularly gneisses and schists, together with quartz, granite and diorite. The third zone begins, on an average, about 150 km east of the coast and extends eastwards for about the same distance. It also is composed of gneisses and granite, as indicated by the outcrops in the surface depressions. Usually, however, it is covered by a thick layer of sand. The fourth zone which is about 30 km broad consists of hornblendelike minerals, mica and talc schist. The quartz veins present contain mineral inclusions and this is the real gold-bearing zone of the country. Further east again, another granite-gneiss belt about 150 km wide occurs. This is very similar to the third zone and never contains gold. Finally the sixth zone resembles the fourth, and is exceedingly rich in gold deposits. It appears to extend eastward for some considerable distance.

These archaean rocks are very rarely of any direct importance insofar as the vegetation of the area is concerned. The strata which have direct significance are the recent deposits, particularly the diverse soils on primary and secondary deposits which owe their origin to the weathering of the archaean massif.

The already mentioned narrow band of littoral limestone found bordering the west coast and to some extent also the south coast, is regarded as being Pleistocene in age by the Australian authorities. This formation contains fossils (particularly molluscs) which are very similar to recent forms. Their origin is probably due to a recent uplift of the coast.

The recent deposits, the surface layers of sand and soil etc., are by far the most important for the vegetation of Western Australia. Unfortunately, information regarding their nature and origin is very sparse. A detailed scientific investigation of their geology has not as yet been made. All geological studies so far have of necessity been concentrated on purely applied aspects, in particular the needs of the mining industry.

Conglomerate [lateritic] soils, coloured red-brown or brownish-yellow by iron oxide, are very widespread in the south-west area. The present Government Geologist of Western Australia, A. Gibb Maitland (writing in the latest (12) edition of the West Australian Year Book, 1900-1901) simply lists them as “surface deposits” and expresses himself as follows with regard to them (p. 115):

“Under this heading comes a large series of deposits not already referred to, the main ones of which are the “gravel” and “ironstone” which cover a considerable extent of the south-western portion of the colony.

These deposits are in reality hardened, nodular, ferruginous “claystones” called gravel, sometimes cemented by iron and forming conglomerates [laterites] and ferruginous sandstones. Both of the latter are locally known as “ironstone”. They result from the disintegration of the different underlying strata (mostly crystalline rocks), and show their strongest development in the forest ranges. The best stands of Jarrah, for instance, occur on this conglomerate [laterite]. The so-called “gravels” are often of considerable thickness and are largely used for ballast along the railways. Their origin is difficult to understand, as they cap the highest ridges up to an elevation of 400 m”. It will be apparent from these remarks of Gibb Maitland how little the professional geologists know of these deposits.

Sand, whose extensive distribution has made the colony notorious from the farmer's point of view, comes into the category of detritus formations. Among these sand formations even the layman can distinguish two kinds: the common sand deposits and the true 'Sand Plains'. Gibb Maitland (*loc. cit.)* follows this customary usage and separates the recent coastal sandplains from the sandplains of the interior, which he considers to be Pliocene in age. Why these sand plains of the interior should be considered Pliocene I do not know. No reasons have been given for this assumption and I consider it quite incorrect. However, Gibb Maitland has given an excellent description of the sand plains as such and this is set out below (loc. cit. p. 114). "Sand Plains - These form one of the characteristic features of Western Australia, extending as they do from one end of the colony to the other. The great sand plains of the interior are often 30 to 50 km wide. In places, however, they contain a good deal of clay and iron which cement the grains of sand together. Consequently, as there is a reasonable rainfall, they are covered with a hardy vegetation which, during the two spring months is ablaze with flowers. Later during the summer months they provide good grazing ground. These sand plains mostly appear to overlie the desert sandstone formations which form the tableland of the interior of Australia." On what evidence the last statement is made I do not know. In the areas mentioned I have only seen basic archaean rock, never desert sandstone.

With regard to the sandplains of the coastal plain, Gibb Maitland makes the following remarks (*loc. cit.* p. 115): "Coastal Sand Plains - These plains are met with in the southern portion of the Colony, extending from the foot of the ranges, and covering the lower ground between the scarp and the sea. The sand here is much looser than in the interior, and is often of considerable thickness. It appears reddish-yellow in colour below the surface, and exhibits false bedding, indicating that it is aeolian or windblown in origin. There are many lakes and swamps on the plains. The water in these is often retained by deposits of peat."

The fine detritus, loam and clay deposits, collect in the coastal districts at the foot of the edge of the plateau or in valleys of the coastal plain, particularly in river-beds. Because of the mostly less intense rainfall in the Southwest Province, the extent of these deposits is not nearly as great there as in the more northerly regions with their frequent, flooding tropical summer rains.

In the Eremaea, the alluvial material forms salt pans which have been briefly described by Gibb Maitland as follows (*loc. cit.* p. 114): "Alluvium of lakes basins - Throughout the interior there occurs a series of what are called lakes. In reality they are nothing more than large salt flats, boggy marshes or clay pans. They are almost on a dead level and drain one into the other and eventually, if the season has been wet enough, discharge into the upper reaches of some river. This however, rarely happens, owing to the enormous surface they present for evaporation. One result of this is that in almost every year these large flats receive a fine covering of clay upon which the salts contained in the water crystallise out. Later they may redissolve and continue to be added to from time to time. Finally, in some places, which may be at a slightly lower elevation than the rest, or where some obstruction occurs to check the flow of water, very large deposits of salt accumulate. These lakes are surrounded by red clay flats, which also contain a great deal of salt. In fact the whole interior of the Colony is salty, since the salts which are leached from the rocks are either carried away to the clay or are redistributed over the surface of the country by the wind."

From these descriptions it is apparent that there are many gaps and uncertainties in our knowledge of these soil deposits. A thorough investigation of such soil deposits in the region is clearly one of the most urgently needed studies.

We can, however, make one very important point at the present time. That is, that when the character of the West Australian surface and soil deposits is considered as a whole, the land appears to be a playground in which steady uniform action, under the influence of external factors, has been going on over a long period. This action, both in its direction and strength, differs very little from that operating now.

CHAPTER 2 CLIMATE

Over the last few years, considerable advances have been made with respect to our knowledge of the climate of west Australia. For this we are indebted in particular to the work of the present Government Astronomer, Mr. W. E. Cooke who, in 1901 wrote an excellent review and summary of the meteorological conditions entitled “The Climate of Western Australia from Meterological Observations made during the years 1876-1899”, Perth 1901, 128 pgs., with numerous maps.

So far as the extra-tropical [temperate] portion of the State is concerned, this report contains a mass of useful data. Not only are the average monthly temperatures given, but also the mean temperatures together with the maxima and minima. The rainfall is also recorded. Physiologically important features are also touched upon, as for example, the number of hot days (over 32°C) and cold nights (under 4.5°C), the number of rainy days, and the quanity of rain in single continuous downpours.

No information is available, however, on such biologically important factors as relative humidity, duration of sunshine or strength of the wind. We must, however, be very grateful for the large amount of work which has been carried out in such a short time. It includes a table showing the rate of evaporation at Perth. While this is not completely accurate, it is at least helpful and allows some degree of orientation.

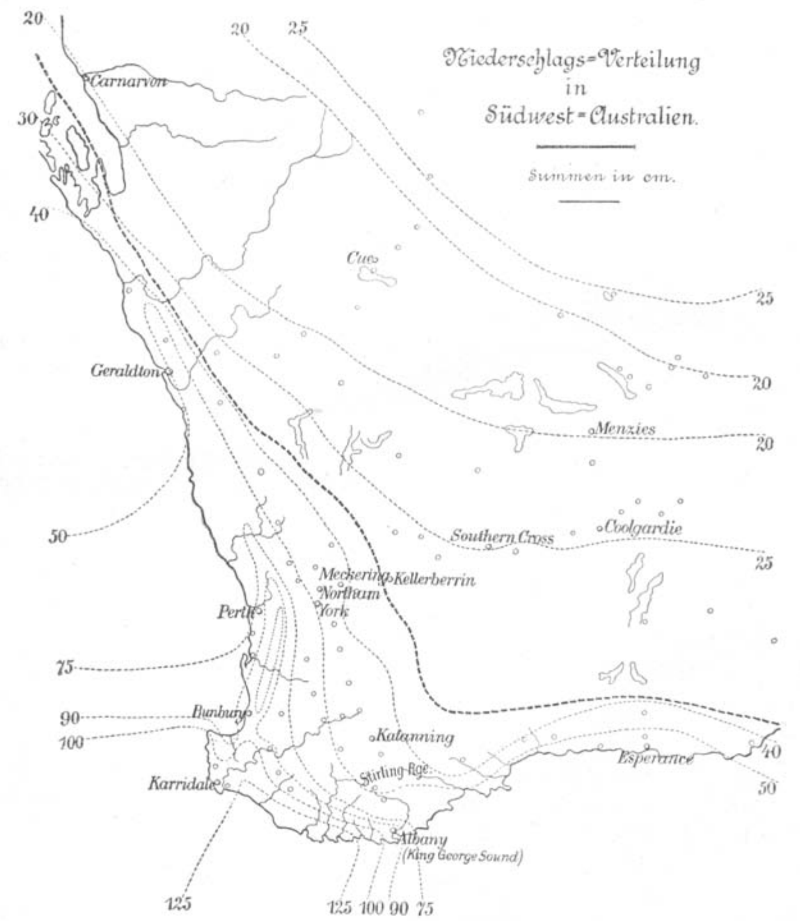


Fig. 2. Niederschlags-Verteilung in Südwest-Australien. Summen des durchschnittlichen jährlichen Niederschlags in Centimetern.
Die stärkere gebrochene Linie gibt die Grenze zwischen Südwest-Provinz und Eremaea an.

I. Rainfall

The distribution of rainfall over the region is given in Figure 2. From this it may be seen that the south-west corner of the country receives most. On the coastal area between the Swan River and King George Sound the average annual rainfall lies between 75 – 100 cm. It will be noted also that within this region the highest rainfall (rather more than 125 cm) falls between Cape Leeuwin and the Denmark River. In addition, due to the rising air currents over the edge of the plateau, the rainfall here reaches 100 cm or more per annum.

The 60 cm, 40 cm and 30 cm isohyets each run almost parallel to the line which marks the boundary of the rainy district. These isohyets indicate the zone of medium rainfall. The zone begins just north of the mouth of the Murchison River, widens slowly towards the interior reaching its greatest breadth at about 33°S latitude and then turns gradually towards the east, approaching the south coast as gradually as it left the west coast. The 30 cm isohyet marks almost exactly the floristic boundary between the South-west Province and the Eremaea.

The decrease in rainfall as one passes inland from the edge of the plateau is very uniform everywhere. Although the observation stations from Perth to Southern Cross are, unfortunately, still incomplete, the readings which are available are sufficiently representative. The monthly rainfall (in millimetres) at these stations is given below. It should be noted that it is only for those marked with an asterisk (*) that the records extend over ten years. Records for the others are for shorter periods and consequently are less reliable. Naturally, with more stations and over a longer period, the statistical value of the data will increase. The distances of stations inland from the Darling Scarp are given in kilometres.

km		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
49 w	*Fremantle	5	10	18	43	113	145	143	125	65	43	15	18	738
31 w	*Perth	10	10	20	45	122	168	160	145	73	53	20	18	825
20 w	Guildford	10	3	33	15	103	170	178	108	70	50	8	10	750
-	Mundaring	3	8	43	23	98	120	213	195	108	50	18	23	1000
Stations are missing here														
67 e	Northam	5	13	33	10	40	85	93	133	35	13	3	8	375
102 e	Meekering	0	3	13	25	60	70	48	45	30	25	3	3	350
168 e	Kellerberrin	0	8	8	15	38	50	40	40	28	13	8	8	250
241 e	Burracopin	8	20	10	28	50	50	40	40	18	5	3	3	250
322 e	Southern Cross	10	13	23	10	30	38	30	25	15	13	13	13	225

In the extra-tropical Eremaea, insofar as it may be said to belong to Western Australia, the average annual rainfall lies between 30 cm and 20 cm To the north-west, stretching from Shark Bay inland, the region becomes increasingly drier, and at many places less than 20 cm per year is recorded In contrast to this, as we approach the upper reaches of the Murchison River, the influence of the tropical summer rains begins to be felt. Thus the rainfall at Lake Way and at Peak Hill, for instance, rises to about 30 cm per annum.

Because of its seasonal distribution, the rainfall in our region may be divided into an area of winter rain and an area poor in winter rain. Both areas are almost, but not quite, separated by the 25 cm isohyet. Winter rains often make themselves felt on the dry side of this line. On the coast at Shark Bay, however, the whole of the scanty rainfall (often less than 20 cm per annum) belongs to the winter type.

The true region of winter rain extends over the triangle bounded by a line running from Shark Bay to Esperance. It is characterised by a marked periodicity. The rains during the months May to August provide about 50% or more of the yearly total[1].

This periodicity tends to decrease as one moves down the coast from the north towards the south-east. At Carnarvon the average rainfall from May to August is about 76% of the yearly total; in Geraldton it is 78% at Perth 71%; at Karridale 68%; at Albany 58% and at Esperance only 50%

An important point brought out by these figures relates to the slight extension of

1 In Supan's representation in the Ergäenzungscheft 124 of Petermanns Geogr. Mitteilungen (1898) Table. 3, this does not stand out with sufficient clarity.

the rainy season into the warmer part of the year. This is the case along the whole of the south coast, and it also holds good for some distance inland. Thus, between October and December, Esperance and even Coolgardie receive more than Geraldton.

This distribution of rainfall, together with the quantity, is important in defining the dry season. If one regards as very dry months those for which less than 3 cm of rain is recorded, then the length of the dry season in months may be determined. The table below gives the results for different locations.

Southwest coast		South coast		Eremaea	
Geraldton	7	Karridale	2	Carnarvon	10
Perth	5	Albany	3	Cue	11
York	7	Esperance	5	Southern Cross	9

Values for the degree of cloud cover may also be considered. The figures for the south coast are the highest, as may be seen from in the following table (after Hann).

	Max.	Min.	Year
Perth	6.0 (June)	2.1 (Jan.)	3.8
Bunbury	6.4 (June)	2.5 (Jan.)	4.5
Albany	6.4 (May)	5.5 (Dec.)	5.8

The periodicity of rainfall in the northern part of the Eremaea, insofar as it concerns us, tends to approach that of the summer rain areas. Thus at Lake Way and Peak Hill more than half of the annual rainfall occurs during the warmer months of January to April thereby clearly showing the influence of a tropical regime. While this condition mostly holds good for the whole of the Eremaea and also may extend as far as the south-eastern coastal regions, it never extends as far as the south-west coast. The observations of W. E. Cooke have shown that tropical depressions occasionally cross the whole continent obliquely from the North West Cape to the Great Bight and then the Eremaea receives quite heavy rains. This is the cause of the great floods which are responsible for certain features of the surface of the interior. In the more northern and western parts, where such rainy periods are more regular, one finds well-defined valleys (Gascoyne, Murchison, etc.). Further south where heavy rains are sporadic, they result in salt-pans. One such cross country cyclone took place in April 1900, and because of its importance for the vegetation of the Eremaea, an extract of Cooke description is appended (from “The Climate of Western Australia” p. 16). It must be noted, however, that this particular occurrence was of greater intensity than any previously described in Western Australia. At the end of April 1900 Cooke wrote:

“This month will long be remembered as the month of the great floods. These were so severe that all telegraphic communication north of Geraldton was interrupted, and the postal service in the interior completely disorganized. The extensive dry plains were converted into inland seas or lakes and the rivers became raging torrents. Peak Hill and Lake Way Stations, situated in the great inland desert, were completely cut off from all food supplies. At Peak Hill where almost 25 cm of rain has fallen this month one can now sail a boat over 100 km. The weather was of a monsoonal character, and traveled from the north-west coast in a more or less south-easterly direction, towards the head of the Great [Australian] Bight. It may be said to have first set in on the 2nd of March. After the main storm passed away, the weather continued unsettled, with occasional showers throughout the remainder of the month. Rain recommenced in earnest on the 1st April, and from then until the 20th a dense cloud bank covered nearly the whole of Western Australia, and the rain was almost unceasing. Perth (i.e. typical of the Southwest Province) escaped even the cloudy weather but the edge of the rain could be seen day after day behind the Darling Range. We have, unfortunately, scanty records from which to make a comparison with past years, but, from all that can be gathered, the present fall has been the heaviest, the most general, and the most persistent ever known and no man living has ever seen the country flooded to the same extent."

In concluding this section on the rainfall, a table is appended which gives the actual monthly rainfall at various places in the Southwest Province and in the Eremaea.

	Monthly Rainfall (cm)												
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Year
South-West													
Geraldton	1	1	1	3	17	12	10	7	3	2	1	0	45
Perth	1	1	2	5	12	17	15	15	7	5	2	2	83
Karridale	2	2	3	6	15	23	20	18	10	8	3	3	110
Albany	2	2	3	7	12	13	12	13	10	7	3	3	85
Esperance	2	2	3	3	7	10	9	10	6	5	3	2	61
York	1	1	2	2	6	8	8	8	3	3	1	1	43
Katanning	1	1	3	2	5	6	7	6	5	4	1	1	40
Eremaea													
Southern Cross	1	1	2	1	3	4	3	3	2	1	1	1	23
Coolgardie	1	2	1	1	3	3	2	2	2	2	2	2	20
Menzies	1	4	1	1	3	4	1	2	1	1	1	1	19
Cue	2	2	2	3	2	5	1	1	0	0	0	1	19
Carnarvon	1	2	1	1	2	8	5	2	1	1	1	1	20

II. Temperature

Temperature conditions in Western Australia correspond exactly with its geographical position and physiography. Of the two littoral regions, the west coast is by far the warmer and consequently less temperate than the south coast. This will be seen below, which gives the average temperatures for the two extreme months.

	February	July	Difference
Geraldton	24°C	15°C	9°C
Perth	24°C	13°C	11°C
Albany	19°C	11°C	8°C

The surprising influence of the southern ocean is highlighted by the figures. It is responsible for the lower summer temperatures of Albany and almost all the south coast. Perth, and likewise Albany, however, for the same reason, show a considerable warming effect in winter. This moderating influence of the sea is quite considerable but it is confined essentially to the coast. Consequently there is a very great contrast between the climates of the inland areas and the coastal region. This becomes clearly apparent when we compare the average maximum and minimum temperatures for coastal and inland stations.

Coast	Max January	Min July	Difference
Perth	31	8	23
Albany	22	8	14

Interior	Max January	Min July	Difference
York	33	7	28
Katanning	31	4	27
Menzies	35	6	29
Cue	39	7	32

A further example of the favourable effect of the sea on the south coast may also be noted. Thus at an inland station, e.g. Katanning, which is only 160 km from the coast, the difference between the two daily extremes of temperature (during January and July) is twice as great as at Albany. The fall in temperature during the night is particularly striking. It results in the Katanning area being one of the coldest parts of Western Australia in winter. While the number of July nights when the air temperature falls below 4°C is on the average three for the south coast, the number for Katanning is eighteen. The records also indicate frequent night frosts. These may occur as early as June when the temperature there may fall 1 or 2 degrees below zero. Frosty nights may continue to occur as late as September.

In the Eremaea the extremes of temperature are even greater than in the lower south-west. This is due to the greater heating up during the day in summer. Thus while Cue is 8° hotter than Katanning in summer, it is only 3° warmer in winter. For details, see below.

Mean Temperature of the Different Months (°C)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Soulhwest												
Perth	24	24	23	19	16	13	13	14	15	17	20	22
Karridale	19	19	18	16	15	13	13	12	13	14	16	18
Albany	18	19	18	16	14	12	11	12	13	14	16	18
Esperance	20	20	19	17	15	13	12	13	14	16	18	20
York	25	25	22	18	14	11	10	11	13	16	21	24
Katanning	22	21	19	16	12	10	9	10	12	14	18	20
Eremaea												
Cue	31	30	28	23	17	13	14	14	16	20	25	29
Menzies	28	26	24	20	15	12	12	13	16	19	24	27
Coolgardie	26	25	23	19	14	11	12	13	16	18	22	25
Southern Cross	26	25	23	18	14	11	11	12	14	17	22	25

Mean Daily Variation of the Differences (°C)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept	Oct.	Nov	Dec
Southwest												
Perth	14	14	13	13	11	9	9	10	10	11	12	13
Karridale	10	11	11	10	11	8	8	9	9	8	9	11
Albany	7	6	7	7	7	7	7	7	7	7	7	7
Esperance	10	9	10	11	10	9	9	10	10	10	10	10
York	15	15	13	13	12	10	10	11	12	13	14	15
Katanning	18	15	15	14	12	9	10	11	13	14	16	17
Eremaea												
Cue	15	15	16	14	14	9	12	13	15	15	17	16
Menzies	15	14	15	14	12	9	12	11	14	15	15	16
Coolgardie	17	15	15	14	13	9	11	11	14	15	16	17
Southern Cross	18	17	17	15	14	11	14	13	15	17	18	18

III. Evaporation

Due to the character of the climate, evaporation necessarily reaches very high values in Western Australia. Data, however, are available only for Perth. Even here, at this sub-littoral station, the figures show quite high values (see below).

Evaporation Figures at Perth (average for 24 years, after Cooke)

October	15 cm	April	11 cm
November	21 cm	May	8 cm
December	25 cm	June	5 cm
January	28 cm	July	5 cm
February	23 cm	August	6 cm
March	20 cm	September	10 cm

Comparative data from other places on the earth are unfortunately scarce. One comparison may be made with Europe. According to Hann, the maximum evaporation at Vienna reaches 11.3 cm in July, while in October it is 4.7 cm and in January it reaches the minimum of 1.3 cm.

IV. Yearly Weather Cycle

a. SOUTHWEST PROVINCE

The periodicity of the weather in the winter rain area is indicated by the much higher rainfall in the winter months. It may also be noted that on the south coast light falls of rain do occur throughout the whole of summer. This does not apply, however, in the Swan River area. Here the rainfall is only very slight between November and April. The climate of Perth may consequently be regarded as being more typical of the winter rain area. The two seasons, winter wet and summer, are sharply separated.

Towards the end of April or in early May at the lower latitudes, the onset of stormy winter weather commences. A rapid fall of the barometer indicates the approach of rain and the wind in Perth veers round to the north and north-west. It often blows very strongly and the whole of the west coast may sometimes experience a severe storm. The rain falls in very heavy showers which, however, seldom last for more than a few hours. Almost every year falls occur in which 3-7 cm are precipitated within 24 hours. The wind then veers round from the north through the west to the south, while heavy seas are experienced at Cape Leeuwin. In the Swan River area, however, the showers gradually become lighter and shorter in duration. Sunny, cloudless days tend to become the rule again.

This type of weather now prevails from May to the beginning of October. It of course shows some variation, being rather longer in some years and shorter in others. Cloudy days occur between the sunny periods and may sometimes last for from 8 to 14 days. But on the whole, even during the cyclonic period, there is plenty of sunshine. The pleasant daytime temperatures, together with the fact that the nighttime temperatures rarely drop to zero, gives support to the view that during the winter the climate in the Swan River area makes the place almost a paradise to live in.

Modifications to this climatic scene take place according to the geographic conditions encountered as one moves towards the north, the south, or inland to the east.

As we travel north, the peak for the rainy season occurs earlier and the temperatures are also higher. The effect of this is that, at Champion Bay [Geraldton] for instance, even in the middle of winter one may experience quite warm humid weather.

Passing inland, even by the time York is reached, we may observe that the intensity of the rainfall has decreased well below that experienced on the coastal plain. Due to the high radiation, great diurnal extremes of temperature occur (see Table 9).

On the south coast, however, each cyclone makes itself felt, and the unsettled weather which often follows is particularly noticeable. In most years, therefore, the winter months are really unpleasant there, with a great deal of rain and few really bright days. This is an important difference from the climate of the west coast. In addition, the transition from winter weather to summer-type weather occurs later in the year, and is more gradual. Antarctic depressions sometimes bring a succession of rainy days in the middle of the dry season.

In Perth the summer dry season does not set in as suddenly as does the rainy season. In October the rains become markedly less frequent and the thermometer may rise to over 30°C. A cool sea breeeze, however, frequently blows in the afternoon and the nights are cool. The clear air, the constant blue skies, and the low humidity make the first months of the dry season very pleasant. However, the heat in January, when for days the temperature rises to about 35°C in the early afternoon, can sometimes be very trying. It is in February and March, when the sirocco-like east wind predominates for longer periods, however, that the dry season really becomes intolerable. With the coming of late March there is a gradual increase in the number of days when the sky becomes overcast. In the evenings, lightning becomes visible towards the interior. The bush is tinder dry and fierce bushfires frequently occur. The smoke fills the air and everybody eagerly awaits the rains which eventually must come.

On the whole, the climate of the south-west is characterised by its regularity. The differences between individual years are not nearly so great as, for example, they are in eastern Australia. Extreme conditions, such as severe droughts and floods, changes from almost unbearable heat to chilly conditions, in short all the influences of the Eremaean climate which so radically affect the climate of eastern Australia do not occur here.

b. EREMAEA

The Eremaea part of south-west Australia benefits, although to a lesser degree, from the more favourable conditions of the deep south-west. It would be a desert region of the worst type if the tropical rains from the north and the winter rain area of the south-west did not exert an ameliorating influence. The climate is consequently the result of the interaction of opposing factors. "Sometimes[2] the tropical rains pass right across it, while at other times the winter storms of the south-west and south extend rather further inland. When, as sometimes happens, both types of rainfall fail to occur, drought follows." As a rule, apart from exceptional years, one can expect a certain mixture of Mediterranean-type weather up to about 30°S latitude. This occurs because, in winter, light rains can still occur up to this line and, in summer, the heat waves may be interrupted now and then by cool spells passing from west to east along the south coast. In unfavourable years when both are absent no amelioration of conditions is possible north of the 30° parallel. Consequently the summer there becomes almost unbearable. The heat is extreme and it is often windy, with the result that the atmosphere is full of dust. The only relief which may occur comes from an occasional tropical thunder storm, which can be quite destructive. The winter season, however, provides some degree of compensation due to periods of quite dry, cold, clear weather and the air may be quite bracing.

CHAPTER 3. SUBDIVISION OF THE REGION BASED ON ITS GEOGRAPHIC CHARACTER AND ITS VEGETATION

From the discussion of the general geography of the extra-tropical part of Western Australia, it became clear that the area fell naturally into two parts of unequal extent. These comprised the Southwest Province which was bounded on the interior by a line from Sharks Bay in the north-west to Russell Range near the south-east coast, and the Eremaean Province which accounted for the remaining area. Physiographically these two regions are very different and this is closely related to the differences in climate. It is not, therefore, surprising that the vegetation in the two regions should also show great differences. Any study of the vegetation and the floristic features of extra-tropical Western Australia must first and foremost take account of this duality.

The Southwest Province is, in climate and vegetation, an area which shows considerable but very finely graded degrees of diversity. Zones of vegetation run almost exactly parallel with the boundary from Shark Bay to Esperance, and coincide with the zones of varying rainfall. Along the coast one first meets shrubland and light woodland. Next we encounter the compact denser Jarrah forest region. Further inland still, we meet the lighter stands of other *Eucalyptus* communities and finally the end of the western tree zone is reached. Following on this we come to the zone of low shrubby undergrowth on the sand heaths and the areas invaded by the eremaean vegetation. These are the chief steps in the change of vegetation. Paralleling them we find a similar sequence of stages in the distribution of those units of the flora with a smaller growth-form. The adaptability of the Australian hard-leaved sclerophyll vegetation to different conditions is a well developed feature in Western Australia, and it is more extensive in the Southwest Province than anywhere else.

2 Cooke in Climate W. Austr. p. 16

The Eremaean Province occupies quite a different position and it is difficult to draw a parallel with the Southwest Province. The latter is a closed unit, a world in itself, while the Eremaea extends far beyond the conventional boundaries of Western Australia. It stretches almost unaltered, in fact, to the far east of the continent. Over this huge area the climate, vegetation and flora are very uniform and so contrasts markedly with the adjacent province. This at least holds good for by far the greater part of the region. Only the south-west border, from about 129°E longitude is affected favourably by the winter rains and has produced woody vegetation. Otherwise it is only along the banks and beds of moist valleys that we may find well-grown species of *Eucalyptus.* In the wilderness of sand only gnarled trees survive. The usual plant cover that is present on the hard reddish soil consists of sparse, straggly *Acacia* bushes and a number of desert shrubs. Areas occur where the frightful *Triodia* grass deserts have crowded out other growths. It is only rarely and for short periods that the stern visage of the Eremaea presents a more smiling appearance-that occurs when the rain flora awakes for its transient existence.

PART III

The Vegetation of the Southwest Province

CHAPTER 1 GENERAL CHARACTER

The geographical features of the south-west are determined by the amount of winter rain; for this to be adequate the annual rainfall should not fall below 25-30 cm. The degree of erosion and the surface conditions of this area provide a reasonably good indication of the volume of winter rain that falls. The south-west is characterized by large valleys, while salt pans are present only in the border areas. These salt pans, however, do not affect the typical landscape of the province. The soils in general illustrate the effects of weathering and erosion of the granite bed-rock of the country.

The coast is fringed in many places by a narrow band of limestone. This may be covered by dune sand, or vegetation may be present which helps to weather it. In such places the soil is fertile and the vegetation is lush and strongly developed.

Passing in from the sea shore, the land either rises gently to the height of the plateau or extends as a flat coastal plain to the foot of the hills, which form the edge of the plateau. In both cases sandy soils, derived from fine detritus removed from the rocks of the plateau, are of prime importance in determining the character of the landscape. They are covered with xeromorphic bushes, both in the north and south-east. In the heavy rainfall districts of the deep south-west, however, trees are common. Eucalypts and large casuarinas help to form woody communities. In some low-lying places the sand is replaced by loam. The finely granular soil is clayey or loamy and during the rainy season may be inundated for weeks or months at a time. Gnarled melaleucas, myrtaceous thickets, and members of the family *Restionaceae* grow in the water-logged soil. When it dries out, herbaceous plants germinate and grow quickly to maturity. Where the land is less exposed to water-logging, other types of communities are present. The finest examples of the grass tree, *Xantorrhoea Preissii* (Lil.), for instance, occur here. Thick bushland consisting of low-growing members of the Myrtaceae and Epacridaceae constitutes the dominant vegetation on the south coast. This vegetation is, however, lacking in exposed areas where the bare ground is inundated during the wet months.

The slopes of the plateau and its margins are dominated by Jarrah forest. This is the heartland of the Southwest Province where the rainfall usually exceeds 60 cm. The frequent rains during the cooler half of the year keep the soil moist.

As we travel further east the rainfall decreases, the climate becomes more extreme and the woodlands become less dense. Different species of *Eucalyptus* appear, the undergrowth decreases in density and patches of bare soil begin to appear between the shrubs and trees. Finally, over quite considerable areas, the trees disappear altogether and only shrubs remain. These include a variety of types similar to those which are so characteristic of the south-west. It may be noted that it is only during the flowering period that these species are at all colourful. At that time, however, the floral variety shown by members of the Proteaceae, Podalyrieae, Myrtaceae, *Hibbertia* (Dill.)*, Acacia, Stylidium,* Sterculiaceae, and many others, is amazing.

The zone in which these characteristic shrubs show their strongest development is fairly broad and corresponds with the region of medium rainfall. The isohyets which run from 50 to 30 cm enclose a zone of woodland in the south-west. Over its whole extent gravelly and sandy soils predominate. It is only on sandy soils, however, that the rich shrub flora reaches its peak.

The strikingly uniform appearance of the vegetation on the clayey heavy type of soil appears in marked contrast, being especially noticeable where the zones adjoin. The area is characterized by the presence of one or two species of *Eucalyptus* and *Acacia.* The undergrowth shows poor development and only a few shrubs are found here and there, while woody types of undergrowth are lacking altogether. The vegetation is essentially conditioned by the periodicity of the rainfall. Grasses and herbs only appear in the winter wet season. They begin to disappear in October and by summer the red or grey soil is bare. We are then able to see how different the two types of undergrowth in this middle zone are. On sandy soils a tremendous variety of evergreen species is present. On clay soils a transient greenness is characteristic, combined with a similarity of shape and a small number of species.

In this, the vegetation of the clayey soils shows an eremaean-like character - one might even say that it really belonged to the Eremaea. The two Provinces of Western Australia do not show a sharp line of demarkation but merge in a kind of neutral zone where there appears to be a certain amount of give and take on both sides. This depends essentially upon edaphic factors.

The flora of the Southwest Province is characterized by the strong development of certain families which are only poorly developed in neighbouring areas. In particular, the tribe Podalyrieae [of the family Papilionaceae], and the families Tremandraceae, Proteaceae and Epacridaceae may be mentioned. Many species of these families are in fact almost endemic in the south-west. The situation is rather different in the case of the monocotyledons. While it must be noted that the family Conostylideae (Amaryll.), which possesses many endemic species, is almost entirely confined to the Southwest Province, it must also be noted that many of the highly characteristic members of the families Orchidaceae, Restionaceae, Centrolepidaceae and Cyperaceae re-occur in south-east Australia.

The number of genera in the above large families, which must be regarded as important members of the Southwest Province (although not exclusively so since many of their species also occur in the Eremaea), is considerable. Examples are *Hibbertia* (Dill.), *Drosera, Stylidium* and *Patersonia* (Irid.).

Other important groups are, the Lasiopetaleae (Sterculiaceae), the dry-fruited Myrtaceae, and the Goodeniaceae. Most, however, do clearly belong to the south-west and numerically they come close to being equal in number to the purely south-western elements. They join forces to bring the endemic species of south-west Australia to a value (amounting to about 82%) which is scarcely matched by any other flora of the world.

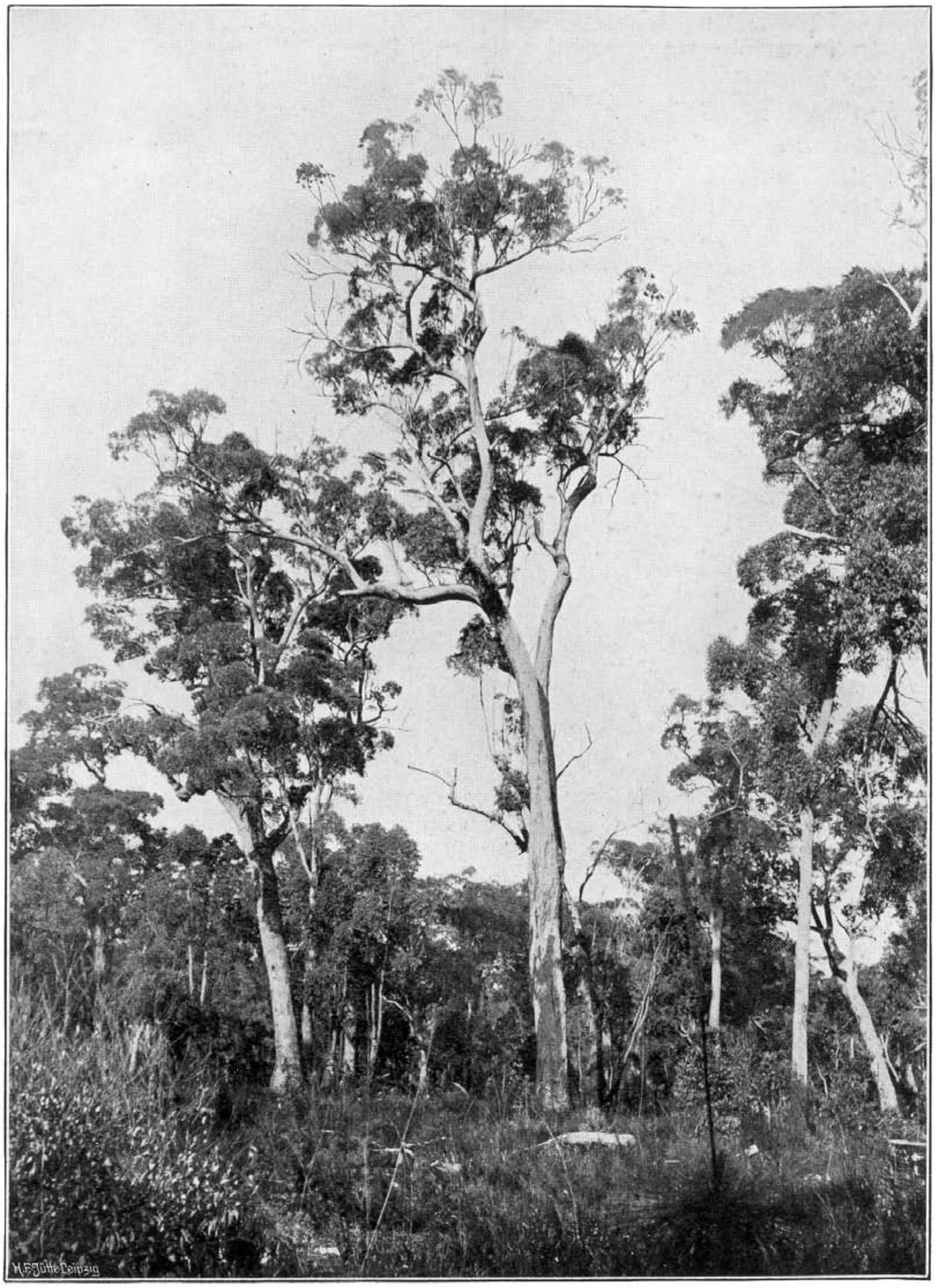
From the economic point of view, the *Eucalyptus* forests of the south-west, namely *E. marginata* (Jarrah) and *E. diversicolor* (Karri) are extremely valuable. Apart from these, it is poor in plants of economic importance. Exotic cultivated plants can only be grown successfully in certain areas. The broad sand areas so characteristic of Western Australia have not proved suitable for the cultivation of crops. But the alluvial flats of the valleys and the clay soil of the middle zone successfully carry cereal crops, various vegetable crops and many kinds of temperate fruits. Cultivation has also been attempted in the conglomerate [lateritic] regions of the hills, e.g. grapes in the north and fruits in the south. These attempts are, however, still in their infancy. Their extension is only proceeding slowly as the clearing of the Jarrah forest is very expensive and involves much labour. The bulk of the land is still more or less in its original state.

CHAPTER 2 PHYSIOGNOMICALLY IMPORTANT PLANTS

I. The Eucalypts

Nothing portrays more clearly the peculiarity of the Australian vegetation scene than the dominance of the genus *Eucalyptus.* There is no other area in the world, of comparable size and with such variations in climate and soil, that is similarly dominated by a single genus. While in its finer details the flora of south-west Australia shows a striking degree of independence, it too, like the rest of Australia, is dominated by the genus *Eucalyptus.*

Five species are particularly well represented in the true Southwest Province. These are: Jarrah, Red Gum, Karri, Wandoo and Tuart. Each species is characteristic of specific areas.



Eucalyptus marginata Sm., »Jarra«.

Im Vordergrund rechts *Xantorrhoea Preissii* Endl.

Distr. Darling, Darling Range bei Mundaring. — E. Pritzel phot. Februar 1901.

1. *Eucalyptus marginata* (Jarrah)
(Plate I., see also Plate XIII)

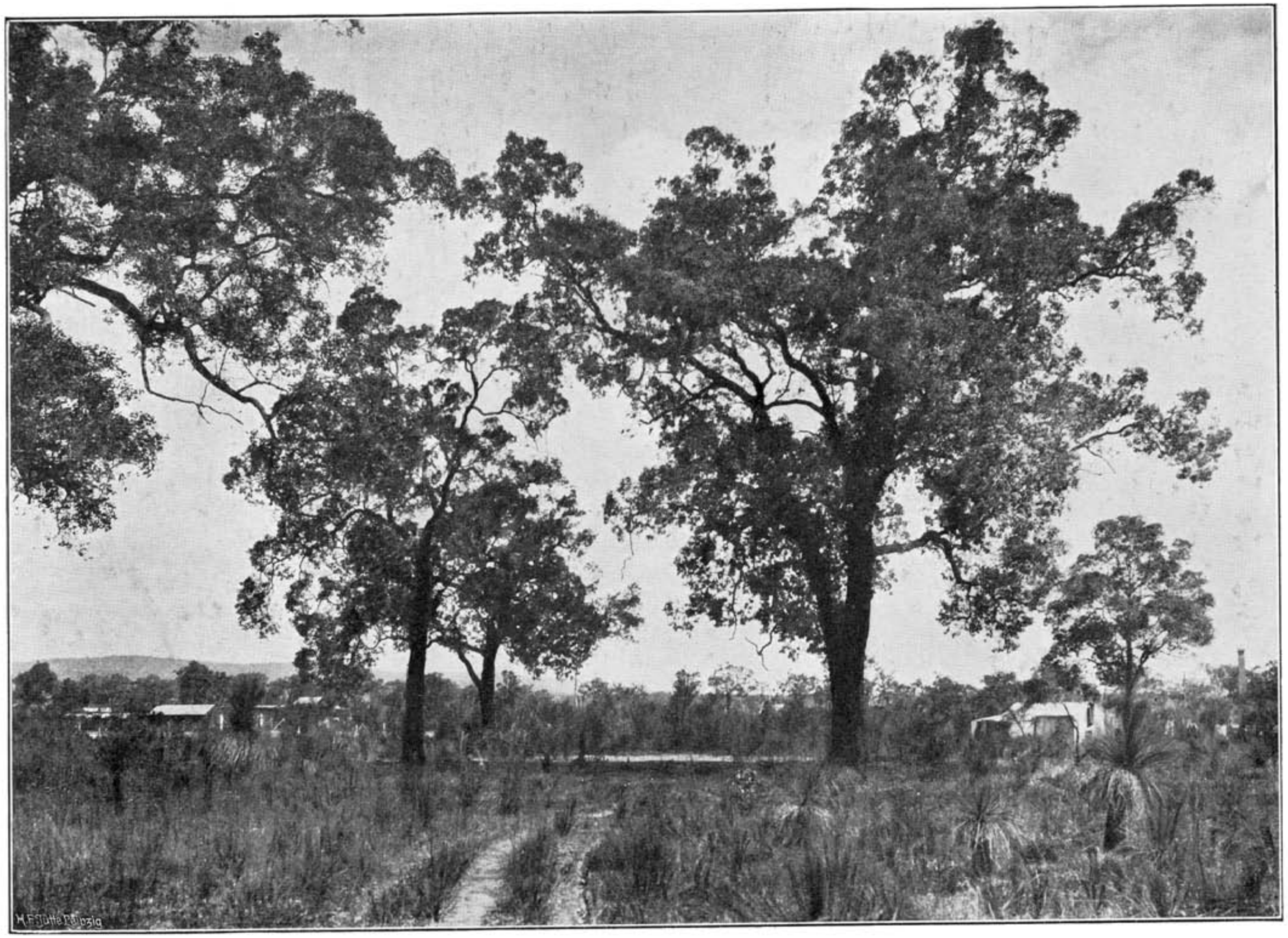
Jarrah (*Eucalyptus marginata* J. Sm.) in its typical form belongs to a polymorphic group in Western Australia. It needs to be distinguished from *E. patens* Benth. and *E. buprestium* F.v.M. It is impossible to say which of the numerous eastern Australian species is most closely related to *E. marginata.* What is almost certain, however, is that no closely related species occurs in the Eremaea.

Amongst the Western Australian eucalypts, Jarrah is easily recognised by its flowers and fruit. The character of the stamens is also important. The filaments are twisted in the bud but not bent inwards as is the case in many other species. The anther has a kidney-like shape. The rather large fruit is also clearly recognizable by its inverted oval or almost spherical shape and its marked contraction round the rim (see Fig. 3).

Fig. 3. *Eucalyptus marginata* Sm.: *A* Blüten-Zweig. *B* Fruchtstand. *C* Samen. (Original.)

In favourable situations, Jarrah reaches a height of from 30 to 40 m, with a diameter at the base of from 0.75 to 1.5 m. It is covered by dark-grey fibrous persistent bark, and it is only at a considerable height that it tends to become gnarled and somewhat irregularly branched. That at least is the normal form of the tree when it grows in slightly dense stands. In more open situations it shows greater development. Branching commences lower down and the crown projects further out. The leaf is typical of the genus and hangs in the usual vertical position. It is blue-green in colour but in consistency and certain other minor details it varies somewhat according to the locality.

In the south-western parts of the province, Jarrah develops so strongly that it forms forests covering a considerable area. These forests follow the coast from about the Moore River to Two People Bay (east of King George Sound), in a zone about 75 to 120 km wide. They are also most characteristic of the hilly region (100-300 m) on the outer margin of the tableland. The Jarrah forest, in fact, shows its best development here. It grows almost equally well in the lower sandy loams of the western coastal plain, however, and in this



Eucalyptus calophylla R. Br., »Red Gum«.

Im Vordergrund mehrfach *Xantorrhoea Preissii* Endl.

Distr. Darling, Bellevue östl. Perth. — E. Pritzel phot. April 1901.

very lightly wooded area it is the most striking feature of the vegetation. On the Swan River near Perth one may see many fine examples, and in Perth suburbs those Jarrah trees which remain from the original bush are quite a roadside feature.

The conditions necessary for its optimum growth are indicated by the situations in which the tree is found. It does not grow in swampy areas. Here its place is taken by *Eucalyptus rudis.* It prefers the sand and the conglomerate- [laterite-] covered granite of the plateau margin where it is more or less restricted to those areas with a high rainfall. Where the annual rainfall falls below 75 cm one seldom sees typical Jarrah. In places, however, one finds bushy or mallee-like members of the species. These indicate that the limits of the Jarrah area of distribution are being reached.

The boundary of this area almost coincides with the 75 cm isohyet. This has been more or less correctly shown on the valuable map in Ednie Brown's Memoir. The total area of the Jarrah forest is estimated by this authority to be over 3 million hectares and its total value about £85 million sterling.

Because of the great area over which it extends and the large number of trees of considerable economic value, Jarrah is by far the most important tree of south-west Australia.

2. *Eucalyptus calophylla* (Red Gum)

(Plate II)

Among the important *Eucalyptus* species of the south-west, the Red Gum (*Eucalyptus calophylla* R. Br.)is taxonomically the most distinct. It may easily be recognized by the very large urn-like fruits, but the leaf is also quite unmistakable. It hangs more horizontally than in most other *Eucalyptus* species of the district, and consequently the tree gives much more shade. In addition, the venation of the leaves is quite different from that of other species. The numerous parallel cross veins present, which make almost a right angle with the mid-rib, are characteristic. The seedlings with their heart-shaped, rough, hairy, juvenile leaves are also clearly recognizable. They are common on woodland soils.

In size, *Eucalyptus calophylla* is scarcely inferior to Jarrah but its trunk is easily distinguished from that of the latter by the deep red colour of the very thick rough bark. Because of this it was called "Red Gum" by the early settlers. Aesthetically the tree makes a finer picture than Jarrah, because of its richer foliage and the beautiful architecture of the crown. Drummond has compared them to English Oaks.

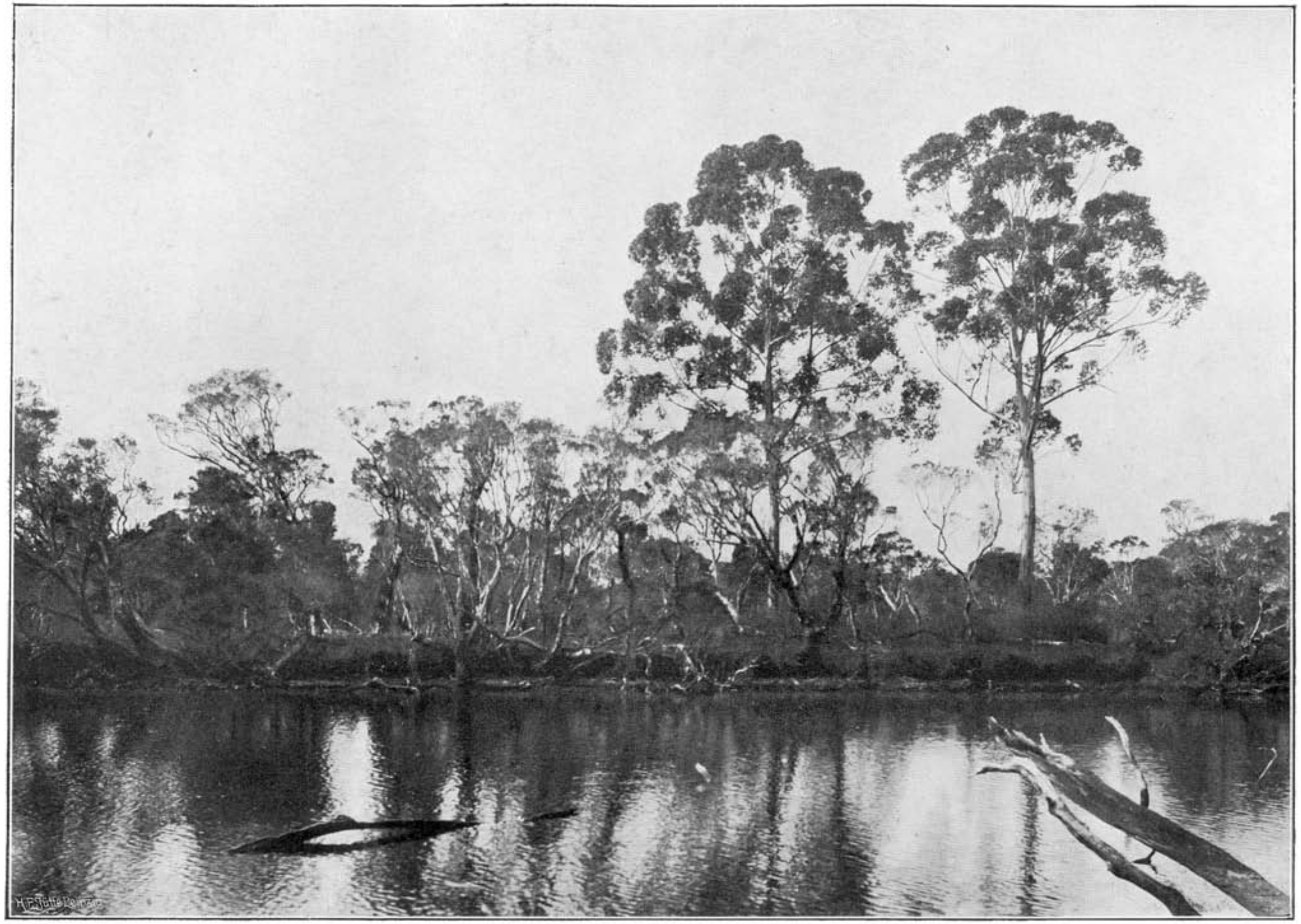
E. calophylla is more gregarious than the other main representatives of the genus in the south-west. It is usually not only found associated with Jarrah or Karri, but also with *E. redunca* and *E. loxophleba.* Occasionally, over a small area, it does become the dominant tree but it very rarely occurs in large pure stands. It is more usually found in scattered and isolated positions. Its distribution is considerably more extensive than that of Jarrah. Quite impressive specimens are found as far north as Watheroo and Dandaragan, while it also grows on the Avon River and to the south in the Stirling Ranges.

It appears, therefore, to be able to survive under a lower rainfall than *E. marginata,* or else it is more edaphically adaptable. In general, it grows better on the richer alluvial deposits or valley areas. In such places (as, for example, between the Moore and Preston Rivers on the coastal plain) it often becomes the dominant tree. Similarly in the Jarrah forests it grows best in more low-lying situations, where it is common. In short, it is a tree which, in association with others, plays a prominent part in the physiognomy of the vegetation of the south-west.

3. *Eucalyptus diversicolor* (Karri)

Plate III

As with Jarrah, it is not possible to speak with any certainty on the subject of the taxonomic relationships of Karri (*Eucalyptus diversicolor* F.v.M.). Even amongst the Western Australian species of *Eucalyptus* it does not appear to have any closely related members. The flower and fruit are not particularly distinctive but the leaf structure, as determined by the marked dorsiventral arrangement of the green tissue, is important.



Eucalyptus diversicolor F. v. M. »Karri«.

Der Baumstrauch dicht am Ufer *Melaleuca rhaphiophylla* Schau.

Distr. Warren, Denmark River. — E. Pritzel phot. Juli 1901.

F. v. Müller refers to this in his account of the species.

Karri is the largest of all Western Australian trees, and it is also the finest in the country. Its enormous size not only places it above all other trees in Western Australia, but places it amongst the princes of the plant world. On an average, Karri measures about 65 to 70 m in height, and at one metre above the ground such trees have a diameter of over 1 m. The first branch appears at a height of 40 to 50 m. Not far from the Warren River, where the finest examples are found, individual trees of over 100 m in height have been recorded with their first branch over 60 m up and the trunk at chest height having a circumference of 10 m[1].

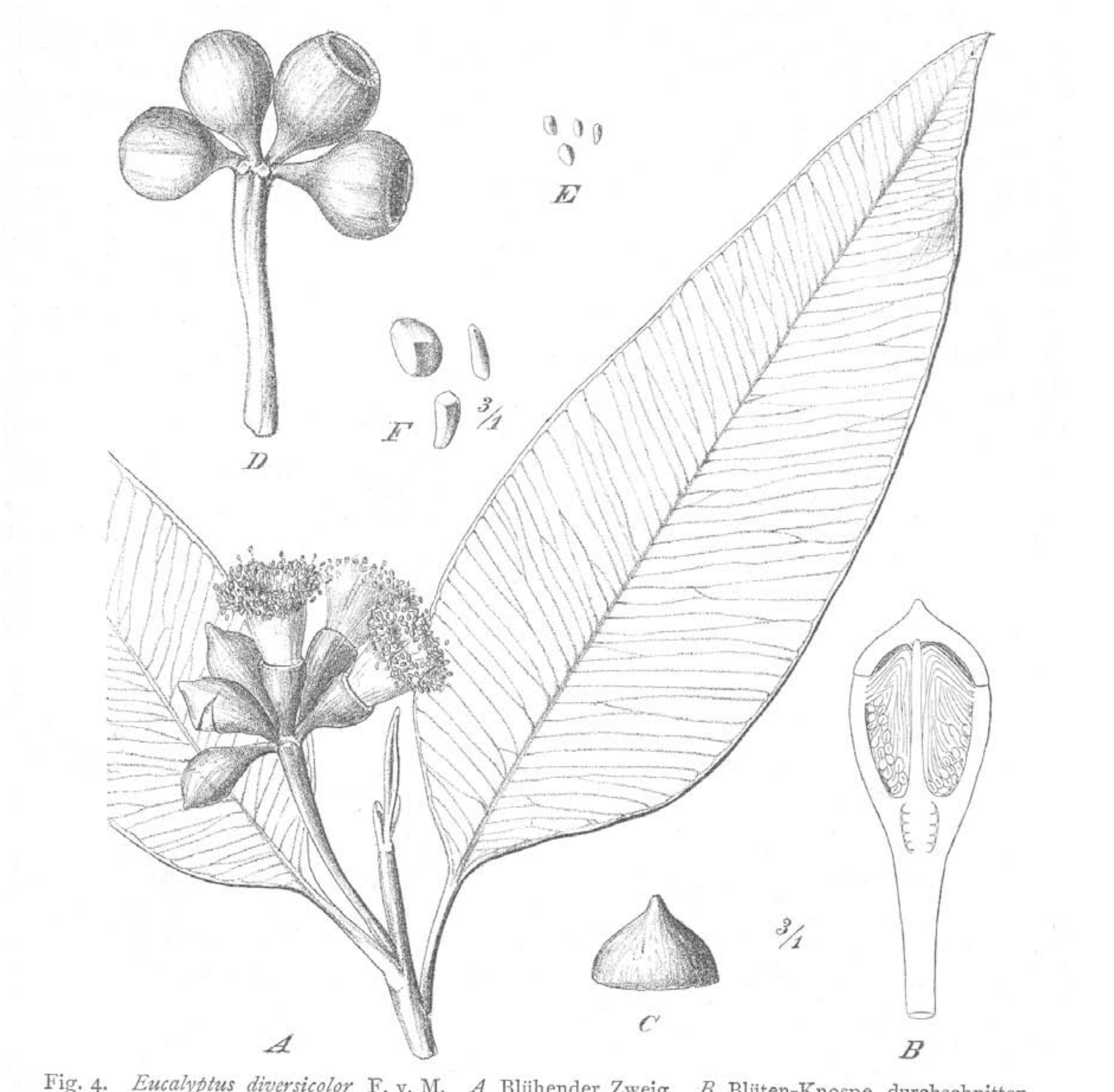


Fig. 4. *Eucalyptus diversicolor* F. v. M. *A* Blühender Zweig. *B* Blüten-Knospe durchschnitten. *C* Operculum. *D* Fruchtstand. *E*, *F* Samen. (Original.)

The bark of the Karri tree is very different in appearance from that of the Jarrah or the Red Gum. It peels off in large flakes from the trunk, which in consequence always appears to be glistening yellow or red-white in colour. It is a wonderful sight to see the straight bright trunks standing in the forest like a number of giant candles. Branching only commences at a considerable height. The primary branches tend to make close angles with the trunk and as a result we get a rounded crown.

Ecologically, Karri resembles Jarrah insofar as it tends to form closed communities.

1 J. Edine-Brown, The Forests of Western Australia and their Development. Perth 1899,p. 13.

E. calophylla may sometimes be present in its vicinity, but otherwise it forms absolute pure stands over almost the whole area of its distribution. It occupies the wettest parts of the south-west, particularly areas close to the south coast. The rainfall there is higher than in the Jarrah country and rises above 85 cm per annum. In addition, the temperature conditions are the most uniform in Western Australia.

As the Karri forest communities are treated in a later section it will suffice here to point out that the area covered by them is much smaller than that covered by Jarrah. It is interesting to note the manner in which these two communities share the high rainfall area of the south-west corner of Australia.

4. *Eucalyptus gomphocephala* DC. (Tuart)
(Plates IV and XI)

A closer study of the composition of the *Eucalyptus* species of the south-west of Australia shows that several floristically and ecologically distinct types are present. Among these is *E. gomphocephala* DC. Its hemispherical operculum covering the calyx-tube is a distinctive feature which is only as strongly developed in a few other species. The shape of the large fruit is also an unmistakable feature. Because of their uncommon brilliant green colour, the leaves and developing inflorescences are also characteristic.

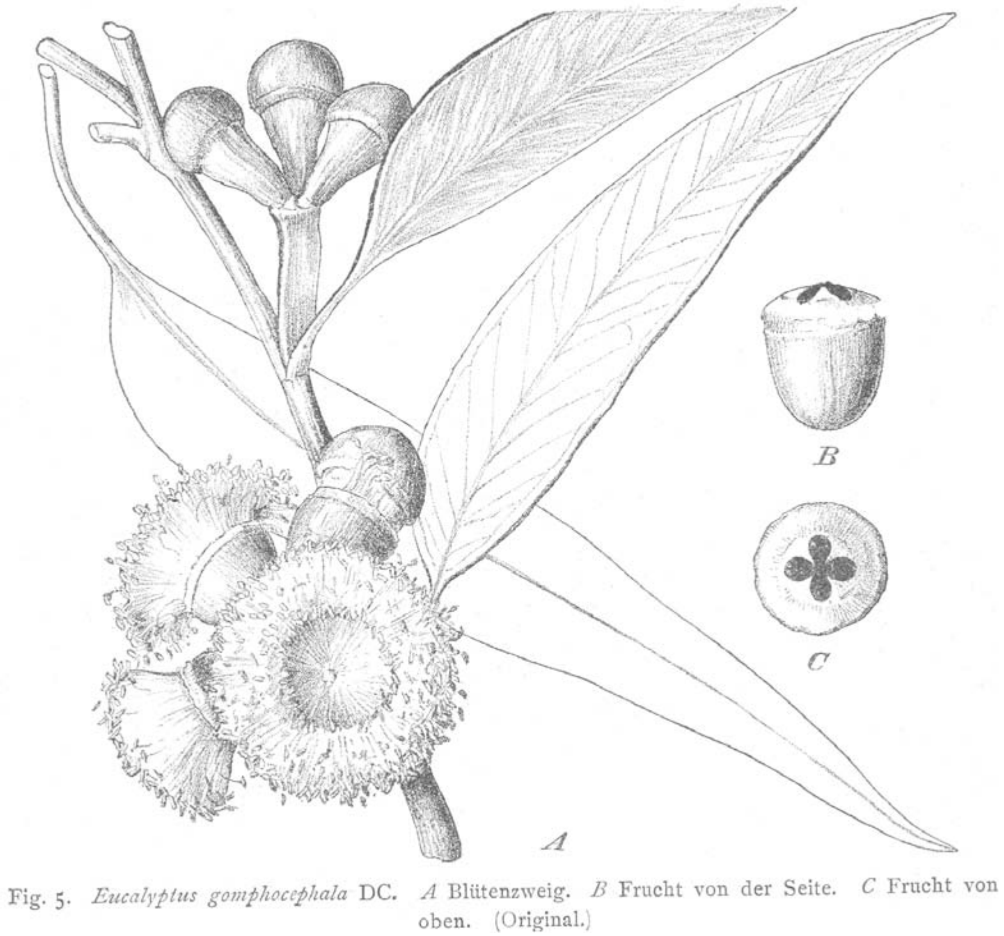
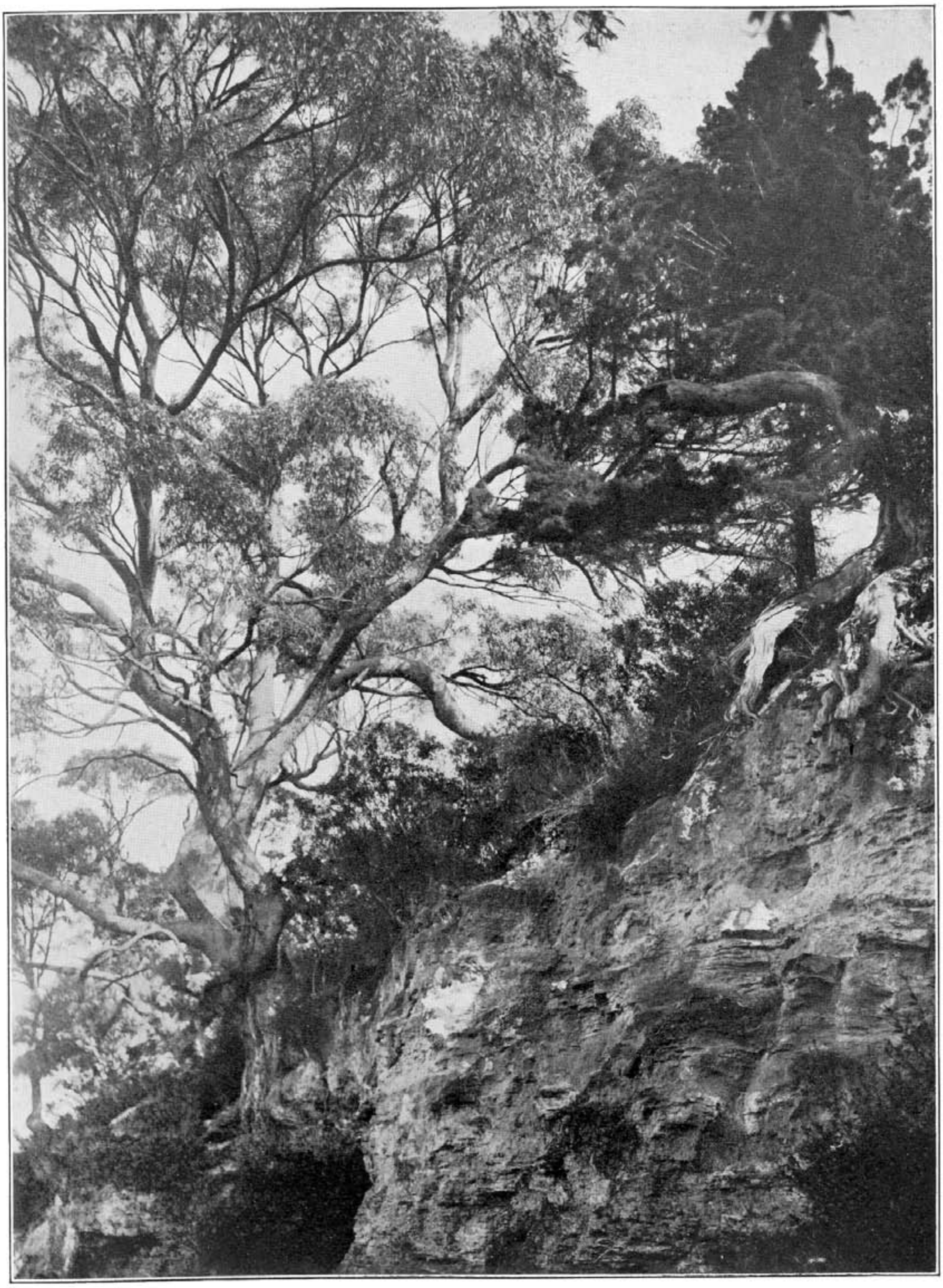


Fig. 5. *Eucalyptus gomphocephala* DC. *A* Blütenzweig. *B* Frucht von der Seite. *C* Frucht von oben. (Original.)

The height of well-developed Tuart trees varies between 15 and 50 metres. The bark is persistent and coarsely fibrous with a peculiar light-grey colour. This enables one to distinguish the tree from Jarrah or Red Gum. Branches commonly arise from the unusually massive and solidly built trunk at a very short distance above the ground. As a result we get a broad shady crown.

Tuart usually occurs in a somewhat scattered fashion, making full use of the surrounding space in its growth habit. The distribution of this species is much more restricted than that of any of the three eucalypts already discussed. In fact, its distribution is so



Eucalyptus gomphocephala DC. »Tuart«.

Rechts oben *Callitris* (*Frenela*) *robusta* A. Cunn.

Distr. Darling, Osborne Cliffs, Litoralkalk am unteren Swan River. — E. Pritzel phot. November 1901.

limited that Tuart would not stand a chance of being listed amongst the chief members of the south-west vegetation were it not for the fact that it is so markedly characteristic of the narrow zone it inhabits, and in addition is such an imposing tree.

According to the observations of F. v. Müller and others, *E. gomphocephala* is confined to the narrow zone of recent limestone present along the coast from north to south. The tree first appears just north of the Swan River [in fact Jurien] and its distribution extends southwards to about the Vasse. The limestone formation extends further north and south than these points, but the Tuart is restricted to the middle portion where the rainfall lies between 75 - 90 cm per annum. It is thus both edaphically and climatically a restricted species of the plastic genus *Eucalyptus.* In this connection it resembles *E. erythrocorys,* which plays a similar role not far from the Murhison River [sic], or *E. ficifolia,* which inhabits a much smaller area on the south coast.

5. *Eucalyptus redunca* Schau. (Wandoo)
(Plate Xlll)

In contrast to the four eucalypts already mentioned, which are comparatively distinct taxonomically, *E. redunca* Schau.gives clear widespread evidence of its relationship to other members of the genus. The species itself has also been separated by taxonomists into a number of varieties, most of which have a shrubby habit of growth. One very distinctive type, however, develops into a fine-looking tree -this is the Western Australian eucalypt known as the “Wandoo”. It is sometimes also termed the “White Gum” as the bark comes off in flakes like Karri revealing a yellow-white trunk.

As a rule, the tree only reaches a height of about 15 - 25 m. One may sometimes come across larger specimens but usually the tree is of relatively low stature. The crown is broad with the chief branches being arranged at a considerable angle. The foliage is dark blue-green enabling one to easily recognize the tree. Other useful characteristics for recognition are illustrated in Figure 6.

E. redunca is one of the more gregarious species of the south-west and over the greater part of the area of its distribution it forms closed communities. It only occurs in isolated patches near the limits of its distribution. Wandoo occurs largely on relatively infertile soils which are also stated to be cold, hard, acidic and underlain by clay. Such soils becomes very wet in the rainy season and then dry out very hard in summer.

The chief Wandoo region lies between the rainfall isohyets of 60 and 40 cm. Consequently the tree first appears in considerable numbers to the east of the crest of the Darling Range. Here it forms light woodland communities. Passing eastwards, as the rainfall diminishes, it is gradually replaced by the eucalypts of the Eremaea and finally it disappears altogether. It is still uncertain how far into the Eremaea the Wandoo extends. Ednie Brown mentions Wandoo as one of the chief trees of the goldfields, but I have never seen it there and believe I have grounds for doubting this statement.

One often finds *E. calophylla* occurring in the same areas as *E. redunca.* In its southern area of distribution *E. occidentalis* is also present, and to the east *E. loxophleba* co-occurs. It rarely mixes with Jarrah and the two are only found together in a narrow zone where the two communities meet. On the other hand, one may find *E. redunca* extending westwards beyond its own special area. Thus one meets it here and there on the foothills of the margin of the plateau between the Swan River and the Collie River. On the coastal plain also there are places where with *E. calophylla* it produces a park-like effect.

II. The genus *Casuarina*

(Plate XV)

When the trees of the south-west are mentioned, the genus *Casuarina* falls into second place. While in general the genus ranks well below *Eucalyptus* and perhaps scarcely surpasses *Banksia,* nevertheless, many species of it do attain a considerable size, being exceeded in this connection only by *Eucalyptus.* We may also note that, like *Eucalyptus, Casuarina* is not restricted to the south-west, but forms an important element in the

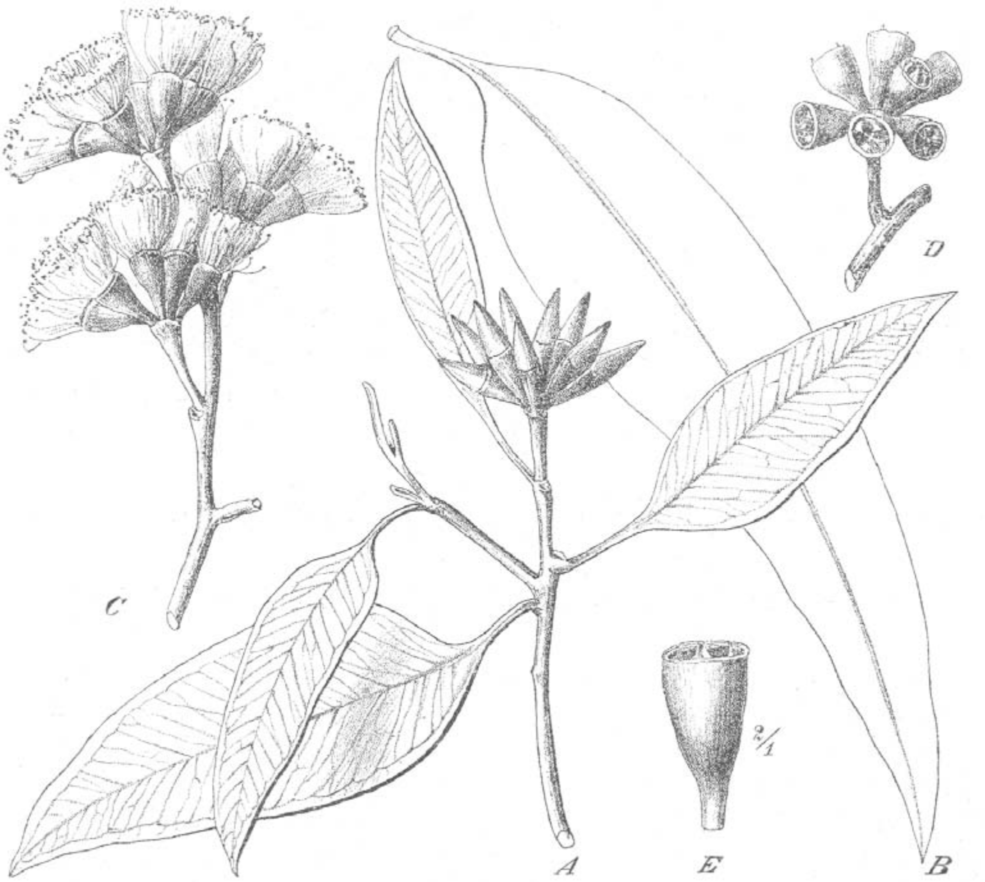


Fig. 6. *Eucalyptus redunca* Schau. *A* Zweig mit Blütenknospen. *B* Blatt. *C* Blütenstand. *D* Fruchtstand. *E* Frucht. (Original.)

Eremaea as well.

Species of the above are found both as tall-stemmed trees and as low shrubs in the flora of Western Australia. Thirteen species occur in the area[1]. The number of species and the limits of the varities have yet to be determined and the relationships of certain eastern Australian types to those of the south-west have yet to be elucidated.

We may first consider the species which grow to tree size. These are very similar in appearance and up to approximately 20 m in height. The bark is persistent, fissured and grey-brown in colour. The branches are borne at acute angles, and as a rule the crown is small. The rather rigid appearance of the whole tree is to some extent modified by the growth of the tiny branchlets which hang down but have their tips directed upwards. The branchlets of the two most important western species (*Casuarina Huegeliana* and *C. Fraseriana*] are flexible and graceful. While they lack the elegance of certain eastern species, e.g. *C. Cunninghamiana,* they are, nevertheless, well developed and form an attractive feature in the landscape.

The most purely south-western species is *Casuarina Fraseriana* which is easily recognised by its large rugose cones. The species is adapted for growth on sandy soil and, consequently, it is very common on the lightly wooded coastal plains. In the Swan River area this species and *Eucalyptus marginata* are the dominant trees, rising well above an understorey of *Adenanthos, Banksia* and *Jacksonia.* It is even more common at King George Sound where it forms entire communities. These are reminiscent of stunted pine forests. The poor development of the undergrowth here also indicates the infertile character of the soil.

At higher elevations on the plateau itself, at least in the moister western parts, the role of *Casuarina* is minor. It is only on the far side of the higher areas that it once again

1 Diels and Pritzel, Fragmenta Phytographiae Australiae occidentalis. In Englers Bot. Jahrb. XXXV 124.

becomes important. In the Wandoo woodlands one occasionally meets specimens of *Casuarina Huegeliana* with extremely light crowns. *Casuarina glauca* is also more common in occurrence here. This species belongs more strictly to the Eremaea. Provisionally it may be included here because of its successful invasion of the Southwest Province. It differs from the other two western species mentioned earlier, in its more rigid appearance. The branches are dry and brittle and assume a more erect position with only their terminal branchlets bent slightly downwards. *C. glauca* is fairly common on the hard clay soil of the Eremaea. In the Southwest Province, however, it tends to occur on the clayey depressions and in narrow valleys where it frequently appears as an imposing tree.

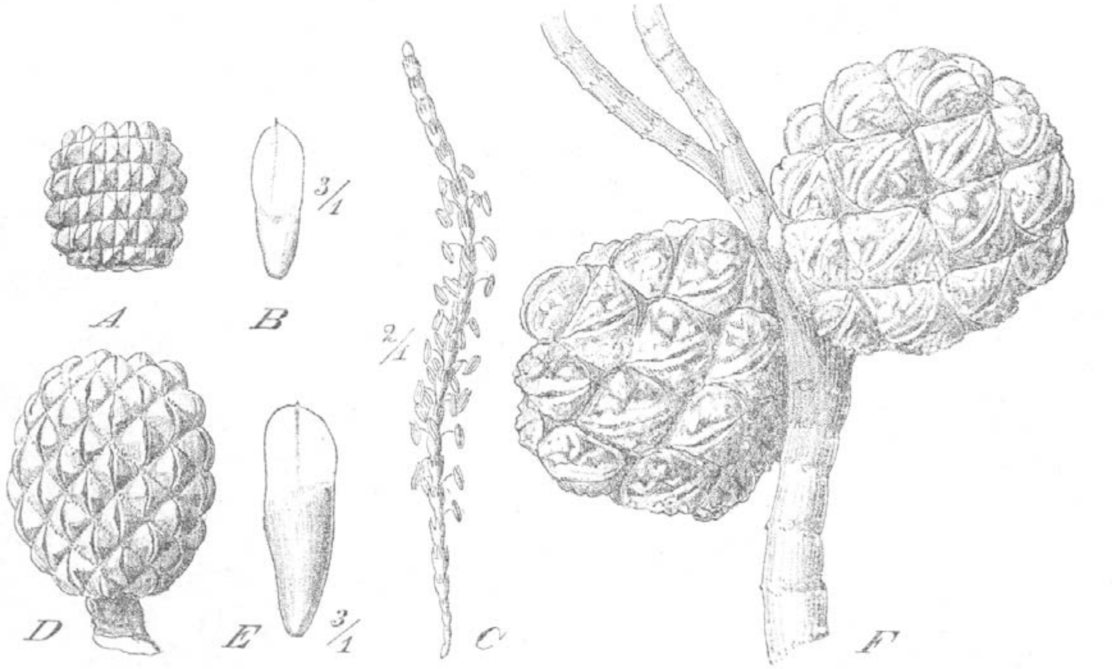


Fig. 7. *A, B Casuarina glauca* Miq. *A* Zapfen. *B* Achaenium. — *C—E C. Huegeliana* Miq. *C* ♂ Kätzchen; *D* Zapfen. *E* Achaenium. — *F C. Fraseriana* Miq. Ast mit Zapfen. (Nach Diels und Pritzel.)

The role of the tree-like *Casuarina* species in the south-west presents many problems. In the Eremaea *C. glauca* is as drought tolerant as are the *Eucalyptus* species of that area. As one travels westward, however, the water requirements of the genus appear to increase remarkably. Thus *Casuarina Huegeliana* and *Casuarina glauca* are largely restricted to areas where flooding occurs. It is only as we go further towards the deep south-west that the rainfall again allows them to become independent of soil moisture.

As with *Banksia,* we have by no means exhausted the importance of *Casuarina* simply with a discussion of the tree forms. Its variability in shape may be seen in the more exposed open country where the shrubby species are well developed. In the northern landscapes on the boundaries between sand and clay, one constantly meets the broom-like growths of *Casuarina campestris.* Frequently these growths develop into dense bushy thickets. Large areas of gravel-clay soils between the Irwin and Moore Rivers are often covered with a low bush consisting of *Casuarina Drummondiana,* while on sandy soils *Casuarina microstachya* is more strongly developed. Without doubt the most common of the psammophilous species is *Casuarina humilis,* which characteristically colonizes areas where the sand is low in humus. For completeness we must mention *Casuarina distyla* which can even grow in dune sand that it covers as with a flat cushion. It presents a peculiar picture when the brownish-red male catkins grow up above the closely interwoven branches.

III. The Species of Banksia (Prot.)

(Plates V and XII)

In some ways *Banksia is* the most characteristic genus of the Southwest Province. While *Eucalyptus* and *Casuarina* are prominent in the south-west, they are also important physiognomic genera in the Eremaea. *Banksia,* however, is essentially absent from the Eremaea, occurring almost exclusively to the south-west. The species are not as gregarious as *Eucalyp*tus and rarely form communities of any size. At the same time they are constituents of all the other communities.

Banksia species are found both in wooded areas and in more open places. They are present here as trees or as bushes, and even as dwarf-like forms on the sandy heaths of the southeastern parts of this district. It appears that the conditions necessary for its growth here are more complex than anywhere in eastern Australia.

Its diversity in shape is consequently correspondingly greater. Banksias which grow to tree size are restricted to the wetter half of the Southwest Province. They are represented essentially by *B. grandis, B. littoralis, B. attenuata* and *B. ilicifolia.*

Banksia grandis (Fig. 8 and Plate IX), when mature, usually has a treelike trunk. Only at King George Sound and in the Stirling Ranges have I found it in bush form about 2 metres high and yet in flower. Elsewhere the height of the best-developed trees may, according to my observations, range up to 20 m. The mode of branching varies greatly depending upon external conditions. The trees tend to be thickly branched in open woodland but less strongly so in the denser woodland of the south. The most distinctive feature of *B. grandis* is the large leaf. No other plant in Western Australia has such a large one (lengths of 40 to 60 cm with breadths of 10 cm are not uncommon). The strange, superficially fern-like shape of the leaf margin is also peculiar. These large green leaves tend to grow out in the form of a funnel-like cluster at the end of a twig.

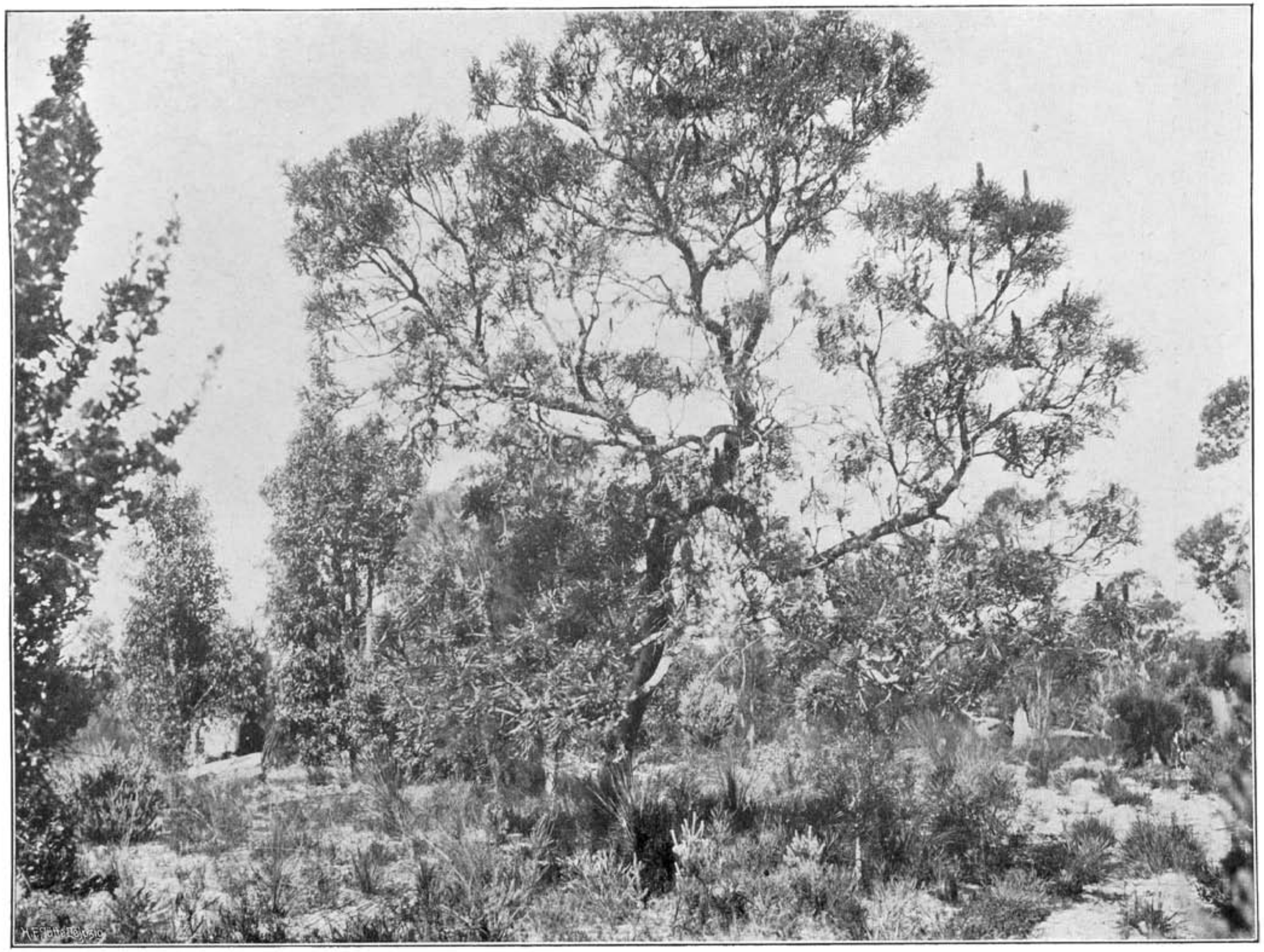
The whole effect is quite different from that of any other species. Like all the other trees of the south-west, *B. grandis* is evergreen. The life duration of the individual leaves, however, appears to be somewhat limited and a complete renewal takes place in little over a year.

As in all the tree-like banksias, the very large flower spikes are terminal, rising from an oblique collar of leaves. In the case of *B. grandis* it is 30 cm or more long and its numerous sulphur-yellow flowers give the tree a spectacular appearance. The flowers are so numerous that the natives have lived on their honey Drummond reports. The fruiting spike is even larger than the flower spike and remains on the tree for a long time, even well after the seeds have been shed. One often sees on the same tree, and at the same time, young inflorescences, fresh flowering spikes, ripe fruit and old fruiting spikes.

B. grandis reaches its maximum development in size and sturdiness of growth in the districts of greatest rainfall. One such area is on the Blackwood River, which has a rainfall of over 75 cm per annum. In the moister Jarrah forests it forms a densely interwoven thicket producing a definite lower storey of tree growth and distributing a thin layer of cast-off leaves over the ground. Like the genus *Eucalyptus, B. grandis* becomes reduced to a bush as the limits of its distribution are reached. This is at least the case, according to my observations, on the south coast. The most eastern locality noted in the literature is Cape Riche.

Banksia littoralis (together with *B. verticillata,* from which it differs in its dentate leaves) belongs to the section *Oncostylis.* It varies in height between 2 and 25 m (see Plate XII). While it agrees with *B. grandis* in its general characteristics, there are important differences in detail and physiognomy. The bark, with its greyer colour, is different. The leaves are much smaller in size, seldom reaching more than 20 cm in length, with a breadth of only 0.5 to 1 cm. The upper side of the leaf is dark green, while the undersurface is white-woolly. Because of this difference in lower surface leaf colour, the crown may appear silvery. The flower spikes are more slender than those of *B. grandis* and bear reddish-yellow flowers. In all other respects they are similar. The features described above are characteristic of the genus.

In general, the area of distribution of *B. littoralis* coincides with that of *B. grandis.*



Banksia attenuata R. Br.

Links am Rande *Banksia ilicifolia* R. Br., im Hintergrunde junge Exemplare von *Eucalyptus marginata* Sm.
Distr. Darling, Bayswater östl. von Perth. — E. Pritzel phot. Dezember 1901.

In places, however, one species may be present and the other absent, for while *B. grandis* tends to grow on well-drained land, *B. littoralis* appears better adapted to lower-lying areas subject to flooding. In such low-lying areas, at least in the southern districts, it is an unmistakable and characteristic plant. Near the Swan River it is much less in evidence, although one can still count on finding it on the margins of wetland areas.

In terms of external shape, *B. attenuata* has much in common with the preceding species even though taxonomically it is not closely related. It does, however, fall into the section *Cyrtostylis* with *B. grandis*. The leaves are very similar to those of *B. littoralis*. The flower spikes are also similar, but the colour is, however, pure yellow.

B. attenuata exhibits a graded series of growth forms from low shrubs (1-3 m) to quite imposing trees (up to 10 m high). One can, however, often find flowers present on quite low bushes. On the more northern sandy areas this bushy condition is the rule, but further south towards the coast, while it may still be observed, it is less common. On the Swan River, both forms grow in close proximity. The wider distribution of *B. attenuata,* as compared with the preceding species, may possibly be correlated with this greater adaptability. It is also present in the Murchison River district, particularly in the wooded region near the sea. Further south on the wide sandy areas near the Arrowsmith River, the closely growing shrubs with their yellow flowers form a characteristic feature during the dry season. Again, they play an important part in the Swan River district and are very common in the bush around Perth. Here, in November, *Nuytsia* and *Banksia attenuata* are the two most spectacular flowering plants in the landscape. This still applies all the way down to King George Sound where they were both discovered by Robert Brown. How far east *B. attenuata* extends is not yet known. It is clear, however, that *B. attenuata* is not only one of the most common species among the taller forms of the genus, but is also one of the shrubs of first-rate importance in the scenery of the south-west. It is of particular physiognomic importance on the sandy soil so common in that area.

Two additional species which are physiognomically similar to *B. attenuata* and which belong to the section *Orthostylis* are also sufficiently important to be listed. They are *B. Menziesii* and *B. prionotes* which are important constituents of the vegetation. The above-mentioned *B. attenuata* resembles *B. Menziesii* in its climatic and edaphic requirements. In many places both are found associated, as for example, bordering the Swan River on the sandy surfaces of the coastal plain. The two species would be dominant here were it not for the presence of Jarrah, or, here and there, of *Casuarina.* In this small community, the differences between the two *Banksia* species may be clearly seen. The perianth of *B. Menziesii* is red and the pistil dark red so that the flower spike has a general soft light-red colour which harmonizes well with the green of the leaves. On the Swan River, the flowering time of *B. Menziesii* occurs later than that for *B. attenuata.* The flowers of the former species do not appear until February, while those of *B. attenuata* have long since bloomed. This does not hold good everywhere, however, and I have seen *B. Menziesii* in flower as early as September at Champion Bay.

The distribution of *B. Menziesii* is far more limited than that of *B. attenuata.* Although both coincide in the north, the boundary of the former is soon reached south of the Swan River. It is absent from the entire south coast.

In leaf and flower, *B. prionotes* appears to be almost a double of *B. Menziesii.* It differs, however, in its general form and in the character of its stem. Branching usually commences near the ground. The branches grow out at acute angles and rise sharply. The leaves are also arranged in a steeply upright manner. As a result, the shape of the tree is like that of an inverted cone. This is unusual for a *Banksia* but it fits in well with the scenery of the regions where this species is present. In such areas the vegetation is rich in trees of this shape.

A closer examination of the stem and branches of *B. prionotes* discloses further peculiarities. The bark is relatively smooth and of a grey-blue colour, quite different from the rough granular bright rusty-brown scaly bark of *B. Menziesii.* The height of the trees varies between 0.8 and 8 m.

In its distribution *B. prionotes* differs markedly from all the species of *Banksia*

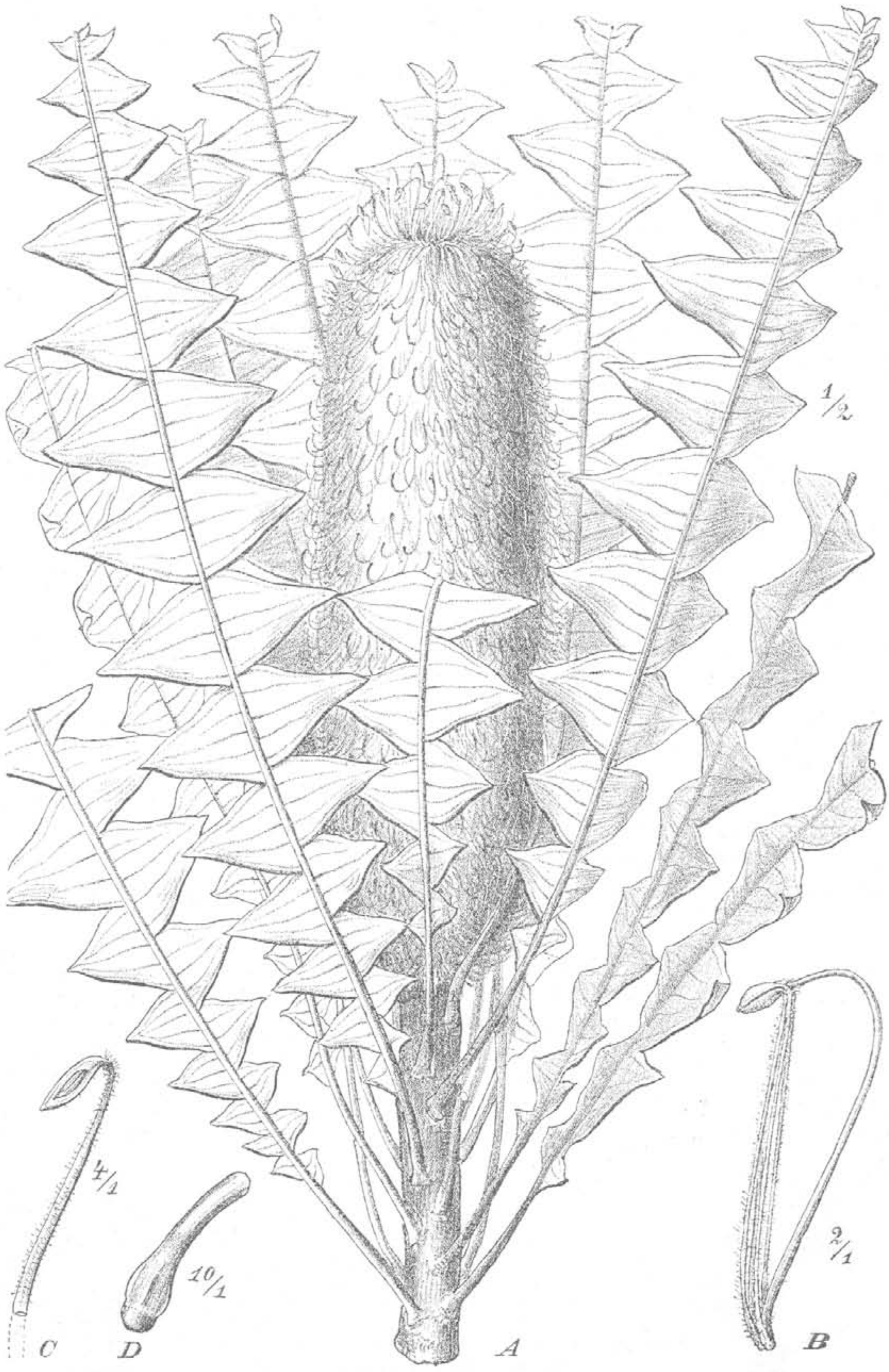


Fig. 8. *Banksia grandis* R. Br. *A* Blühender Zweig. *B* Blüte. *C* Blütenhüllblatt mit Staubblatt. *D* Narbe. (Original.)

referred to above. While it does occur associated with *B. attenuata* and *B. Menziesii* on sand-clay soils in the northern parts of the province and in the Gingin area (where it even occurs in association with *Eucalyptus calophylla),* nevertheless, from there southwards, it turns away from the coastline and extends through the dry interior to the east of the plateau margin. It is present in districts where there is 45-30 cm of effective rainfall and where none of the other large Banksias can exist.

The only other *Banksia* which attains tree-like dimensions is *B. ilicifolia,* and this species occupies a very peculiar position. Taxonomists have created a section for it alone *(Isostylis).* In many ways it seems more closely related to the genus *Dryandra* than to the other *Banksia* species. As a matter of fact, *D. floribunda* resembles it so closely in external appearance that both in the literature and in the herbarium, experienced botanists have mistaken one for the other. This species must be considered therefore to form a link between the genera *Banksia* and *Dryandra.*

The plant is known to exist in two externally very different forms, but unfortunately insufficient material is as yet available to make clear the relations of the two and further investigations are necessary. On the Swan River *B. ilicifolia* occurs in the form of a small conical tree or shrub 3 - 7 m in height. Well-developed specimens, seen from a distance, give one the impression of a Cypress. At King George Sound, on the contrary, I have met with differently shaped plants on the sandy ground of old dunes. The stems of these were distinctly reduced and a broad, rounded crown was present. Apart from these differences, the two types agreed in the character of the leaves (which are dark green and rigid), the short inflorescence, and the colour of the flowers which are sulphur yellow at first, becoming red later.

The area of distribution of this species and the conditions governing its growth are still incompletely understood. Beyond the two localities already named, none are known to me, although without doubt the intervening region is inhabited by the plant.

In addition to the six species so far described, about 30 others are present in the Southwest Province. Many are closely allied to the shrub-like forms of the *B. attenuata* group, but besides these there are low bushes with greatly reduced leaves, and even ericoid-leaved heath-like dwarf plants which appear like miniature editions of the larger species. They agree ecologically with the dominant life-forms of their communities. Finally, there are some species with quite peculiar shapes in that the stem with all its branches lies close to or under the surface of the ground like a rhizome.

Some of the numerous species are widely distributed (e.g., *B. sphaerocarpa);* others are very much localised in their occurrence. Many are so isolated, that from the scenic point of view they are of little value, while others are locally of very considerable physiognomic importance.

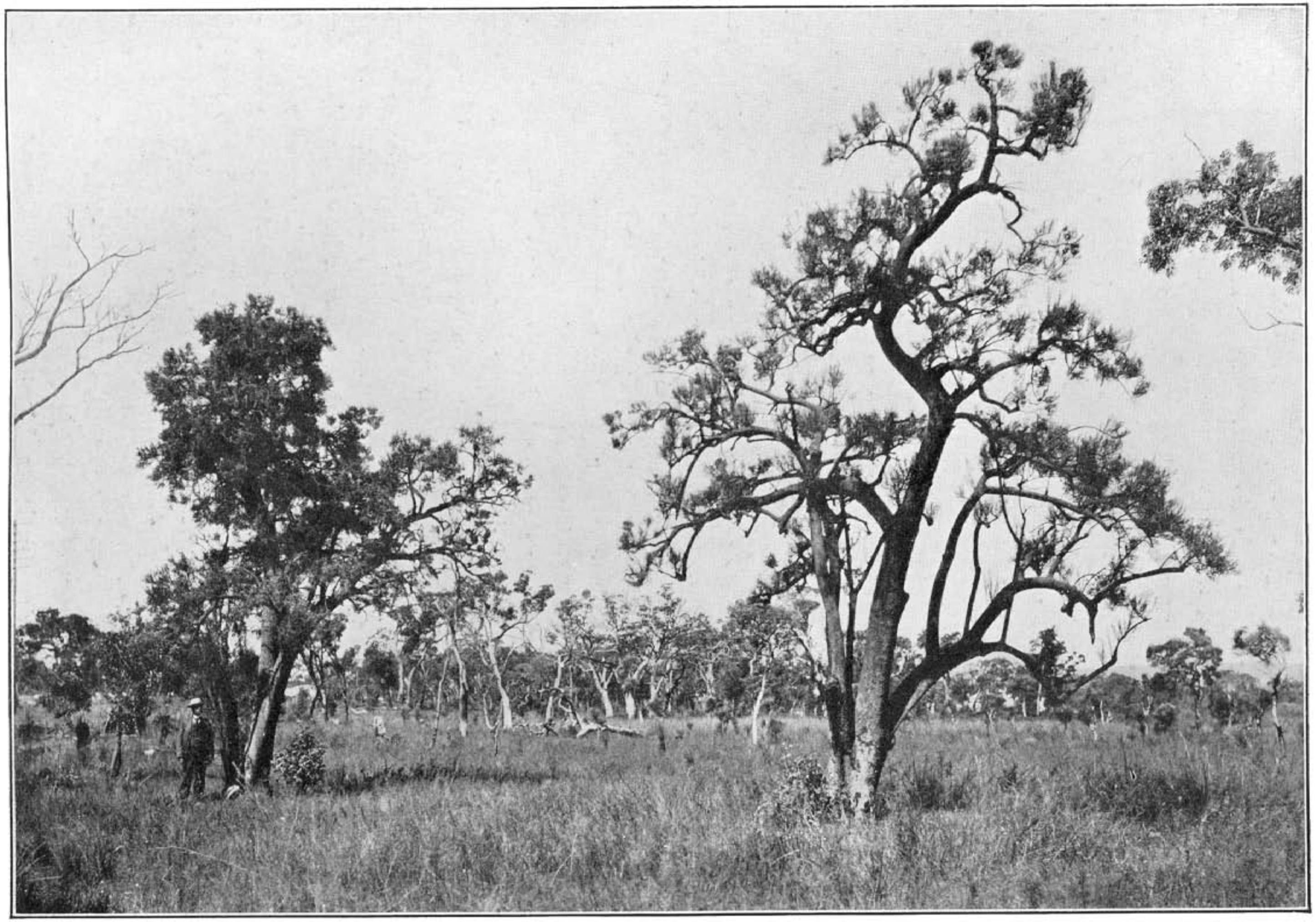
IV. *Nuytsia floribunda* R. Br. (Loranth.), "Christmas Tree"

(Plate VI)

Amongst the plants whose presence enriches the physiognomy of south-west Australia in a most striking way is the endemic species *Nuytsia floribunda.* However, it is quite widely distributed in the south-west, indicating that many suitable areas for its survival exist.

Taxonomically, *Nuytsia* is regarded as a member of the Loranthaceae (Fig. 9), but it would be more scientific to consider the genus as a representative of a group which originated from the Loranthaceae on the one hand and the Proteaceae on the other. There is really nothing binding *Nuytsia* closely with either the one or the other family as they exist today. It differs from the true Proteaceae in the six-partite corolla, and in the fruit; the "calyculus" is not so different since it is similarly poorly developed in many Proteaceae. The genus diverges from the true Loranthaceae because of its fruit and also its habit which reminds one more of many of the grevilleas.

The height of the plant in the mature flowering condition varies from 1.5 to 12 metres. Associated with the main stem, which is covered with grey scaly bark, there are often numerous underground stems which grow almost horizontally below the surface



Nuytsia floribunda R. Br. »Christmas Tree«.

Die Bäume im Hintergrund *Melaleuca Preissiana* Schau.

Distr. Darling, Guildford. — E. Pritzel phot. Dezember 1900.

of the ground until they reappear, often at some distance, and produce leaf-bearing axes (suckers).

The general appearance of this remarkable plant is clearly seen in Plate Vl. I do not know of anything similar in the vegetable kingdom. I am not in a position to state what conditions are responsible for its strange growth form. A cross-section through a branch shows that the upper side is developed most strongly, in fact new growth only takes place there, and this leads to a curvature of the structure towards the ground. As soon as this bending becomes too great to meet the needs of the foliage, growth ceases at the apex and degeneration sets in. One of the neighbouring branches then develops sympodially in the direction of the former axis and takes over its function.

The leaves develop on short axes directed vertically and in somewhat crowded bundles. They are thick, of a peculiar firm fleshy consistency and blue-green in colour.

As the end of the rainy season approaches, one may observe the flower buds developing from the numerous leaf clusters, and the young panicle soon becomes recognisable from a distance due to its yellow colour. It is only, however, near Christmas time, when the tree is in full flower and a mass of flaming orange that one can appreciate how extraordinarily rich is the flower production of this tree.

It is surprising how poor the production of fruit appears to be following the rich development of flowers. Only on a very few trees in the Perth region, where the Christmas tree is common, could I discover a few poorly developed specimens in the summer of 1901. I was tempted to consider this as due to something abnormal about that year, had not other naturalists told me that this fact had already been mentioned by Harvey. In the Hookers Kew Journal VI 219 this writer states that Drummond had also found no ripe fruit in spite of long and careful search.

How far this holds good for the whole country it is impossible to state. In any case it explains why it was difficult to obtain viable seeds from the Perth region and also the difficulty of observing germination in nature. In spite of this, Dr Morrison was successful in observing newly germinating seeds and young seedlings situated in a place not far from the Swan River after a season of very heavy rain. This evidence is very important in connection with attempts made to explain the life history of the plant.

On account of the relationship to the Loranthaceae, one might feel inclined (as some already have) to doubt the autotrophic nature of *Nuytsia.* The peculiar habit of the plant perhaps supports this view. Whatever the case, the relationship to *Loranthus* has been taken as ground for the belief that parasitism was at least a possibility. This view was put forward by Harvey (Hookers Kew Journal VI 219), who believed it extremely probable that a union with the roots of other plants took place. The solution of the problem is not easy. Culture experiments have still to be set up. They would probably be unsuccessful in Europe without the negative results being of any value. The investigation of the subterranean parts of the plant in many localities was impracticable since the underground portions often stretched for very long distances. Webb (Victor. Natural. X (1893) 158, 159), who was encouraged by F. von Müller to make some observations on this tree, stated that he had never been able to find the roots attached to anything. He put forward the view that the Christmas tree is an independent plant which requires, however, a certain type of soil which can only be present as the result of the growth of certain other plant species. This theory is rather vague. *Nuytsia,* however, often occurs in situations which make parasitism appear extremely improbable. Thus, for example, it grows in an isolated fashion on the dry sand heaths, being the only tree form for many kilometres. For a full-grown tree it would seem improbable to assert that adequate nutriments could be obtained from the roots of the comparatively dwarf bushes which grow near the foot of the plant. In addition to this we have the observation of Dr Morrison that germination of the seeds can occur independently. Until contrary evidence is brought forward, we must assume that the *Nuytsia floribunda* is an autotrophic plant.

Fig. 9. *Nuytsia floribunda* R. Br. *A* Blühender Zweig. *B* Teil der Infloreszenz. *C* Cyma letzter Ordnung. *D* Gynaeceum mit Calyculus. *E* Teil eines Fruchtstandes. (Original.)

V. *Macrozamia Fraseri* Miq. (Cycad.) "Cycas-Palm"

(Plates VII and XII)

Macrozamia. Fraseri Miq. is one of the most important, perhaps the only representative of the Cycads in the south-west. Taxonomically the species is not very distinctive and is closely related to both the eastern *M. spiralis* Miq., and the central Australian *M. Macdonelli* F.v.M. So much so, in fact, that all three species appear to be modified from a single type which, apart from certain gaps, is found right across Australia between 25° and 35°S latitude.

The south-western species appears to be taller and more sturdily built than its eastern relations, and in this respect is only inferior to *Macrozamia Perowskiana* Miq. of tropical Queensland. Its stem varies greatly in height: sometimes it is scarcely visible above the ground, while in other cases it may be from 1 - 1.5 m high. It has been reported that specimens with stems 3 to 4 m high occur but I have not seen any of this size. The stem averages from about 0.3 - 0.5 m in diameter.

The conspicuous rigid pinnate leaves crown the stem. They are about 1.5 - 2 m long with a breadth of 0.2 - 0.3 m, and each bears about 70 pinnae on either side of the midrib. The bright shiny green of the upper surface of the leaf makes the plant attractive. The leaves are arranged in the form of a wide funnel shape. Only on the taller-stemmed forms is there a tendency for their tips to bend somewhat more towards the ground. Where this occurs the crown of leaves becomes very widely spread and open, giving the plant a more elegant appearance. The cones (male and female on separate plants) are borne in the middle of the circlet of leaves and usually several are present.

The female cones are very large (up to 0.5 m in length). The fruits are somewhat rare in occurrence in some regions. In the sandy woodland of the coastal plain, where I have most frequently found the species, I have only seen fresh cones in a few cases. Drummond, who gives a similar account, also mentions that *Macrozamia* bears more numerous cones in the hills on the edge of the plateau. This led him to suggest that the species is better adapted to more elevated regions from 300 – 350 m. It has been further suggested that *Macrozamia* might have been introduced by the aborigines to the coastal plain area.

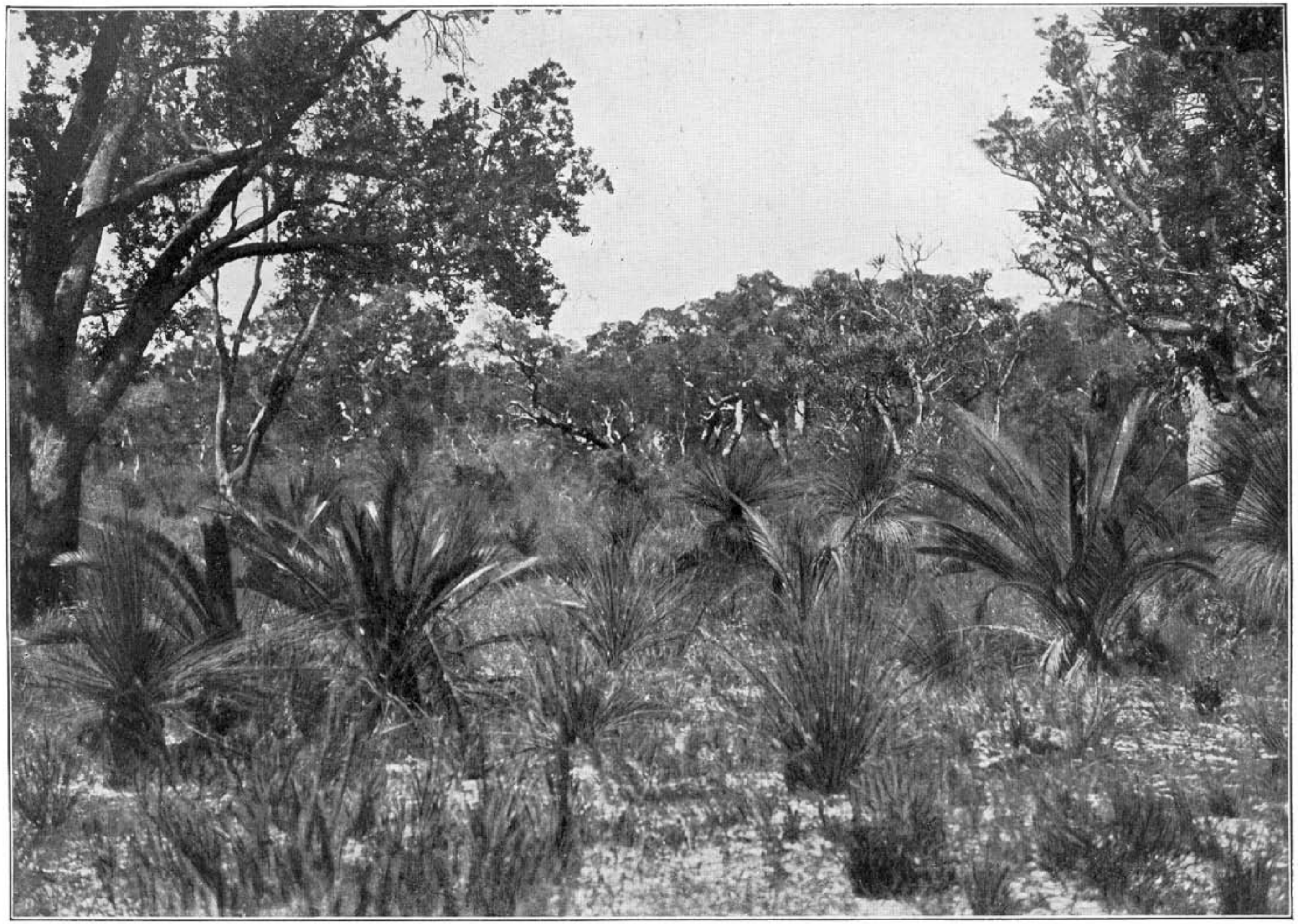
This view is probably incorrect, however, when one takes into account the distribution pattern of the *Macrozamia Fraseri*. It is not confined to the moist south-west hilly region and the plains below but extends north and east far beyond the woodland area. Cycads are unusually numerous in the region of the lower Irwin River. The bush vegetation present here consists of a mixture of *Acacia* and *Banksia* plants. Again, far to the east, the species is met in the form separated by F. von Müller as *Macrozamia Dyeri* which is found north of Esperance. The Zamia palm can thus grow successfully in an area where the yearly rainfall is only approximately 50 m [*sic* 50 cm]. Soil conditions seem to have only a small influence. *Macrozamia Fraseri* is present on soft sand, on the conglomerate [laterite] of the highlands, and on the clay soils of the low country. Its local distribution is rather irregular. Wide stretches occur where it is rare, while elsewhere it is common, sometimes being present in large numbers. What conditions determine its absence or abundance have not yet been discovered.

VI. Tree-like Liliaceae

Plate VIII also see Plates XX and XXII

The Grass-trees which belong to the Liliaceae are rightly famous amongst the unusual members of the Australian vegetation. In the landscapes of the east coast, which were the first to be investigated by settlers and scientists, they provide throughout the country a strange and decorative feature. Owing to this, they have become inseparably associated with the traditional descriptions of the vegetation. However, it should be noted that they are almost entirely absent from very extensive areas of the dry interior. They are also quite rare in the tropical regions. On the other hand, they are nowhere so varied and important as in the heartland of the Southwest Province.

While in eastern Australia only species of the genus *Xanthorrhoea* are present, the



Macrozamia Fraseri Miq. »Cycas Palm«.
Links *Eucalyptus marginata* Sm., im Hintergrunde *Melaleuca Preissiana* Schau.
Distr. Darling, Bayswater östl. Perth. — E. Pritzel phot. Dezember 1901.

taxonomic variability of the Grass-trees is strikingly shown in the south-west. Thus, in addition to *Xantorrhoea,* we have the morphologically distinct genus *Dasypogon,* and the interesting genus *Kingia,* all belonging to the well defined tribe Calectasieae. These different genera exhibit distinct traces of relationship, though for the most part they show such a degree of divergence that a direct relationship between them could scarcely be imagined.

Because of its wide distribution and frequency of occurrence, the most important Grass-tree of the south-west is *Xantorrhoea Preissii* Endl. This is the "Blackboy" in the true sense of the colonists. It occurs in a variety of mixed communities and is one of the most important elements of the vegetation of the Southwest Province.

Those who have only encountered the species once may find some difficulty in recognizing it again elsewhere due to the variability of its external habit. Very often the caudex remains short and scarcely appears above the ground. This applies not only in the case of young plants but also in those of mature age. In typical cases in the west and in the south, the caudex which is about 20 - 25 cm thick grows without branching to a height of about 1.5 to 2 m. Oldfield is correct, however, in stating that specimens ranging up to 5 m high do occur. Such specimens are quite impressive, especially when one includes the flowering spikes in the overall picture. The branching of the stem is quite important in that it affects the appearance of the plant. In some regions (particularly on swampy ground) branching is often quite marked and the stem shows division into six or more candelabra-like arms.

The subterranean part of the caudex also tends to branch and consequently one often sees stems close together which appear to be separate individuals but which are, in fact, bound together by a common base.

The greater part of the bulk of these stems is formed by the persistent leaf bases which overlie each other in closely compacted rings. They thus indicate the growth of many years. The outer surface of the stem is almost always blackened due to bush fires which have at some time passed over it.

The caudex is crowned by a variable but usually large number of fresh, green leaves. The number of leaves is apparently determined by environmental conditions. The shape of the leafy crown also varies considerably. It ranges from an almost spherical mass in strongly developed examples, to a modest funnel-shaped group of leaves sitting on the summit of the caudex in others. A striking character of the leaf is its highly brittle nature.

A flower spike 1 - 2 m high appears in the second half of the rainy season and bears ripe fruit in summer. The spike often remains on the caudex for some time, often still crowning the peculiarly built plant when the next year's spike is growing. In consequence, the fully grown Blackboy is rarely without the strange ornament of its inflorescence. This first bears white flowers, then becomes brown during the period of seed ripening, and finally appears black and dead.

Our knowledge of the distribution of *Xantorrhoea Preissii* is, unfortunately, as yet not complete. We know that it is present from the south coast region of *Eucalyptus diversicolor* to the Swan River region where *Eucalyptus marginata* is present. A very similar type is also known to extend far to the east, beyond the area of these trees, and is to be found on the sandy heaths of the Avon district. This inland form is, however, distinct from the other in many ways, as pointed out by Drummond. Its leaf is very delicate and more blue-green in colour, while the spike is usually much shorter. Whether other specific differences exist is not yet known and more detailed investigations of the different species are needed.

Grass-trees were also observed by Spencer Moore in sandy areas in the Eremaea at Yilgarn, and Giles mentioned their occurrence at Queen Victoria Springs. Members of the Elder Expedition also noted them at Camp 55 in the Victoria Desert, where they still possessed stems of about 5 m in height. There are no further references available in the literature but I might also add that to the north of Esperance Bay a species of *Xantorrhoea* grows on the sandy bush heath. I do not know to what extent the genus occurs in the

Baumartige Liliaceen West-Australiens:

Xantorrhoea Preissii Endl. (links) und *Kingia australis* R. Br. (rechts). Außerdem von *Xylomelum occidentale* R. Br. ein kümmerliches Exemplar (linker Rand), und *Banksia grandis* R. Br. (zwischen den beiden Kingia).
Distr. Darling, Serpentine. — E. Pritzel phot. Dezember 1900.

north. The overall area of distribution may therefore be considered as covering the total area of the south-west (excluding, perhaps, the northern portion), but with considerable expansion into the southern part of the Eremaea.

Xantorrhoea Preissii is very versatile and grows on a variety of soils. It is more or less similar in this respect to *Macrozamia,* with which it is often found associated. A matter of special interest is its occurrence on the swampy soils of the south-west coastal plains from Geographe Bay northwards. In this region, alongside the railway line between Perth and Bunbury, for example, one may see most luxuriant thickets of Blackboy.

The second species of *Xantorrhoea,* which is present in the south-west, is called *X. gracilis* Endl. So far as I am aware this is always a 'stemless' species, that is to say, it shows nothing of the stem above the ground. Its leafy crown is very similar to that of *X. Preissii.* From the centre of the crown of leaves, rise the flowering spike which may be up to 2 m long. This is the only sister species of the south-west Grass-tree which is of interest. Physiognomically it is not nearly as striking and is much less important. It is commonly found in the region of the Jarrah forest and occurs almost without exception on the ironstone gravel [laterite] in thickly wooded regions. Whether it occurs in the district to the other side of the 80 cm. isohyet is as yet unknown. I should not, however, expect to find it there.

Next to *X. Preissii,* the most important Grass-tree of the south-west is *Kingia australis* R. Br. The general structure of the vegetative parts agrees on the whole with that of *X. Preissii,* and in the vegetative condition the appearance of *K. australis* is not very different from the Blackboy. It is, however, much taller than the latter, and specimens 5 m or more in height are fairly common in favourable areas. I have no doubt that specimens up to 10 m in height may be found as stated by Drummond. The greater the height attained by these Grass-trees, the greater the disproportion between the stem and the leafy crown appears. This is due to the fact that the crown always remains the same size. It does not become correspondingly larger as the stems grow taller. Branching at the base of the stem also occurs in this Grass-tree.

Branching above the surface of the ground, however, is very much rarer than in *Xanthorrhoea.* The leaf, whose extremely peculiar internal structure has been described by Tschirch[1], is externally very different from that of *Xantorrhoea.* When its photosynthetic function is over and it dies, it is displaced downwards by the new growth so that a grey collar of old leaves surrounds the apex of the stem below the living leaves. The old leaves remain on the stem in this condition longer than they do on *Xantorrhoea* and the resulting appearance is a feature of the plant.

The inflorescence, together with important differences in the finer details of the structure of the flower (Fig. 10), constitute the most important and characteristic features of *Kingia.* A number of flower stalks arise in a close, apparently whorl-like series. They remain much shorter than the leaves and each carries a club-shaped inflorescence. The general appearance of the whole is clearly shown on Plate VIII.

The habitat conditions for this plant are very similar to those of the other Grass-tree genus. *Xantorrhoea Preissii* is frequently found closely associated with *Kingia* (see Plate VIII). This is due, in the first place, to the similarity of the edaphic conditions which are favourable to both genera. *Kingia,* however, is more restricted by climate than *X. Preissii* or *Macrozamia Fraseri.* It does not grow below the 60 cm isohyet and consequently the plant is confined to the south-west corner of the State. On the west coast it extends northwards only as far as where the Jarrah forest ends. On the south coast, however, in districts further to the east between the coast and the Stirling Ranges, *Kingia* grows on open bush-heaths and plays an important physiognomic role in the landscape. At the same time in these exposed regions it undergoes a slight morphological modification. In the variant of *K. australis* which grows in the area (*Kingia argentea* Endl.), the silky hair typical of the young leaves is retained by the older ones. As a consequence the crown presents an attractive silvery appearance. It presents a strange and beautiful picture in

1 A. Tschirch, Der anatomische Bau des Blattes von Kingia australis R.Br. In "Abhandl. Bot. Vereins Prov. Brandenburg" XXIII (1881).

Dasypogon Hookeri Drumm., der seltenste der westaustralischen Grasbäume.

Der Wald besteht aus *Casuarina Fraseriana* Miq. (links), *Eucalyptus marginata* Sm. und *Banksia grandis* R. Br. (rechts oben).

Distr. Warren, südlich vom Vasse River. — E. Pritzel phot. Dezember 1901.

the wind and sun.

The last of the Western Australian Grass-trees to be described is the genus *Dasypogon.* The more common species is *D. Hookeri* Drumm, (see Plate VIII) [*sic* Plate IX]. Generally speaking, this species is much less physiognomically important than those already discussed because of its restricted distribution. In this alone, however, lies an important clue for the proper understanding of many ecological peculiarities of the district.

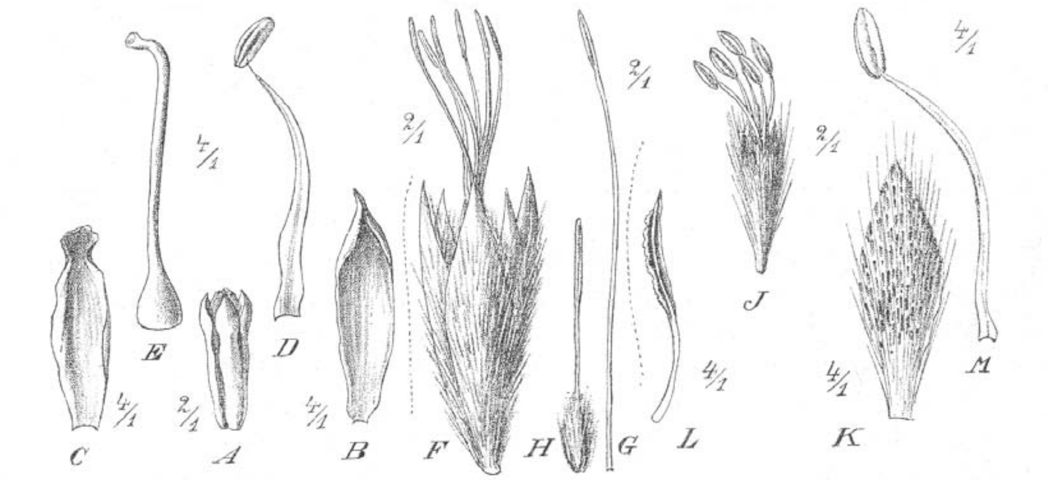


Fig. 10. *A—E Xantorrhoea Preissii* Endl. *A* Blüte. *B* Äußeres Blütenhüllblatt. *C* Inneres Blütenhüllblatt. *D* Staubblatt. *E* Gynaeceum. — *F—H Kingia australis* R. Br. *F* Blüte. *G* Staubblatt. *H* Gynaeceum. — *J—M Dasypogon bromeliifolius* R. Br. *J* Blüte. *K* Äußeres Blütenhüllblatt. *L* Inneres Blütenhüllblatt. *M* Staubblatt. (Original.)

D. Hookeri can only be correctly interpreted by comparing it with one of the only other two species of the genus. This is *D. bromeliaefolius* R.Br., a rare element of the true south-west flora, which grows between the Swan River and the south coast. This plant possesses a subterranean rhizome from which arise several perennial shoots which creep like runners over the sandy ground before becoming erect. They grow close to the ground and are more or less thickly covered with the persistent sheaths of early leaves. The living leaves are linear and from 10 to 30 cm long. A spherical inflorescence, which looks like that of a small *Kingia,* terminates the stem. In general, *D. hookeri* is structurally similar to, and appears as a much larger edition of, its sister species. All the vegetative parts seem hypertrophied. The leaf crown reminds one of the Bromeliaceae and the numerous crowded leaves are from 30 to 90 cm long. Old and rather limp leaves persist on the stem for a long time. The actual stem itself is closely covered by the persistent leaf bases and is about 7 cm thick. The total length of the stem is surprising. When undamaged it may be up to 3 m long. The appearance of the plant is very different from *Xantorrhoea* or *Kingia.* In those genera, the stem appears somewhat clumsy because it is too thick for the size of the leaf-crown. In *Dasypogon* the opposite is the case. It is rare to find erect stems - most being markedly curved. It appears as if some inner force is operating to form runners. This tendency is clearly expressed in *D. bromeliifolius.*

D. Hookeri is very restricted in its distribution. It is known best from the lower Blackwood River district where it is present among rather dense *Eucalyptus* communities. It commonly occurs on brown conglomerate [lateritic] soils, while the climate is the most moist and equable in Western Australia. In fact, taking everything into account, one can say that the species is a product of the climate where all extremes are avoided and even the summer dry period is less severe.

Amongst the plants, apart from *Eucalyptus* spp., associated with *D. Hookeri,* the following may be mentioned: *Casuarina Fraseriana, Banksia grandis, Xantorrhoea Preissii, X. gracilis* and *Kingia australis.* Thus in this area we find all three genera and four species of the tree-like Lilaceae of south-west Australia all occurring together.

CHAPTER 3 THE CHARACTERISTIC FAMILIES AND THEIR LIFEFORMS

1. Proteaceae.
2. Myrtaceae.
3. Podalyrieae- [Leguminosae].
4. *Acacia.*
5. Epacridaceae.
6. Goodeniaceae
7. Cyperaceae.
8. Liliaceae.
9. Stylidiaceae.
10. Orchidaceae.
11 Sterculiaceae.
12. Restionaceae.
13 Rutaceae.
14. Umbelliferae.
15. Conostylideae.
16. *Hibbertia.*
17. *Drosera.*
18. Centrolepidaceae.
19. *Cassytha.*
20. Families also common in the Eremaea.
21 Families which are relatively poorly represented in the Southwest Province.

As well as the previously described types which are important in physiognomic terms, there are certain important families which give characteristic to the vegetation of the Southwest Province. Their members do not resemble one another sufficiently, however, to exert any marked influence of any specific kind on the physiognomy, but they do enrich the floral picture, either by the similarities between individual organs of the plants or by their general appearance.

This influence on the constitution of the total flora is, however, not dependent upon the number of species in any particular family. Nevertheless, the families will be examined in the order determined by the number of species they contain. This appears to be the only way in which we can assess their relative importance.

Only those facts relevant for the phytogeographic study of the area will be presented here. Further detailed information important for the understanding of individual families is contained in Diels and Pritzel "Fragmenta Phytographiae Australiae occidentalis" (Englers Bot. Jahrb. XXXV 55-662).

1. Proteaceae: About 400 species. These are separated into several relatively distinct tribes.

It is an exceedingly important family in the Southwest Province because it has such a large number of representatives. The family owes its premier position not only to the participation of several separate tribes, but also to the variation arising from the high degree of adaptation to the environment characteristic of most of the species in the different genera. The plasticity of the vegetative organs is extraordinary and is not approached by any other family in Australia. One cannot reasonably speak of a 'proteaceous form' as Grisebach has done, because of the difficulty of grouping such a variety of shapes under one type.

In this family the generic complex often falls into a number of mutually exclusive local types whose vegetative characters appear to be an adaptation to the environment. For example, *Petrophila* (Fig. 11), and *Isopogon* are very characteristic of open heaths with gravelly sandy soil. Seen from a distance, the bright purple or yellow masses of flowers suggest that the plants are very gregarious and uniform. Closer inspection, however, shows that the species involved show some degree of variation in their vegetative characters, even over a short distance.

In addition, almost every genus of the Proteaceae has its own physiognomically important species. *Xylomelum* provides the south-west landscapes with an imposing tree (*X. occidentale*), distinguished by its holly-like leaves. This character is also present in other genera of the family, e.g. *Hakea. Persoonia*. Sect. Amblyanthera also includes some small trees of *Acacia*-like appearance. These grow only in the moister parts of the south-west, often under the protective shade of the taller *Eucalyptus* species.

I On conglomerate [lateritic] soils where, as already mentioned, well-developed *Eucalyptus* woodlands are present, the number of species in some genera of the family Proteaceae is quite high. *Petrophila* and *Isopogon* develop here in great variety. *Dryandra* also shows great diversity. The most commonly occurring species of this genus is *Dryandra nivea* which often covers a considerable area with its fern-like leaves. The most important genus, however, is *Hakea*[1]. On ironstone gravels [laterite] "this genus shows a rich variety of species. This is all the more remarkable considering how few *Grevillea* species are represented in such areas. The vegetative structures show great diversity

1 Fragm. Austr. occid. p. 426

and a whole series of gradations between entire and complicated divided leaves is encountered. On the Stirling Ranges the strange tall growing species of *Hakea Brownii* and *H. cucullata* overshadow the lower bushes. Again, in the moist woodland of the Karri country, *H. oleifolia* appears. This is present as a tree form which rivals *Banksia* in size. *H. ampexicaulis*, with its large and very spiny leaves, is found occurring throughout the entire Jarrah zone from King George Sound to the Swan River. *H. ruscifolia* is also present there. Its white flowers are abundant in the height of summer when the bush is otherwise more or less drab and colourless. Another species, *H. lissocarpha* is perhaps even more common in the hills. In contrast with *H. ruscifolia*, its leaves are finely divided and its delicate inflorescences open up in the winter rainy season."

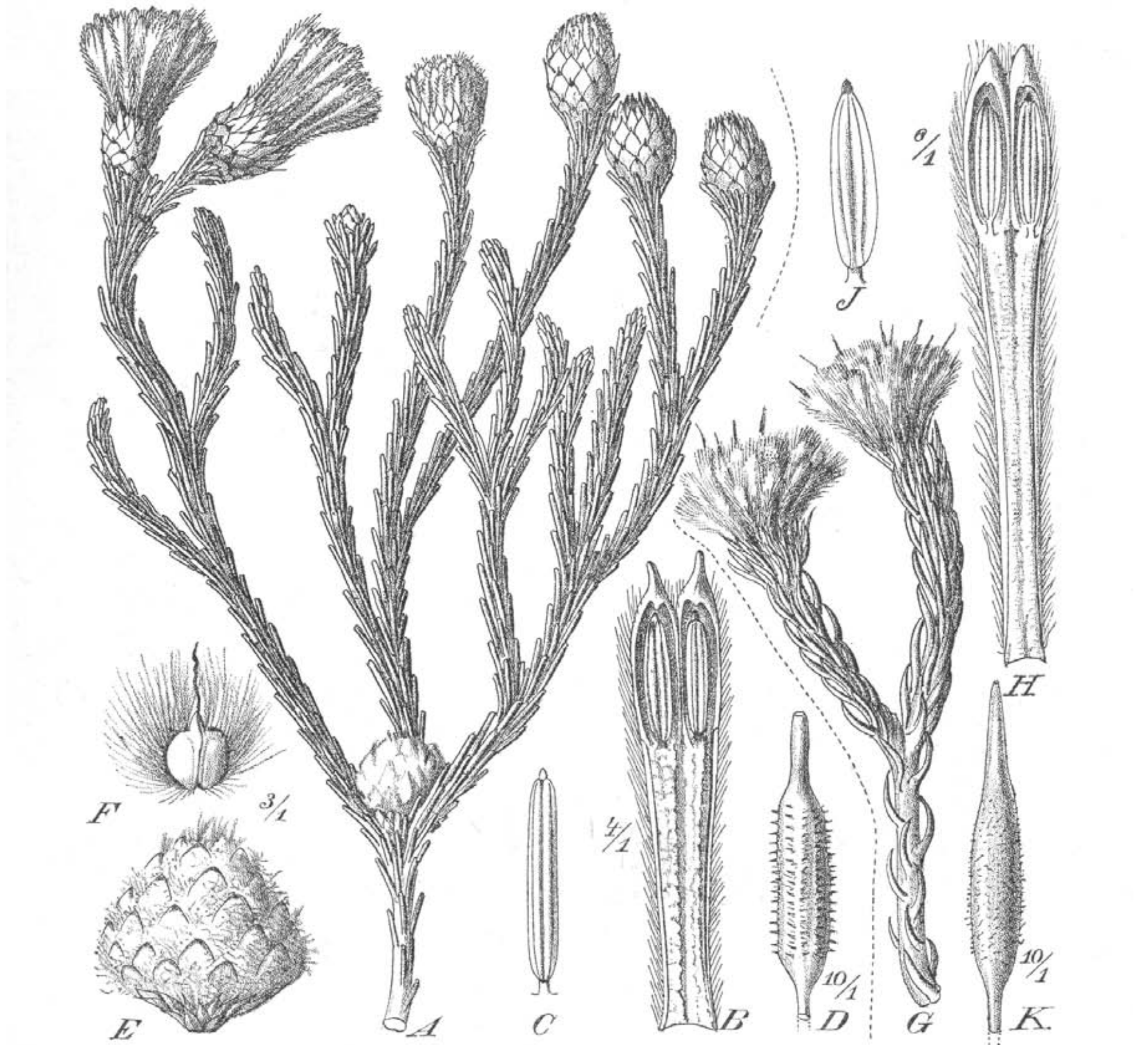


Fig. 11. *A—F Petrophila ericifolia* B. Br.: *A* Vorderer Teil eines blühenden Zweiges. *B* Blüte durchschnitten. *C* Staubblatt. *D* Narbe. *E* Zapfen. *F* Junge Frucht. — *G—K Petrophila scabriuscula* Meissn.: *G* Blühender Zweig. *H* Blüte durchschnitten. *J* Staubgefäß. *K* Narbe. (Nach Diels und Pritzel.)

Members of the Proteaceae occur much less commonly on water-retentive soils, i.e., clayey or loamy subsoils. Here, particularly on the banks of streams, one may find a few willow-like grevilleas with slender branches and somewhat delicate leaves, e.g. *G. diversifolia.*

Many members of the Proteaceae appear to thrive on sandy soils and particularly so where no trees are present in the plant associations. Gregarious types of shrub-like species are particularly common in such spots, e.g., the ericoid-leaved *Petrophila ericifolia*

(Fig. 11), *Grevillea pilulifera* and the unusual and diverse types of Flannel flowers belonging to the genus *Conospermum*. These are most effective physiognomically because of their white woolly inflorescences (Plate XXI). Two other proteaceous species which are present towards the south-east, namely *Adenanthos cuneatus* and *Isopogon trilobus* with their peculiar broad fan-like leaves, must also be included here. Associated with them we find the impressive *Lambertia inermis* which can reach a height of 3 m. In the south-east this shrub is a typical indicator of sand-heath country. The hard-leaved *Dryandra* species may also be observed in similar places. Among the *Hakeas*, the terete-leaved species predominate (extremely rigid growths with well-developed sclerenchymatous tissue) (see Fig. 42).

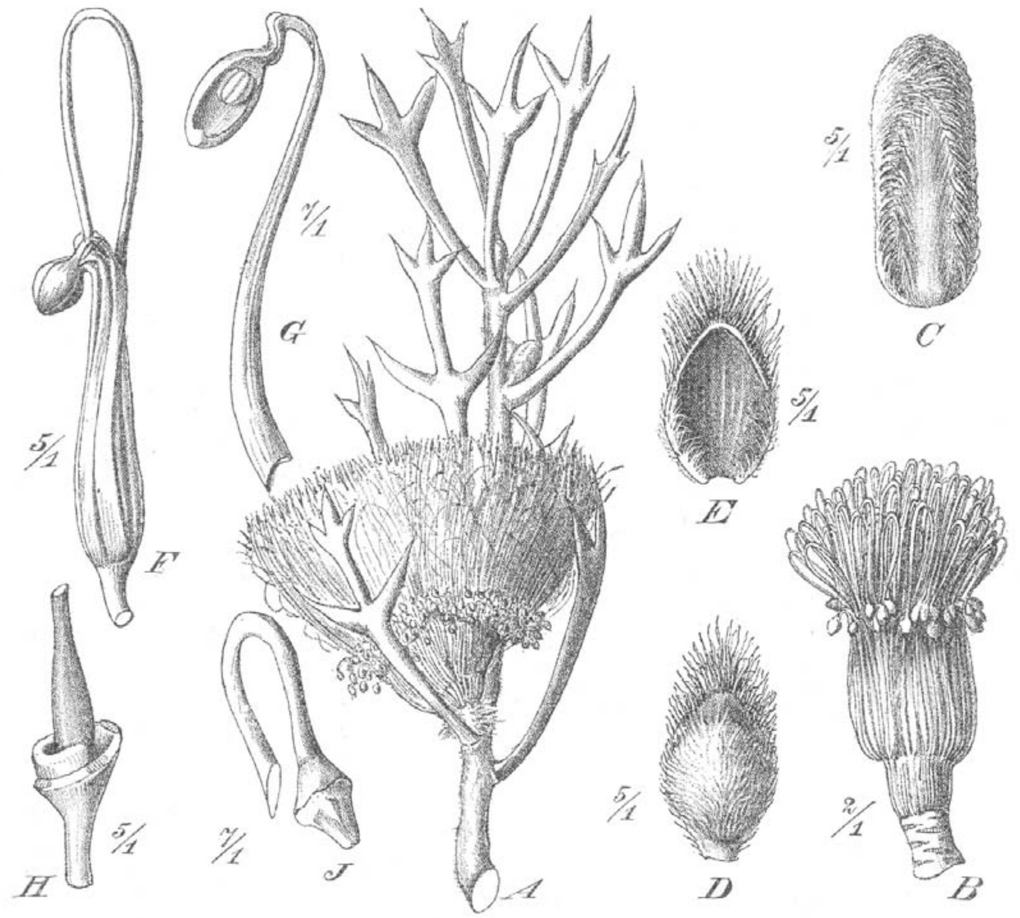


Fig. 12. *Hakea dolichostyla* Diels: *A* Blühender Zweig. *B* Blütenkopf. *C* Knospe. *D*, *E* Schuppen. *F* Blüte. *G* Blütenhüllblatt. *H* Discus und Ovarium. *J* Oberer Teil des Griffels. (Nach Diels und Pritzel.)

Among these psammophytes a small group of morphologically variable, fine-leaved species of *Adenanthos* occur, e.g. *A. sericeus* and *A. cygnorum*. These are somewhat Cypress-like in appearance and in favourable habitats grow to a height of 4 - 5 metres. Their sombre forms are present on the coast, often extending out to the inner dune area. No other member of the Proteaceae is able to colonize such areas to the same extent.

The greatest number of species of Proteaceae found in the Southwest Province occurs in an area running from the coast inland to the 40 cm isohyet. As we go further inland, the number of species rapidly diminishes until they are no longer of any physiognomic importance.

2. Myrtaceae: About 370 species.

A rough estimate of the number of Myrtaceous species in south-west Australia indicates that the family Myrtaceae ranks close behind the Proteaceae in the hierarchy of important families. The only other family whose variety of form approaches that of these two families is the Leguminosae. A comparison of the nature of these three undisputed leading families of the region shows, however, that there are many differences, particularly between the Proteaceae and the Myrtaceae. In the Myrtaceae, the variability of the flowers is an important factor in producing diversity of form. There are also some adaptational vegetative modifications but the leaves of genera in the Myrtaceae do not show anything like the degree of variation shown by *Grevillea* and *Hakea.* The fundamental character of the adaptation to the environment is different in the two groups. In the Myrtaceae the leaves are much more delicate and there is much less sclerenchyma present than in the rigid leaves characteristic of most members of the western Proteaceae.

Fig. 13. *Melaleuca Preissiana* Schau. in Blüte.
Distr. Darling, Bayswater östlich von Perth. —
E. Pritzel phot. Dezember 1900.

If the types of adaptation in the 370 species of Myrtaceae investigated, it will be found that the simple leaf with entire margins is the most common. It is also usually longer than broad. Only a few species of *Verticordia, Scholtzia* and *Hypocalymma* possess leaves which show a tendency towards the terete form. Reduction in leaf size is often noted and may be considerable. Quite a large number of species of the gregarious genera of the Myrtaceae possess such reduced structures, e.g. *Astartea,* together with some species of *Melaleuca* and *Leptospermum.* Much-branched shrubs, thickly covered with erect, quite small leaves, may also be observed. Further reduction results in the 'rolled' or ericoid form of leaf found in a still greater number of members of the family. Almost all the genera in the family would have to be mentioned if one wished to include all those containing ericoid-leaved species in Western Australia. It will suffice to mention *Verticordia, Darwinia, Calythrix, Lhotzkya* and *Beaufortia.* These are particularly rich in shrubs possessing a heath-like habit.

Generally speaking, members of the family Myrtaceae, such as the genus *Eucalyptus,* show a striking variability in height and stem thickness. In several other groups we have species which, under favourable conditions, attain tree-like dimensions while retaining their shrub-like habit elsewhere. Good examples include the coastal species *Chamaelaucium uncinatum* and *Agonis juniperina* (this latter species is usually seen only in the bushy condition and grows 5 - 8 m high in swampy low-lying areas along the south coast.) The related species, *A. flexuosa,* usually appears in tree form, or perhaps more correctly, as a giant arborescent shrub. With its unusual weeping willow-like habit, it is an important constituent of communities along stretches of the south-west coast. Perhaps of more importance because of the frequency of their occurrence are the tree-like species of *Melaleuca.* Among these *M. cardiophylla* and *M. Huegelii* are coastal plants and consequently their range is more restricted. Much more widespread and of greater importance physiognomically are the species growing in the wet alluvial areas. Here *M. viminea, M. rhaphiophylla* and *M. Preissiana* influence the scenery by virtue of their large number, close association and striking appearance. "*Melaleuca Preissiana* (Fig.13, 56), in particular, because of its whitish papery bark and unusual knotty branches, catches the eye. it is all the more important because it is the characteristic plant of the *Melaleuca* swamps of the south-west, being the dominant tree in the communities there"[1].

The presence of the more important species of *Melaleuca* and *Eucalyptus* in the flora of the moist alluvial country indicates an ecological difference between the Myrtaceae and the Proteaceae. Closer inspection of the communities (see later) reveals a big difference between the two families in this respect. The Myrtaceae are nowhere so important and those of the family Proteaceae nowhere so unimportant as on such marshy country. In addition, however, the dryest and most barren sand areas have their own characteristic Myrtaceous flora. This indicates that the ecological adaptability of this family is greater than that of the Proteaceae. This ecological adaptability offsets to some extent the apparent disadvantages the Myrtaceae suffers because of the lack of variability in its leaves.

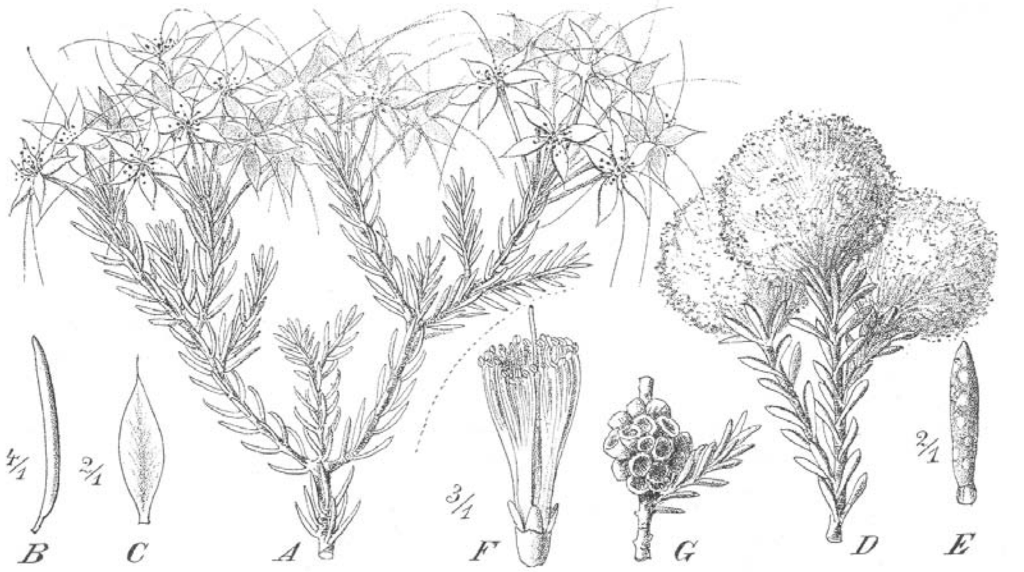


Fig. 14. Myrtaceae der Südwest-Provinz: *A—C Calythrix flavescens* A. Cunn.: *A* Habitus eines Blütenzweiges. *B* Blatt. *C* Blumenblatt. — *D—G Melaleuca seriata* Lindl.: *D* Blütenzweiglein. *E* Blatt. *F* Blüte. *G* Fruchtstand. (Original.)

The number of species of the Western Australian Myrtaceae that may be regarded as being more or less hydrophytic in nature is not very large. They are, however, extraordinarily gregarious in occurrence. Species such as *Astartea fascicularis* (Fig. 56) and *Agonis parviceps*, which cover the low swamp lands of the south-west, represent typical community-forming species of the flora.

On gravel and conglomerate [lateritic] soils, hydrophytes are much less abundant. The shrubby members of the Myrtaceae play a much less important part here than either the Proteaceae or the Leguminosae. Some species of *Darwinia, Baeckea camphorosmae, Agonis, Beaufortia* and *Calothamnus* are the main types which represent the family.

On sandy soil a new development takes place. Here the dense, usually bright-red or yellow flower-heads of *Melaleuca* (Fig. 14, Plate XVII), *Beaufortia, Eremaea* and *Petrophila*-like species of the Proteaceae dominate the undergrowth. Members of the tribe Chamaelaucieae, which include *Darwinia, Calythrix* and *Verticordia*, are, however, much more important. With their small ericoid leaves, they occur scattered in the heath. However, when their flowers open they become most conspicuous, surpassing all other plants, with their bright colours. There is practically no 'sand plain' in the whole of the

1 Diels and Pritzel, Fragm. Austr. occid. p. 426

south-west where one cannot see the snow-white or golden-yellow patches or rose-red crests of *Verticordia* (Fig. 15). Species of *Calythrix* (Fig. 14) with their startling yellow or bright-violet flowers also attract attention from a distance.

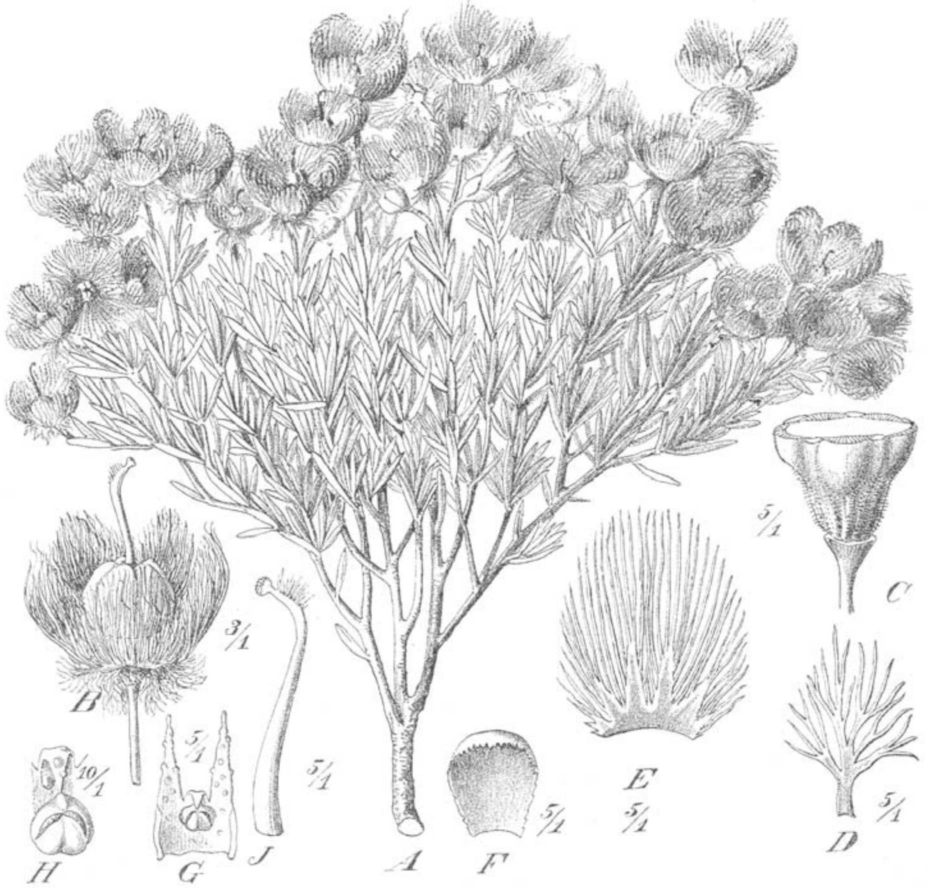


Fig. 15. *Verticordia Pritzelii* Diels: *A* Habitus. *B* Blüte. *C* Kelchröhre. *E* Kelchabschnitt erster Ordnung. *D* Kelchanhängsel. *F* Blumenblatt. *G* Staubblatt und Staminodien. *H* Staubblatt. *J* Griffel. (Nach DIELS und PRITZEL.)

The further one penetrates inland from the boundaries of the south-west, the smaller the absolute number of members of the Myrtaceae present becomes. The reduction, however, is much less marked than is the case with the Proteaceae. At Mount Churchman, for instance, beautiful *Verticordia* spp. still occur and, even at Coolgardie, *Calythrix* is present. Less conspicuous genera, e.g. *Baeckea, Micromyrtus*, etc. also show no obvious reduction in their ability to colonize most parts of the Eremaea.

3. Leguminosae - Podalyrieae: About 270 species.

The degree of adaptation characteristic of the tribe Podalyrieae is in many respects intermediate between the mean for the Proteaceous and Myrtaceous types. The conditions needed for survival by this group suggest on the whole a better agreement with the Proteaceae. The plasticity of the vegetative organs, while not equal to that of the Proteaceae, does at least approach it. A detailed discussion of the relationships concerned has been given by E. Pritzel (in Diels and Pritzel Fragm. Austr. occid. p. 215 on.). The following extract is helpful in enabling one to form an opinion regarding the physiognomic importance of this group.

"Almost all members of the Podalyrieae are shrubby growths. As compared with *Acacia, Myrtaceae,* etc., however, only a few such as *Jacksonia Sternbergiana, J. furcellata* and *Oxylobium Callistachys* form tall shrubs or small trees. There are no annuals, although in some species the above-ground parts are in effect practically annual, e.g. *Sphaerolobium* Sect., Roea, and some species of *Gompholobium* and *Isotropis.* All the members of the group show some degree of xeromorphism. This is expressed particularly by reduction in leaf area. The pinnate leaf, normally so characteristic of the Leguminosae, is present only in species of *Gompholobium* and *Burtonia.* The commonly occurring simple leaf (Fig. 16, 17) is in many cases, although not all, a reduced pinnate leaf. Evidence of this is provided by the small stalk which is frequently present between the leaf and the end of the petiole. On the other hand, where no reduction of the leaf area has taken place, the xeromorphic character is indicated by (a) the strong development of sclerenchyma, and (b) the very firm, almost woody, consistency of the leaf. The presence of sharp spines at its tip or on the margins is a further indication. Such large hard leaves are frequently present in the genera *Oxylobium* and *Gastrolobium.* At the same time, these relatively large leaves appear small by comparison with those of trees of tropical rain-forests or even of *Eucalyptus* species.

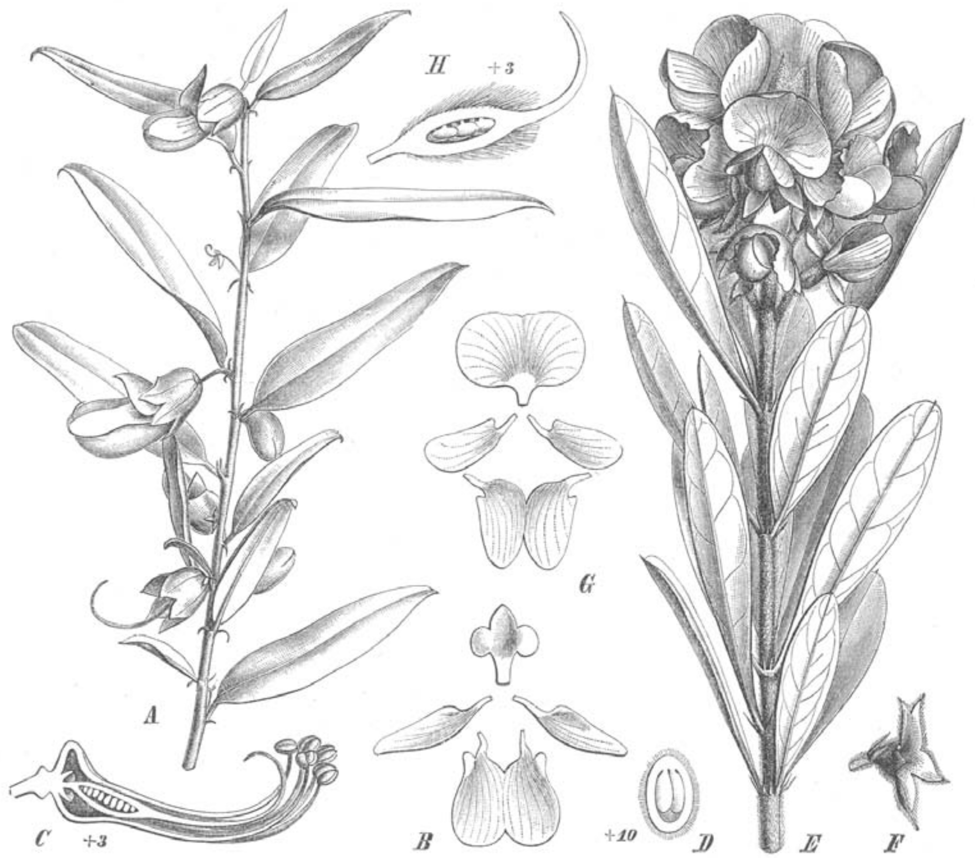


Fig. 16. *Podalyrieae* der Südwest-Provinz: *A* Zweig von *Brachysema undulatum* Ker: *B* Blütenblatt. *C* Längsschnitt durch den Fruchtknoten nebst Staubblatt. *D* Samen im Querschnitt. — *E* Zweig von *Oxylobium retusum* R. Br.: *F* Kelch. *G* Blütenblätter. *H* Längsschnitt durch den Fruchtknoten. (Nach TAUBERT.)

In other genera, reduction of the leaf surface is carried still further, resulting in the following types (Fig. 17):

1. Small firm broad leaves, e.g., many species of *Oxylobium* and *Gastrolobium. Gompholobium marginatum* and *Pultenaea obcordata,* provide further good examples.
2. Large needle-like leaves with incurved margins, e.g. *Eutaxia myrtifolus, Daviesia Croniniana,* and *Chorizema Henchmannii.*
3. Very small, narrow, thick leaves. This is the ericoid shape typical of the genera *Pultenaea, Dillwynia, Eutaxia* and *Aotus* and many species of *Gompholobium*

and *Burtonia,* among others.

4. Leaves with practically no lamina but often with the mid-rib expanded dorsiventrally. Examples are frequently present in the genus *Daviesia.*
5. Rounded, often somewhat long leaves, e.g. species of *Daviesia.*
6. Leaves absent (aphylly); characteristic of the genera *Jacksonia* and *Sphaerolobium.* This condition is also found in species of *Daviesia,* Brachysema and *Isotropis.* From the nature of the stalk, one can also distinguish rush-like, round or flat-stalked species."

This account leads one to expect many parallels with the Proteaceae. In fact, particularly in the case of vegetative organs, this is so. Surprisingly analogous forms occur between *Isopogon* and *Daviesia, Grevillea* and *Chorizema, Daviesia* and others.

Fig. 17. *A—C Oxylobium parviflorum* Benth.: *A* Habitus. *B* Kelch. *C* Gynäceum im Längsschnitt. — *D Oxylobium melinocaule* E. Pritzel Habitus. — *E Oxylobium tetragonophyllum* E. Pritzel Habitus. (Nach Diels und Pritzel.)

As pointed out by Pritzel, the Leguminosae possess much the same ability, although to a more limited extent, to produce tall growths, as do the Proteaceae and Myrtaceae. In the genus *Jacksonia,* however, many large shrubs are present. These have a somewhat strange appearance because of their stiff, flattened branches. *Jacksonia sternbergiana* and *J. furcellata,* even develop a distinct trunk. Their crowns appear unusual since they consist of numerous pendent leafless branches covered with grey silky hair. On marshy or swampy ground we find the graceful "tall shrub" *Viminaria denudata* which is comparable with many species of *Cytisus.* Finally, in the genus *Oxylobium,* we may mention two somewhat willow-like species which also occur on moist or at times waterlogged soil. These are *0. lineare* and *0. Callistachys* which form impressive communities at King George Sound.

These few above-named species comprise practically all the tall-growing forms. The rest of the vegetation is a chaotic mixture of low shrubs and bushes. Only a few of these are worthy of note because of their bright flowers or unusual leaf form. Amongst these plants hydrophytes are rare. They tend to crowd on gravelly soils with adquate moisture or on sandy soils. In some places they develop an extraordinary variety of forms which are concentrated in a small area. They play a very important part in the composition of the undergrowth of the woodlands. It is only rarely that they have any striking effect on the physiognomy. In these situations one finds species of *Brachysema, Daviesia, Oxylobium* (Fig. 17), *Gastrolobium, Gompholobium* and *Chorizema.* They are often stunted due to shade and local moisture conditions, but frequently occur together or in mixed communities. In the dry woodlands of the gravelly higher land, we find a particularly large number of *Gastrolobium* species. These are the feared poison plants of the district. From here, they extend through the treeless shrubby areas further inland. The sandplains possess still other species, all of which show a high degree of xeromorphy. These include species of *Daviesia* and *Jacksonia* which appear so stiff and rigid that they give the impression of being formed of metal. Prickly aphyllous species of *Daviesia,* thorny species of *Mirbelia,* ericoid-leaved species of *Phyllota* and *Brachysema* all occur here. Their whole growth form consists of whitish-grey, curiously branched stem axes without any trace of leaves. As in the Proteaceae, we get the impression of the most extreme xeromorphism possible. We may finally note that members of the Podalyrieae are largely confined to the Southwest Province, and that only a few species extend beyond this region into the sandy wastes of the Eremaea. Those that do manage to survive there appear depauperate.

4. Acacia: About 130 species. (Fig. 19 [sic. Fig 18])

The most reliable approach to the understanding of the Western Australian species of *Acacia* is provided by Pritzel (in Diels and Pritzel Fragm. Austr. occid. p. 276 on). There the adaptations present in the genus in Western Australia are treated in detail, while the differences between the two groups Bipinnatae and Phyllodineae are clearly set out.

The group Bipinnatae (in the moister parts of the area) contains some species which, because of their delicate leaves, represent the true “leguminous form”. Unfortunately there are very few such species in Western Australia. In the most favorable places there are quite imposing shrubs of this type (*A. nigricans, A. pentadenia*) with which the ecologically similar *Albizzia lophantha* act as substitutes, although poor ones, for the Bipinnatae of Eastern Australia where tree-like growths have been developed. The remaining Bipinnatae of the west remain of lower stature but are of varied heights. The most striking example of this adaptive height graduation is met within the polymorphic series *Acacia pulchella*, which by reason of its wide distribution and frequent presence counts as one or the most important types of the south west. As. a matter of fact this species exhibits a very wide range of forms; stately bushes with polyhedral leaves and poorly developed spines in the damp south west, and low dwarf shrubs with ericoid foliage, felt like integument or strongly developed stipular spines, on the sand heaths of the drier regions, being the extreme types developed.

Incomparably richer and more diverse in form are the Phyllodineae. “There are few genera in the vegetable kingdom which can approach the genus *Acacia* so far as the richness and curiosity of leaf form is concerned.” This remark of Pritzel applies in particular to the Phyllodineae of the south west. Pritzel has also clearly indicated the importance of the adaptations in this feature. The presence of hair, the secretion of resin or wax, and the assumption of succulence, is only to be found in a few species: on the other hand the development of sclelrotic tissue and the reduction of: the transpiration surface are xerophytic characters which are widespread. Needle-like small rhomoic or triangular, ericoid, juncoid, ulex-like phyllodes, and leafless forms result and occur in that confusing richness of form which is presented to us. A comparative study with reference to their relationships leads to an instructive insight into the complicated correlation of these structures, one can see how coast species become xerophytic towards the interior and vice versa (see Pritzel *loc. cit.* p. 283).

The acacias are not uniformly distributed in the south-west . The moist regions possess chiefly the Bipinnatae but several Phyllodineae which in other respects must be considered in part as real Eremaean elements, occur in the coastal formations. Otherwise, the Phyllodineae are far in the background. Notwithstanding this however, a few species are widespread such as the scented *Acacia myrtifolia* which forms bushes not far from the south coast, and the species of *Acacia alata* which with its winged stems and pale coloured inflorescence, is a striking feature of the valleys in the hills.

In the drier parts of the woodland area and still more beyond its boundaries the importance of the Acacias increases rapidly. Most or the species are of low stature - heights above 0.5 - 1 m being rare. Like the Podalyrieae they are at home on the gravel and sandy soils and usually many species of different forms grow together, thus failing, to produce any uniform physiognomic effect. As a consequence we find members of the important groups Pungentes and Triangulares showing a predilection for communal growth, groups which favour the zone or moderate dryness which runs north east from the margin of the plateau. Nevertheless there are cases where a single species dominate even produces small single species stands. These species may not be clearly distinguished during many months of the year except by their uniformity contrasting with the tangle of the mixed vegetation. They stand out from afar however, when the flowers unfold. Then whole areas appear as if dipped in deep yellow and for the first time one recognizes that there are also landscapes in south-west Australia where *Acacia* blossom is an indication of the arrival or spring just as in the districts of south east Australia, where its praises have so often been sung.

5. **Epacridaceae:** About 160 species.

The statement has often been made that the sub-family Ericoideae is represented by the family Epacridaceae in Australia, and that the part the latter family plays corresponds to that of the Ericaceae in South Africa. The two groups do present many points of agreement due no doubt to a striking resemblance in their nature. Their geographically limited range and their restriction to somewhat dry, although not too dry, areas are important signs of this resemblance. Again, just as the family Ericaceae is absent from the Karroo plains of South Africa, so the Epacridaceae is practically missing from the Eremaea. Only 2 out of 160 species occur there. The family may thus be regarded as being more exclusively south-western than is the Proteaceae. The distribution of the species suggests that in general they thrive in a temperate climate with a rainfall of over 60 cm. The number of species adapted to more extreme climatic situations is very small.

The Epacridaceae, like the acacias of the south-west, are all shrubs. Most of them are low in stature, rarely being more than 1 m high. Their vegetative form is characterized by the narrow leathery type of leaf which is frequently needle-like or scale-like. Sclerenchymatous tissue is well developed. They possess many features which resemble those of the Myrtaceae. In terms of physiognomy, however, the family is much less important than the three previously mentioned families. Individual species like *Leucopogon Richei* and *L. australis,* found in the coastal woodlands, or the relatively large-leaved *L. verticillatus,* growing in the moist Jarrah forests, are prominent and undoubtedly are of great importance in characterizing these communities.

The majority of the species, however, are lost in the confused mass of so many similar-appearing neighbours in the bush. This is at least the case in the greater part of the south-west. However, the conditions are rather more favourable in the south-east part of the State, where a strong and in fact unparalleled concentration of epacrids occurs. The area involved lies between the Stirling Range and the south coast, extending as far east as Cape Arid. “Epacrids here play a big part in the composition of the lower shrub flora on the granitic coastal hills, on the sandy or clay swamp areas and on the extensive sand heaths. Masses of delicately structured dwarf shrubs (species of *Leucopogon, Andersonia* and *Oligarrhena , Needhamia*) cover the barren sandy ground. This is particularly true of swampy areas where bare patches of soil occur between bushy members of Myrtaceae and Proteaceae. Even though they are of little or no importance in the physiognomy of the vegetation, at least in the rainy season they add very considerably to the colour pattern of the landscape”[1].

1 Diels and Pritzel, Fragm. Austr. occid. p. 459

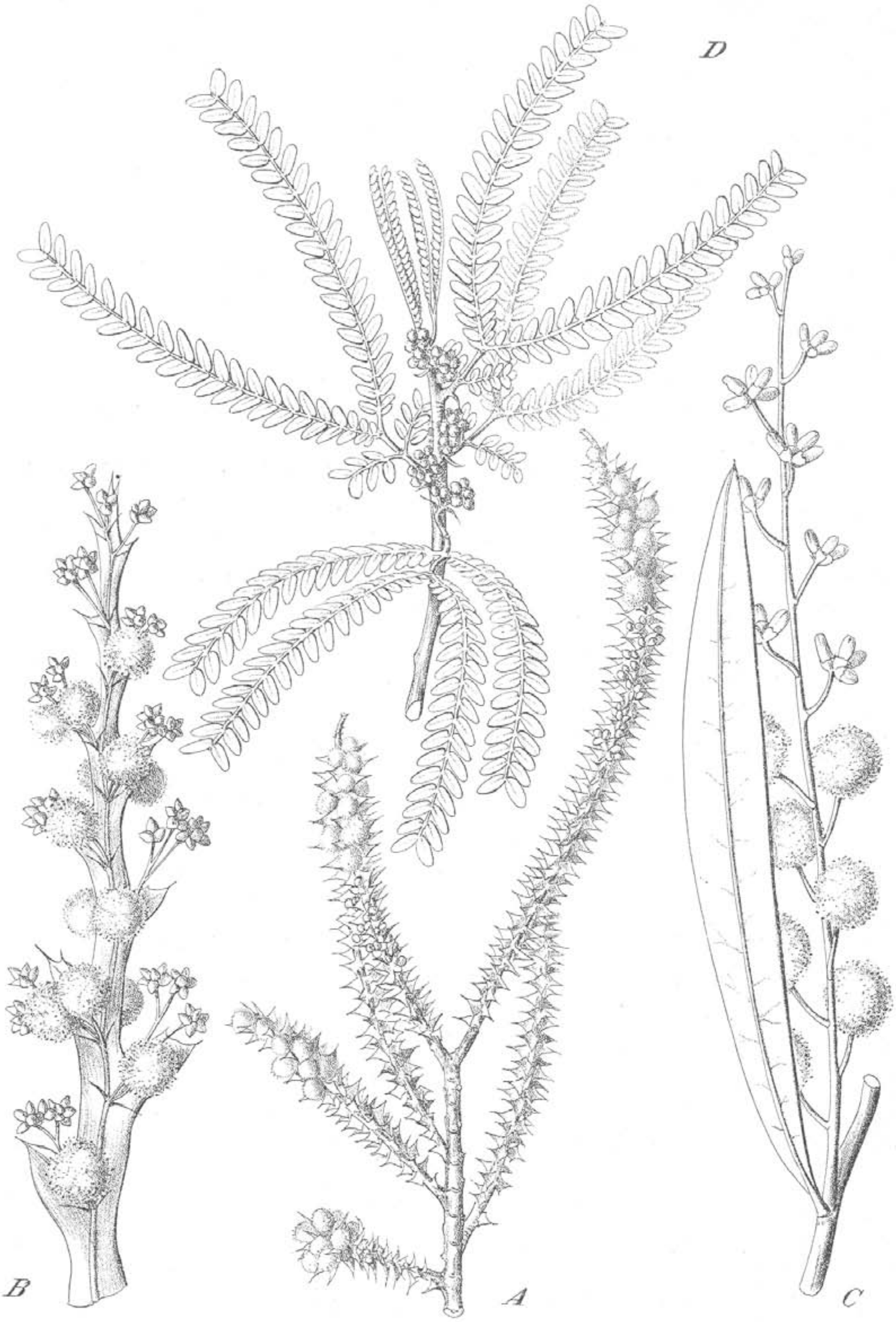


Fig. 18. *Acacia*-Typen der Südwest-Provinz: *A Acacia hastulata* Sm. *B Acacia alata* R. Br. *C Acacia myrtifolia* Willd. var. *angustifolia* Willd. *D Acacia pentadenia* Lindl. (Original.)

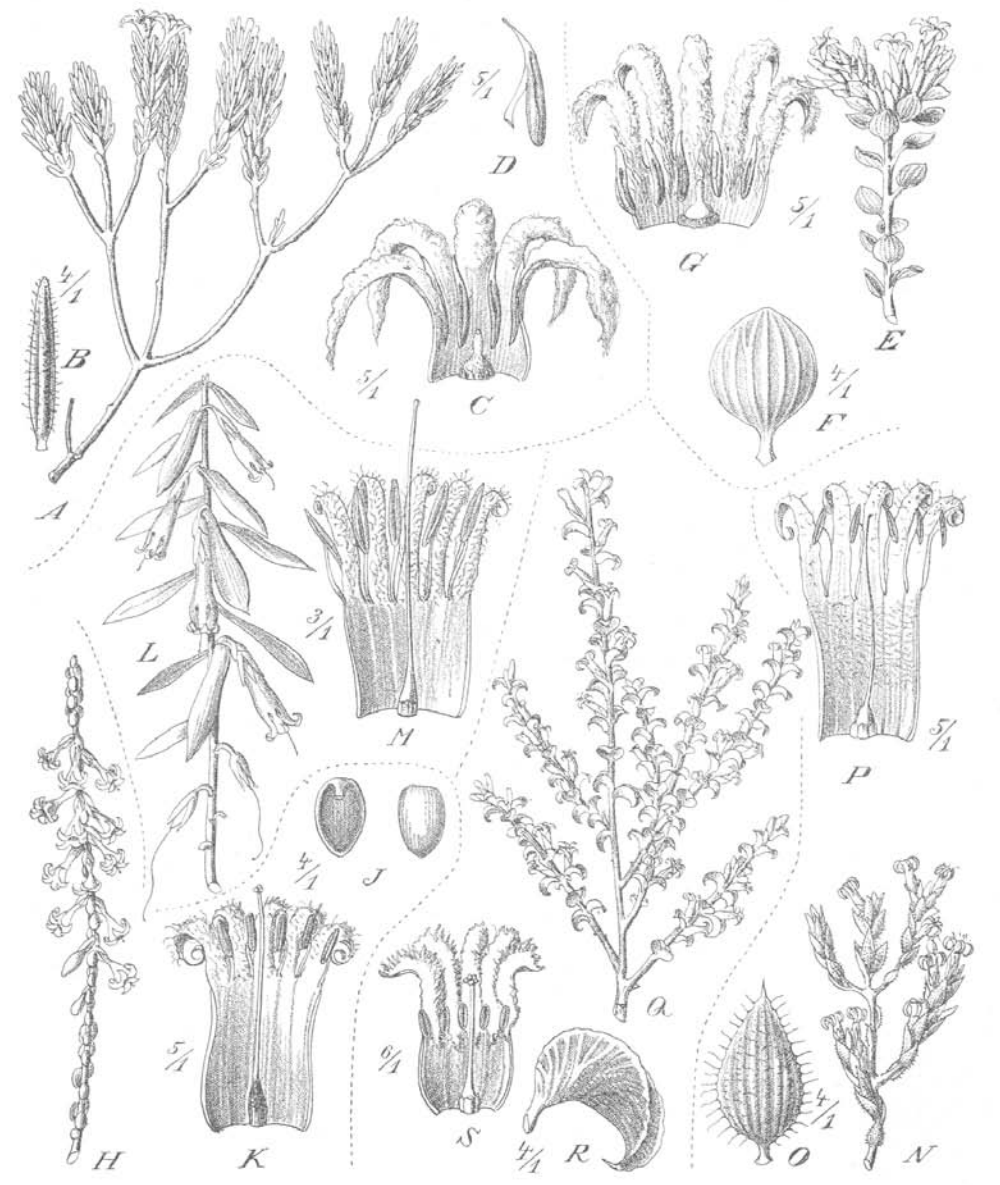


Fig. 19. *Leucopogon*-Arten der Südwest-Provinz. *A—D L. cinereus* E. Pritzel: *A* Ästchen. *B* Blatt. *C* Blüte ausgebreitet. *D* Staubblatt. — *E—G L. psammophilus* E. Pritzel: *E* Zweiglein. *F* Blatt. *G* Blüte ausgebreitet. — *H—K L. Dielsianus* E. Pritzel: *H* Zweiglein. *J* Blatt. *K* Blüte ausgebreitet. — *L, M L. nutans* E. Pritzel: *L* Zweiglein. *M* Blüte ausgebreitet. — *N—P L. hispidus* E. Pritzel: *N* Zweiglein. *O* Blätter. *P* Blüte ausgebreitet. — *Q—S L. hamulosus* E. Pritzel: *Q* Zweiglein. *R* Blatt. *S* Blüte ausgebreitet. (Nach Diels und Pritzel.)

Compared with this well-endowed area of the south-east, the southern Jarrah forests possess only a poor and drab epacrid flora. It is only when we reach the Swan River area in the north that the family is again well represented. In this region it has developed a number of xeromorphic forms. Their foliage feels harsher and more spiny to the touch than that of the south-eastern species. The dwarf type of plant characteristic of the Ericaceae is rare here, its place being taken by thick firm-leaved shrubs belonging to genera such as *Astroloma* and *Conostephium.*

On the whole there is no family which shows more sensitivity amongst the main groups of the Western Australian flora than the *Epacridaceae.* Nor one which is more strongly influenced and moulded by external conditions. These limitations, in fact, make it a most characteristic element of the vegetation of the Southwest Province.

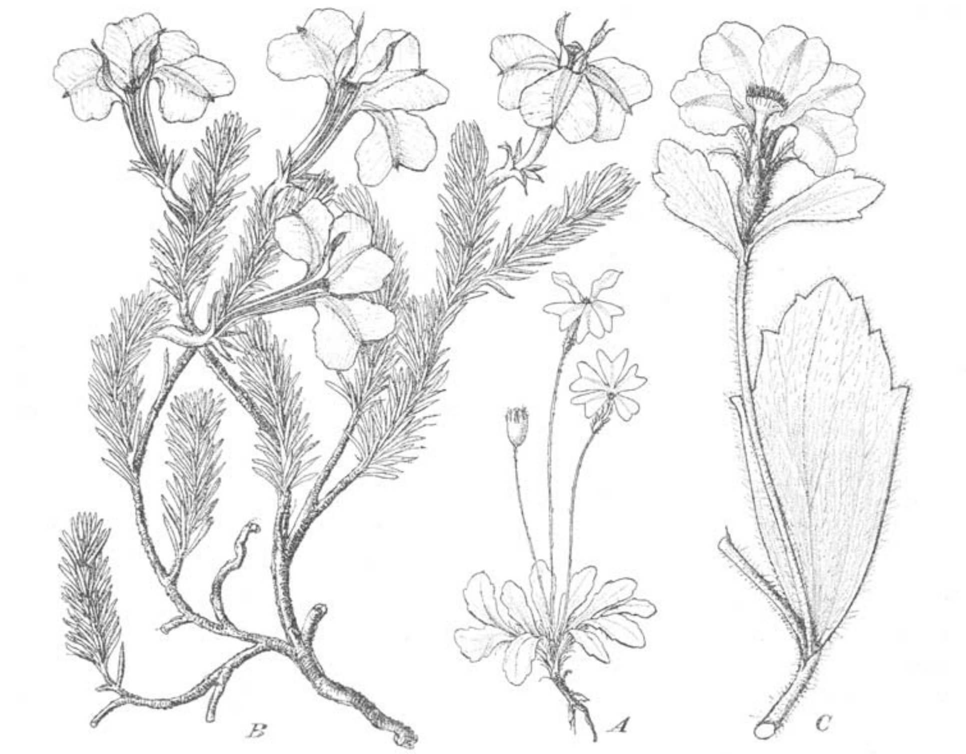


Fig. 20. *Goodeniaceae* der Südwest-Provinz: *A Goodenia tenella* R. Br. *B Leschenaultia formosa* R. Br. *C Scaevola striata* R. Br. (Original.)

6. **Goodeniaceae.** About 140 species. (Fig. 20)

In terms of number of species, this family occupies a position close to the Epacridaceae. However, it is vastly different when its ecological tolerances or its physiognomic effects are considered. Thus, while the epacrids are restricted in form, members of the Goodeniaceae exhibit a degree of diversity which is approached by few other components of the vegetation.

There are, however, no tree forms and even the number of tall shrubs is very limited. In coastal areas, however, one may frequently come across impressive species such as *Scaevola nitida* and *Sc. crassifolia* which are over 1 m high. Similarly in other areas, big shrub-like species of *Scaevola* or *Leschenaultia* may be present. In other genera the growth form remains low, the plants appearing as small bushes or even herbs.

Members of the Goodeniaceae are amongst the most adaptable elements of the Australian flora. In Western Auustralia they flourish in the Eremaea as well as in the Southwest Province. Also not only do they grow on the coast, but they also extend far inland. They are commonly found growing on damp clay sub-soils, on dry sand, in shady forest country and on open heaths. With the exception of the Acacias, there is no group with so many facets. As examples of this feature, we may mention the following forms: (a) ephemeral species with delicate and short-lived foliage (e.g. *Goodenia filiformis* and *Velleia cycnopotamica;* (b) woodland plants with large soft leaves (e.g. *Scaevola striata);* (c) woolly and felted species reminiscent of Mediterranean Labiates (e.g. *Verreauxla, Dampiera incana* and *Pentaptilon*); (d) ericoid undershrubs; and (e) perennial herbs with a cushion-like habit of growth.

Members of the Goodeniaceae are not gregarious plants and consequently, although they are found in almost all the plant communities, they play only a more-or-less minor part in the general picture of the landscape. In the northern part of the Southwest Province I have, however, seen shrub heaths on sandy soil where the slender grey-white forms of *Verreauxia Reinwardtii* are present everywhere between the bushes and influence the general colour scheme of the vegetation. Furthermore, in certain places on damp swampland, *Goodenia filiformis is* very common and so crowded together that the ground seen from a distance appears to be covered with yellow patches. The above constitute the only examples of real physiognomic importance.

From the above account, it would be difficult to form a satisfactory picture of the position really occupied by this family if it were not for the brightly coloured flowers of many of the species. Thus, the dazzling red of *Leschenaultia formosa* and related species is not equalled by anything in the Proteaceae, while the deep blue and violet colours, common in the genera *Lechenaultia, Dampiera, Scaevola* and *Brunonia* are features of the flora of Western Australia. One may sum up, therefore, by stating that although the members of the Goodeniaceae scarcely influence the main features of the vegetative scene in Western Australia, they do add some character to the whole.

7. Cyperaceae: About 110 species.
The Cyperaceae of the south-west Australia is one of the least studied families of the flora. The discovery of many new species may be anticipated in the future.

Owing to the lack of detailed information, much more study is necessary before our knowledge of the part played by the Cyperaceae in the make-up of the communities can be adequately assessed in relation to other important families. I can, therefore, at present only repeat the very provisional statements already made[1].

"The Cyperaceae of the region are present in most communities. It is only on the inland sand plains that genera are poorly developed. Here they are only represented by unusual genera such as *Caustis.*

I am also not very familiar with those species which are strongly hydrophytic. *Cladium arthrophyllum* is typically present on the margins of lakes in the Swan River area, while small species of *Cyperus, Scirpus* and *Chorisandra* are present as annual dwarf plants on the margins of shallow ponds and ditches. In certain areas, on fine gravel one also finds species of *Schoenus* together with members of the Centrolepidaceae.

In the shady woodlands of the extreme south-west, the family Cyperaceae appears to be poorly represented. On the other hand, in the open communities on sand where Jarrah and *Casuarina* are dominant, they sometimes occur as an essential feature of the undergrowth. Sturdy species of *Gahnia, Cyathochaete, Tetraria*, *Tetrariopsis,* tall species of *Lepidosperma,* and above all the striking genus *Mesomelaena,* are commonly present there amongst the low shrubs of the undergrowth. They do not, however, form closed communities.

Lepidosperma gladiatum and *Scirpus nodosus* are characteristic plants of the coastal dunes. Both are also common on the sandy coastal regions throughout Australia.

Evandra aristata grows thickly enough to form true associations of peculiar beauty on the swampy soil of the south coast. The stems which are almost 1.5 m high are often closely crowded together so that their graceful panicles are well exposed."

8. Liliaceae. About 80 species.

By far the most important representatives of the Liliaceae of the south-west are the Grass-trees already described. All the remaining species belong to the perennial herb flora of the region. Some of these are bulbous, while others are rhizomatous. Many are widespread and common in the Southwest Province, but only a few are striking enough to influence the general picture of the vegetation.

In the winter wet season, before the flowering period of the shrubs has really commenced, the countryside is brightened with the white star-like flowers of *Anguillaria dioica* and *Burchardia umbellata.* These are comparable with the much more numerous bulbous plants present in the Mediterranean or Cape regions in spring. Later on *Chamaescilla,* with its bright blue perianth (an equally common plant in the south-west) commences to flower. More important perhaps than these is *Borya nitida* (Fig. 21). This is a remarkable plant which, with its firm cushions, is generally an indicator of granite, although it also occurs on clay soils.

The genus *Xerotes (Lomandra)* also deserves mention as its species occur in all communities. Although there is scarcely one which in external appearance is as impressive

1 Diels and Pritzel, Fragm. Austr. occid. p. 78

as many of the eastern Australian species, e.g. *X. longifolia,* the constant occurrence of these delicate plants in the most diverse situations gives *Xerotes* a place amongst the more important constituents of the flora.

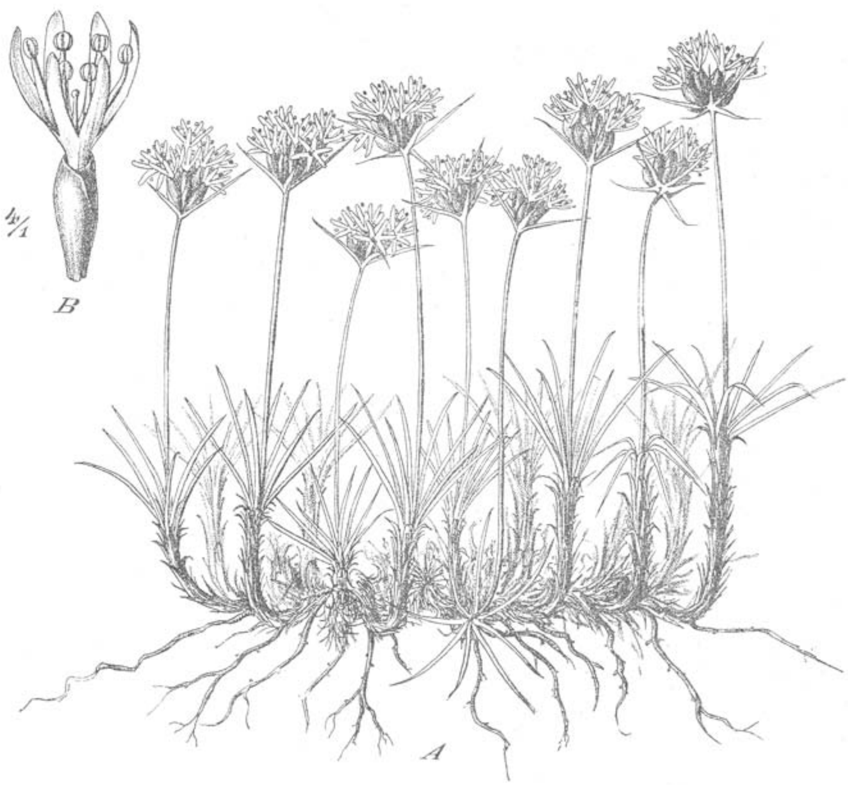


Fig. 21. *Borya nitida* Labill.: *A* Habitus. *B* Blüte. (Original.)

Members of the Liliaceae in the Southwest Province are very closely related to the eastern Australian forms. Many species occur in the Eremaea and are almost pan-Australian in their distribution. The number of species in the Southwest Province is, however, so high that the Liliaceae must be ranked amongst its most characteristic families.

9. Stylidiaceae. About 75 species. (Fig. 22)

It would appear from the detailed discussion of this family in Diels and Pritzel, Fragm. Austr. occid. p. 582 on, that it has much in common with the Goodeniaceae. This is particularly true insofar as its participation in many diverse communities is concerned. It is this constant presence of the Stylidiaceae in the south-west which reminds one of that much more important group, the Goodeniaceae. The family Stylidiaceae differs, however, in the fact that its members are much more common in the Southwest Province, and more particularly in the more southern areas of that Province. This constitutes the "centre of their distribution and endemism". To the north, to the east, and towards the interior, the number of species diminishes rapidly. Beyond the 40 cm isohyet, i.e. the boundary of the Eremaea, few species occur. Passisng up to or beyond the 20 cm isohyet, the number becomes exceedingly small, being essentially represented by *Stylidium limbatum, St. yilgarnense* and *St. Merrallii.*

Vegetatively the family falls into two groups, namely: (a) annuals or semi-annual species; (b) perennial species.

The first group, which falls into Bentham's *Stylidium* Ser. Tenellae and Corymbulosae, together with the genus *Levenhookia* are ephemerals. They appear in large numbers after a heavy fall of rain has moistened the soil, and over a short period (a few weeks) they almost completely cover the soil with their white or bright pink flowers. In growth form (apart from the floral parts), these members of the Stylidaceae are simple - consisting of a short stem and little else apart from two small delicate leaves.

The structure of the perennial species is more complicated and diverse than that of the annuals. However, they do not match the diversity shown in the Goodeniaceae. All the perennials are herbs. In most species the leaves are arranged in a tight rosette. Mostly they do not persist beyond the dry season but die down and appear anew each year. This allows the development of a somewhat more delicate type of leaf. Branching of the perennial axis is rather restricted in many species and the individuals too limited in their occurrence to be of much value physiognomically. In others, however, extensive branching occurs, resulting in the formation of thick mats. These are often so large that here and there the ground is completely covered solely by these plants. *Stylidium repens* and *St. Dielsianum* are the most important of such species. The former species in particular occurs frequently on sandy soil, covering the ground with a dense network of branches. Some of these perennial species thus attain a significance similar to that which results from the gregarious development of the ephemeral forms. The majority of Stylidiaceae do not, however, produce this effect and only detailed observations will indicate how general the distribution of the group is in the south-west.

The woodland areas of the south-west are rich in species and in particular the shady forests of the south. Here, the leafy species of the Sect. Rhynchangium are common. The light open woodlands of the western coast and of the somewhat more northerly region are also well colonized. In moist, sheltered places close to the south coast one finds a peculiar climbing species *(Stylidium scandens)* which possesses hooked leaves.

The annuals, as mentioned above, favour the more swampy areas. In the more sheltered spots of such areas, *St. junceum is* often found. Species peculiar to gravelly and sandy areas also occur but in general, however, these are usually closely related to those of the wooded areas.

10. Orchidaceae: About 75 species. (Fig. 23)

The orchids of south-west Australia present a remarkable contrast to many of the other important families of the country. As pointed out in Diels and Pritzel, Fragm. Austr. occid. pp. 114, 115), they do not on the whole possess any independently developed local features. They in fact agree in all important characters with the Orchidaceae of eastern Australia. They thus differ greatly from the Podalyrieae, the Epacridaceae, the genus *Stylidium,* and various others. They present many analogies to the Cyperaceae (although to a lesser extent), they supply some physiognomically effective additions to the vegetation of the district.

All the orchids of the south-west are terrestrial. Their vegetative organs are functional only in the rainy season. During the dry summer they remain dormant below ground. In their mode of occurrence, these orchids have much in common with the terrestrial orchids of other countries.

Typical examples are present in the south-west, illustrating features held in common. "They include the following: (a) the dependence on a certain amount of humus in the soil; (b) the crowded occurrence of one species in places; and (c) the still more frequent, yet very scattered occurrence of species of *Drakaea* and *Caleana,* together with *Caladenia serratus.*

The specific edaphic conditions required by the different species are rather dissimilar. *Epiblema grandiflorum is* often found growing in waterlogged conditions. Many species of *Prasophyllum, Microtis* and *Diuris* serve as indicators of high soil-moisture content. The majority of the species grow in the soaked sand in high rainfall areas. The gravel [laterite] of the high country, however, also carries numerous species (in particular the less water-dependent members of the genus *Caladenia).* Some of these, such as *Caladenia gemmata* and *C. hirta* appear actually to be restricted to the inner (Wandoo) region of the plateau.

The occurrence of many species in shady or otherwise sheltered localities may be correlated with moisture requirements. The predilection of *Pterostylis* for growing in such areas is so strong that one must include its species amongst the few true shade-loving

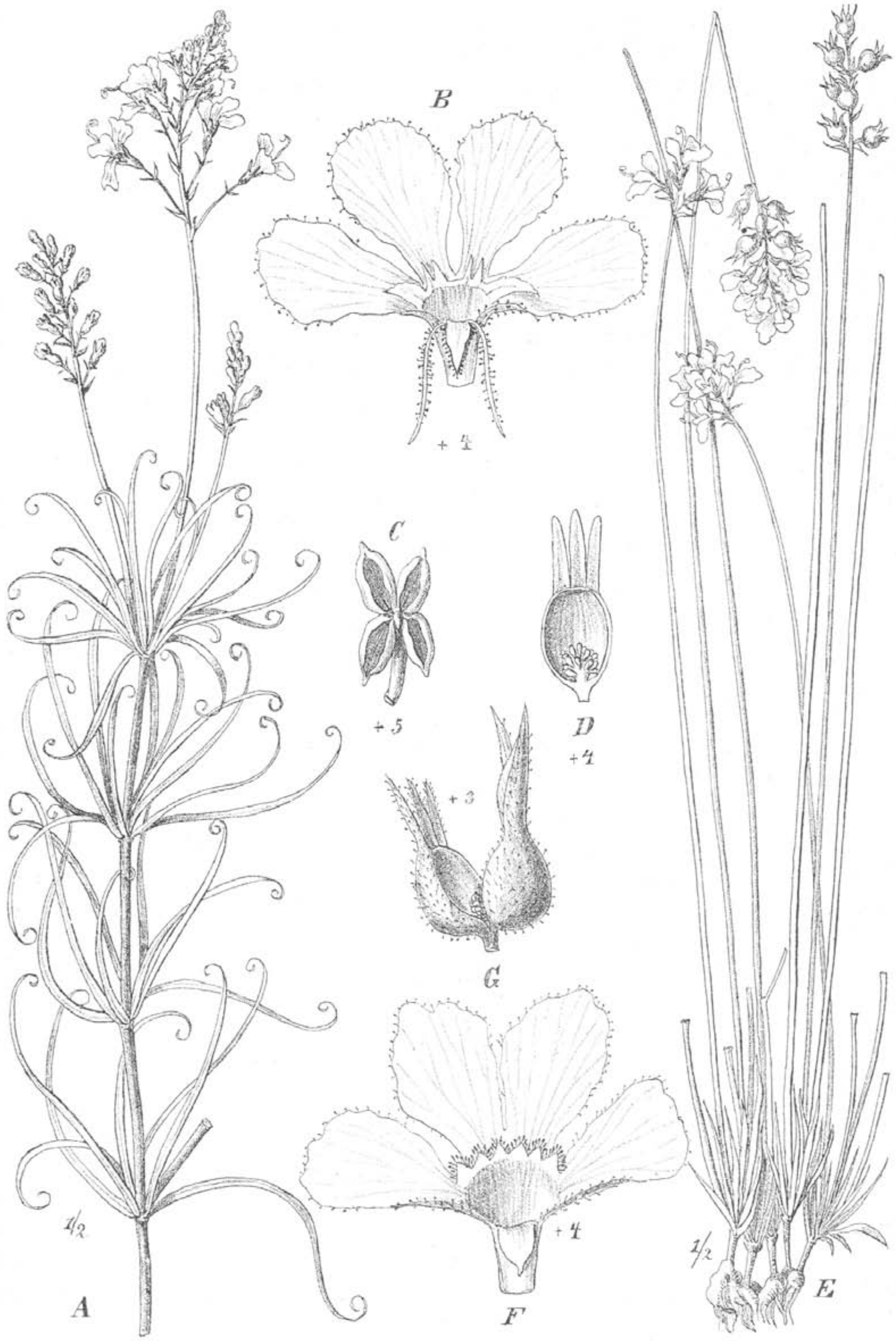


Fig. 22. *Stylidium*-Arten der Südwest-Provinz: *A—D Stylidium scandens* R. Br. *A* Habitus. *B* Blüte. *C* Synandrium. *D* Fruchtknoten durchschnitten. — *E—G Stylidium junceum* R. Br. *E* Habitus. *F* Blüte. *G* Frucht. (Nach MILDBRAED in »Pflanzenreich«.)

plants of Western Australia. Many of them occur only on the forest floor, while dwarf forms of *Pterostylis pyramidalis* frequently grow between the ferns and moss in niches in granite rocks. In such shady situations, the small plant is so independent of direct moisture that it can occur in otherwise quite dry areas of the Eremaea. Apart from such entirely local and easily explainable exceptions, orchids do not flourish east of annual rainfall line of 30 cm.

In more open situations, the orchid flora is typified in the first instance by the genus *Caladenia.* This has bright-coloured flowers and shows considerable diversity and originality in the structure of its perianth. In this connection, it is remarkable how frequently numerous individuals suddenly appear following a bush fire. In fact, some species have actually only been recorded at such spots. This would suggest that burning off is necessary to reduce the shade cover sufficiently for the plant to come to maturity. During the vegetative phase before flowering, the plants are so inconspicuous that they may easily be overlooked[1]".

11. Sterculiaceae: About 70 species. (Fig. 24)

This family is not confined to the south-west. As shown later, because of its Australia-wide distribution and its constitution, it may be regarded as one of the most instructive elements of the Australian flora.

It is important in the Southwest Province because of its presence in very different communities and its corresponding diversity in species form.

The kind and degree of adaptation in the family is somewhat different from that presented by the Leguminosae, Proteaceae and Epacridaceae. For example, the regulation of transpiration appears to be controlled much more by the presence of hairs on the leaves than it is in the three other families. A woolly integument is thus rather common (the only species in which woolly-hairiness remains poorly developed are the so-called "shade-loving" ones). Reduction in leaf area is a second but less important factor in the control of water loss. Incurving of the leaf margins leads to the development of the ericoid or coriaceous form. Aphylly and the development of marked sclerophyllous tissue do not occur in the West Australian Sterculiaceae.

The tallest species grow in the woodlands of the moist south coast where *Ruelingia* shrubs to 3 and 4 metres high occur. This, however is unusual and most species (e.g. *Thomasia, Lasiopetalum* and *Guichenotia)* growing in exposed places on gravelly slopes rarely exceed 1 metre in height. They are not particularly gregarious and seldom form large communities. When, however, species of *Guichenotia* and others are in full flower, their red colour makes them most conspicuous in the bush. On sandy heaths and in clayey areas they are not common enough to produce any physiognomic effect.

12. Restionaceae: About 60 species. (Fig. 25)

All the genera of the Restionaceae which are present in Australia are also present in south-west Australia. A great number of them are in fact endemic to this region, including the entire Diplanthereae group. In the Eremaea, the family is still present, although rather poorly represented. In the south-west itself, the higher rainfall areas are clearly favoured, at least in terms of numbers of members of the family Restionaceae present.

The conditions under which members of the western Restionaceae grow are very diverse. They are only absent, as far as my observations go, from the loamy soils of the Eremaea and the western transition zone to this region. However, some xeromorphic species do survive there. They are present in all other communities, although the majority of the species grow best where adequate ground water is present.

As a consequence, they are particularly characteristic of flat alluvial areas where the clay or loamy soil, deficient in humus becomes waterlogged during the winter wet season. They are also present in the deep south where, even in summer, the soil still has a very high moisture content.

1 Fragm. Austr. occid. p. 115, 116.

Fig. 23. *Orchidaceae* der Südwest-Provinz: *A Microtis alba* R. Br. *B Pterostylis pyramidalis* Lindl. *C Caladenia gemmata* Lindl. *D Caladenia Patersoni* R. Br. *E Prasophyllum parvifolium* Lindl. *F Diuris setacea* R. Br. (Original.)

Fig. 24. *Sterculiaceae* der Südwest-Provinz: *A, B Thomasia solanacea* J. Gay: *A* Habitus. *B* Androeceum und Gynaeceum. — *C, D Guichenotia micrantha* (Steetz) Bth.: *C* Habitus. *D* Androeceum und Gynaeceum. (Original.)

In such places the tallest species of the family are found. "They grow in large stiff tussocks or clumps separated from each other by bare ground. This presents an unusual picture which often recurs in suitable areas throughout the south-west. Many species of *Lepyrodia* and most of the tall species of *Leptocarpus* and *Chaetanthus,* together with some species of *Restio,* participate in this flora on alluvial soils"[1].

Where the waterlogged soil of the low-lying areas is richer in humus, e.g. in the south, other species are found. In such places, e.g. near King George Sound, *Hypolaena gracillima* is present. The felted, inextricably tangled branches form thickets over 1 m high.

Species of *Anarthria, Hypolaena, Loxocarya* and *Lepyrodia* grow well on heath-like, slightly humic, sandy soils. This is the type of soil which carries so many Restionaceous plants in the Cape region [South Africa]. The occurrence of individual species is determined by the degree of moisture present. The vegetative form is very variable, but tall and vigorous species like the *Cannamois* of the Cape, have not developed in the Restionaceous flora of Western Australia.

On the permeable sandy soils carrying open woodland, often where there is some degree of shade, *Lyginia barbata* is a characteristic plant in the undergrowth.

In sandy areas of the drier districts, a strongly developed xeromorphic group of Restionaceous plants is present. *Ecdeiocolea monostachya,* for instance, which is often so gregarious as to form large communities, occurs here (Plate XIX). The genus *Lepidobolus* extends further into the Eremaea. Its representative, *L. deserti,* extends as far as the 20 cm rainfall isohyet.

This invasion of regions with such a low rainfall is an important feature of the south-west Australian Restionaceae. In eastern Australia and also in South Africa, members of the family do not colonize such extremely dry areas.

1 Fragm. Austr. occid. p. 84.

Fig. 25. *Restionaceae* der Südwest-Provinz: *A—C Leptocarpus tenax* R. Br. *A* Habitus der ♂ Pflanze. *B* Stück der ♂ Inflorescenz. *C* Stück der ♀ Inflorescenz. — *D—F Loxocarya pubescens* (R. Br.) Benth.: *D* Habitus. *E, F* Teil der Inflorescenz. (Original.)

13. Rutaceae: About 60 species.

Despite its possessing a fairly large number of species, the family Rutaceae is relatively unimportant physiognomically in Western Australia. The main interest of the family lies rather in its relationships and its plant geography[1].

The Rutaceae is also a group which is not confined solely to the south-west. Recently it has been shown that a considerable number of representatives are present in the southern Eremaea.

The family has developed many characteristic features in the Southwest Province, and consequently qualifies for inclusion amongst the typical elements of the flora. We may note, for example, those very peculiar endemic genera which, in their floristic structure and organization, show analogies with *Darwinia* in the Myrtaceae. These genera are *Geleznowia, Chorilaena* and *Diplolaena,* in which the inflorescences are crowded into heads, the whole being surrounded with corolla-like, often brightly coloured bracts. This feature has clearly evolved independently in each of the three genera.

The genus *Boronia* (Fig. 26) is the main member of the family in Western Australia (it possess the largest number of species). There are scarcely any communities from which it is completely absent. It must not be forgotten, however, that in general it behaves as a hydrophytic type. In Diels and Pritzel (Fragm. Austr. occid. p. 317) I have expressed myself on this point as follows:

"The regions favoured by *Boronia* are those where the highest rainfall occurs. Even within these areas the species tend to grow best in those places where the water content of the soil remains high for the longest period. The little valleys and drainage channels of the most southern forest areas with their very moist soils constitute the best habitats. This is where the *Boronia* species with the most beautiful flowers grow. In these areas, where they are often closely associated with members of the Myrtaceae, we find the finest examples of the Heterandrae. These include the rose-red *Boronia lanuginosa* and *B. megastigma*. The last named species possesses the dark-brown scented flowers which are famous throughout the whole of Australia. On the clayey depressions which as a rule are waterlogged in winter, less spectacular species such as *B. juncea* are present.

In communities growing on drier soil the number of species rapidly diminishes. In woodlands on clayey gravelly soils the beautiful forms of *B. ovata* and others may be seen. Species such as *B. cymosa* and *B. crassifolia*, which occur on the widespread gravel [laterite], show some xeromorphic features. More extreme xeromorphic species such as *B. inornata* and *B. xerophila* with its closely appressed hairs are present on the margins of the Eremaea. Other xeromorphs are to be found among the psammophyllous species growing on shrubheaths. *B. thymifolia* exemplifies the rolled-leaf type. Leaf reduction leading to almost complete aphylly, is illustrated by the Cyaneae series: *B. ramosa* to *B. coerulescens*. These species grow excellently on sand".

14. Umbelliferae: About 50 species. (Fig. 27)

The Umbelliferae of the south-west consist, firstly (and to a limited extent) of widely distributed annuals which are also well represented in the Eremaea (e.g. *Hydrocotyle* and *Didiscus).* Secondly (and to a larger extent), there are genera which reoccur in the moister parts of eastern Australia, although they are almost entirely lacking from the Eremaea. This second group is characteristic of the Southwest Province, since in adaptive diversity of form its members occur in all the botanical districts and communities. Only a few species, however, influence to any extent the vegetation picture. One which does is *Actinotus leucocephalus* (Fig. 27). This plant, the Edelweiss of the country, often occurs in masses covering the gravelly-sandy soil. Because of its beautiful white silky felted involucre, it is one of the most striking elements of the vegetation at the beginning of the wet season.

Hairiness of leaves is also a feature met with in many members of the Apiaceae growing in Western Australia (e.g. *Xanthosia).* A more common development, however, is the marked tendency towards aphylly. In this process, juncus-like species, such as *Tra-*

1 Diels and Pritzel, Fragm. Austr. occid. p. 315.

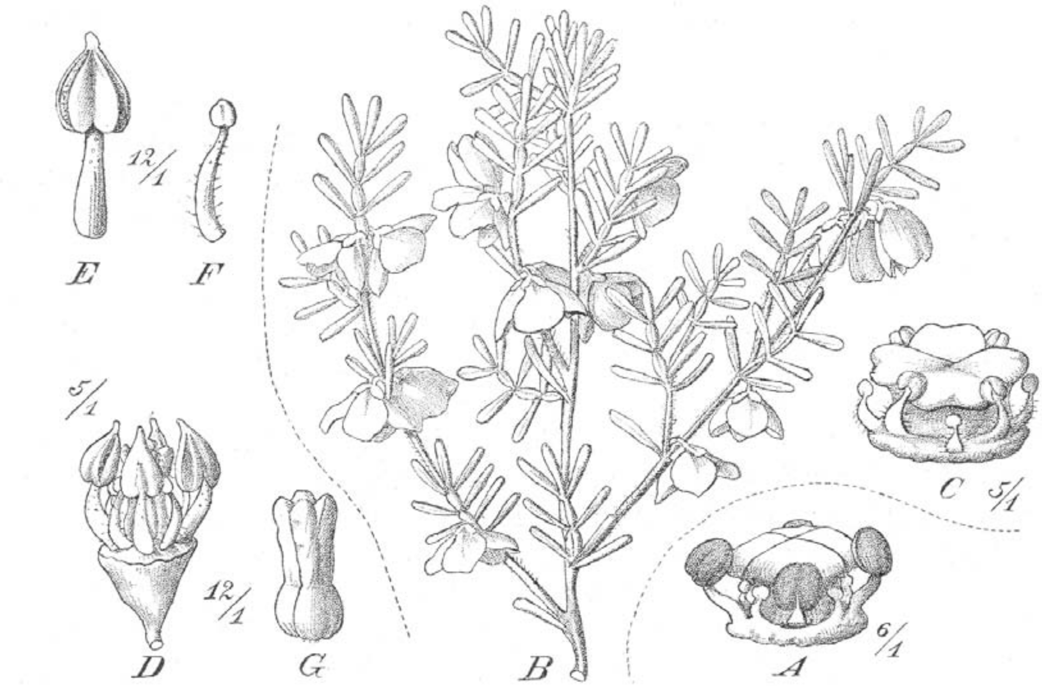


Fig. 26. *A Boronia megastigma* Nees: Androeceum und Gynaeceum. — *B*, *C Boronia Purdieana* Diels: *B* Habitus. *C* Androeceum und Gynaeceum. — *D—G Boronia tetrandra* Lab.: *D* Androeceum und Gynaeceum. *E* Staubblatt. *F* Staminodium. *G* Gynaeceum. (Nach DIELS und PRITZEL.)

chymene and *Schoenolaena,* have originated. Plants, which remind one of *Muehlenbeckia,* have evolved by the development of lateral expansions on the branches. As examples, we may mention *Trachymene compressa* and related species.

Drummond drew attention to an entirely different feature in referring to species in the genus *Trachymene* [*Platysace*] which develop subterranean bulbs. In some of these bulb-forming plants a partly ericoid type of leaf develops on above-ground parts (e.g. *T. ericoides*). Such plants appear decidedly unusual in the family Apiaceae.

15. Amaryllidaceae - Conostylideae: About 50 species. (Fig. 28)

Members of the Conostylideae rank high amongst the characteristic families of the Southwest Province. They are endemic to the region and this alone gives them some degree of importance. There is more to them than this, however, for in south-west Australia they must be regarded as the most important group of the Liliales. In the character of their hairy or woolly floral parts, their colour, and in fact their whole constitution, these plants present lines of evolution which are not seen elsewhere in the vegetation of the region.

Judged by taxonomic criteria, the genus *Conostylis* is by far the most important in the family. It is predominantly a xeromorphic type and vegetatively it resembles members of the Cyperaceae. It occurs characteristically on sandy soils and is very rich in closely related forms which differ in their type of adaptation. They grow uniformly well (a) in the open habitat characteristic of the Jarrah forests, (b) among the undergrowth of the dune depressions, and (c) on the nutritionally poor inland sand-plains. On soil with a clayey substratum they are less in evidence, and on loamy soils their role is insignificant. However, it should be mentioned that occasionally individual species do attain some importance through their close tussock-like habit of growth.

As well as the genus *Conostylis* we have *Anigozanthos.* This is ecologically and visually very important. It may be noted that the species of *Anigozanthos* can be clearly distinguished by well-defined characters, while the separation of *Conostylis* species presents difficulties due to the bewildering variety of forms. Individual species of *Anigozanthos* occur locally in the smaller subdivisions of the province. Their boundaries coincide, for the most part, with the chief plant zones. The fact that they can easily be recognized by their strikingly brilliant and constant perianth colours makes them valuable as floristic types.

Almost all the species of *Anigozanthos* are tall plants. While still in the vegetative stage they initially remind one of the Cyperaceous genus, *Lepidosperma* (equally well distributed in Western Australia). During the flowering season, however, they become very important as they give character to their communities. This is particularly true of *A. flavida* (green-yellow flowers), which, together with *A. Manglesii,* grows well in wetter areas in the south. In this latter species the unusual proximity of two contrasting colours, namely bright red and parrot green, gives an almost barbaric appearance to the perianth.

As compared with *Conostylis, Anigozanthos* appears much more uniform vegetatively, although it occupies much more diverse habits. We have already noted that *A. flavida* thrives in wet conditions. The bright-green flowering *A. viridis is* found on the winter-wet clayey areas of the western coastal plain. *A. rufa* (with brown-purple flowers) and *A. pulcherrima* (with its beautiful yellow perianth) are often found growing on sandy soils bearing low bushy plants (the latter species is restricted to such sand-heaths). According to Drummond, *A. pulcherrima* is "the very loveliest plant which this country can boast". *Macropodia fuliginosa,* with its strange black velvety panicles, grows mostly on gravelly ground. The remaining species are adapted to different soil conditions. All, however, appear to show a strong development in open areas, and particularly where the undergrowth has been thinned out by bush fires. The conspicuously coloured *Anigozanthos* flowers are much more common in occurrence in such vegetatively open areas than in denser communities.

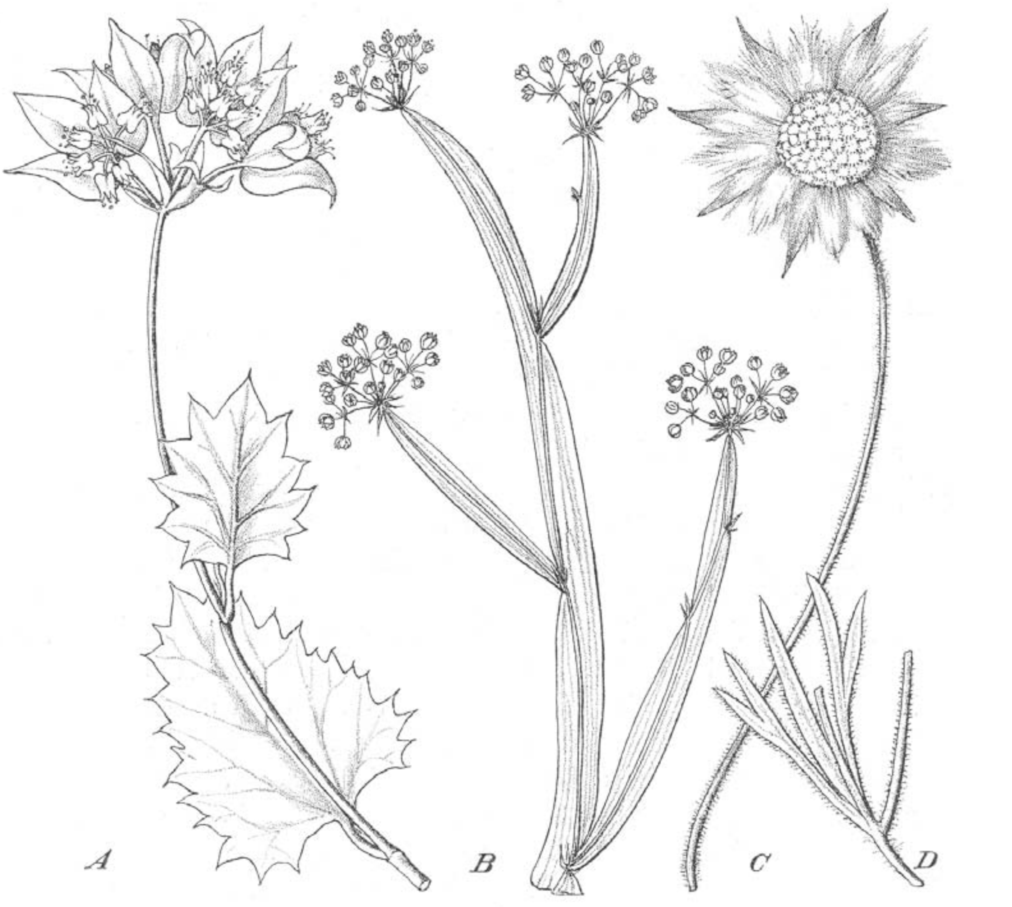


Fig. 27. *Umbelliferae* der Südwest-Provinz: *A Xanthosia rotundifolia* DC. *B Trachymene compressa* (Lab.) Spreng. *C, D Actinotus leucocephalus* Benth. (Original.)

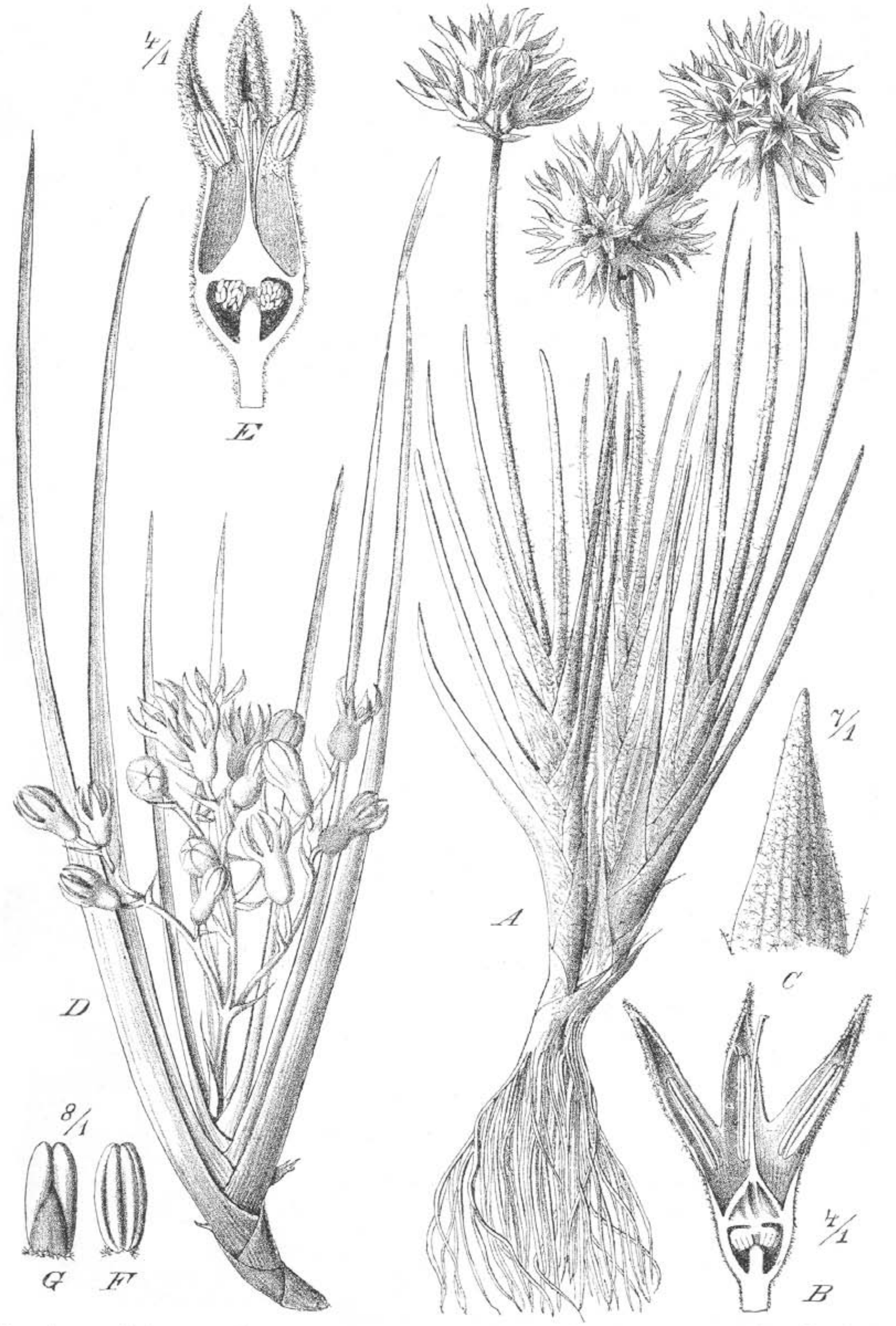


Fig. 28. *A—C Conostylis Dielsii* W. V. Fitzgerald: *A* Habitus. *B* Blüte im Längsschnitt. *C* Perianth-Abschnitt. — *D—F Conostylis phathyrantha* Diels: *D* Habitus. *E* Blüte im Längsschnitt. *F*, *G* Staubblatt von vorn und hinten. (Nach DIELS und PRITZEL.)

16. *Hibbertia* (Dilleniac.): About 50 species.

The genus *Hibbertia* of the Dilleniaceae (with which we are inclined to group the genus *Candollea* of many authors) grows under geographically somewhat similar conditions to the genus *Stylidium.* This is at least the case in south-western Australia where *Hibbertia* occurs in many communities, particularly in the south-west. In contrast to *Stylidium,* however, the habit of growth is quite different.

The species are all shrub - some even being of imposing size. *Hibbertia cuneiformis,* for example, a characteristic plant of the coastal woodland, can reach a height of 2 to 3 metres. Specimens of *Hibbertia montana* have been found to exceed 1 m. Apart from such well-developed shrubs, the genus runs through the whole range of size adaptation to environment similar to that seen amongst members of the Goodeniaceae. Climbers, however, such as those which occur in eastern Australia, are not present in Western Australia (see Ch. 4, Sect. F.)

Many species are present in the thick undergrowth of the southern woodlands near rivers and in valleys. These species, which have soft leaves, are the adaptive counterparts of certain members of the Rutaceae and Sterculiaceae which occur in the same area. On the boundaries of the area of distribution of *Eucalyptus marginata,* where it is drier, and on the light sand of the western coastal plain, it is possible to see a gradual reduction and change in the size and shape of the foliage of *Hibbertia hypericoides.* The normal type of plant bearing linear leaves with incurved margins is illustrated (Fig. 29).

Fig. 29. *Hibbertia hypericoides* (DC.) Benth.: *A* Habitus. *B* Blüte. *C* Kelchblatt. *D* Blumenblatt. *E* Androeceum und Gynaeceum. (Original.)

Hibbertia does not appear to flourish on the rich clay lowlands. However, its growth on sandy soil - noticed in the south - holds good as one travels north and east. Many species of *Hibbertia* are present on the sand plains. They all show the ericoid type of leaf which is physiognomically dominant in those areas. *Hibbertia conspicua,* the only completely leafless species of the genus, also occurs on these sand-heaths.

17. *Drosera*: About 30 species. (Fig. 30)

Drosera is an important element of the Western Australian flora. As it also occurs in the eastern States, many useful comparisons may be made. The genus, however, is only poorly represented in the Eremaean.

In the Southwest Province, representatives of two taxonomically separate groups are present, namely: (a) the Section Rorella; and (b) the Section Ergaleium. The first of these contains the true xeromorphic species which survive the dry season with their terminal leaf buds well protected. They are very small plants, and consequently too insignificant to influence the appearance of the vegetation. The second group, on the other hand, contains some species which are physiognomically quite effective. The above-ground parts are, however, short-lived. They perennate by bulbs. Shoots appear above ground only in the wet season, being then frequently present over the whole of the south-west on both porous and hard sub-soils.

Soon after the commencement of the break of season rains, the rosulate species (recognizable by the basal rosette of crowded leaves) begin to show their delicate white flowers. They carry on the assimilatory process between April and June.

They are followed by species with alternate stalked leaves (Fig. 30). These appear first on the heavy clayey ground of the alluvial regions. Simple species such as *Drosera heterophylla* and *D. Huegelii,* which flower in June and July, come first. Then larger forms such as *D. macrantha* develop on light sand and gravel. This species exercises a peculiar effect in the lower undergrowth because of its climbing habit of growth.

The conclusion of the *Drosera* season is marked by *D. gigantea,* the tallest and most richly branched species in the genus. It is found in favourable places on swampy land and flowers even as late as November. In the section Ergaleium, all members need adequate soil moisture during their vegetative phase.

18. Centrolepidaceae: About 15 species. (Fig. 31)

There is no other part of the world where the small family Centrolepidaceae is so well represented as in the south-western part of Australia. All the genera widespread over the whole continent occur in this area, together with the endemic West Australian genera *Hydatella* and *Aphelia.* However, in contrast to this strong south-western occurrence, the family Centrolepidaceae appears to be poorly represented in the Eremaea. At least one finds very few species there.

The following extract, taken from Diels and Pritzel, Fragm. Austr. occ. p. 92, represents the extent of our knowledge of the conditions under which members of the Centrolepidaceae occur in the Southwest Province. "All the Western Australian species are quite small annual plants. Some in fact are quite tiny and even moss-like. They grow on the sandy clay areas moistened by the winter rains, and in more climatically favourable regions on the loose humus-containing sand. Despite their small size, they may appear quite striking on the margins of ponds, particularly in the latter half of the rainy season. This is due to the crowded character of their occurrence. Together with the dwarf plants of other families, they then form either independent associations or else a kind of undergrowth among the taller-growing community of perennial herbs. Usually several species occur together. If one discovers a particular species, one can usually count on finding others in its vicinity. *Aphelia cyperoides* is the only species which is occasionally found covering large areas of moist soil to the apparent exclusion of other plants. Members of the group Diplanthereae have, so far, only been found living and flowering under water."

19. *Cassytha* (Laurac.): About 9 species.

Although the number of species is small, this parasitic genus may reasonably be included amongst the characteristic genera of the south-west. This is because although it is well represented in south-eastern Australia, it appears to be almost lacking from the Eremaea. I have already indicated elsewhere (Diels and Pritzel, Fragm. Austr. occ. p. 201) that this genus

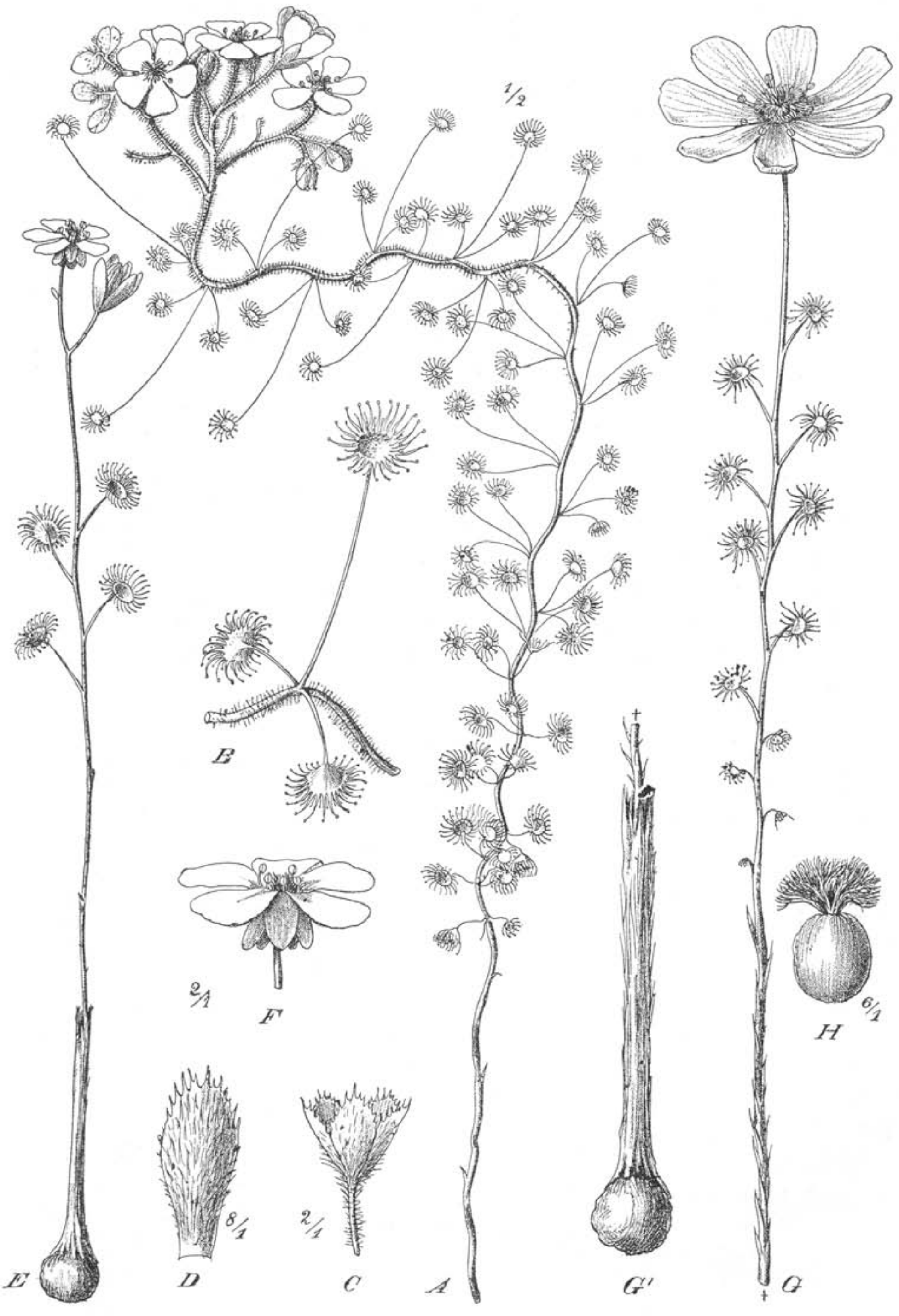


Fig. 30. *Droseraceae* der Südwest-Provinz: *A—D Drosera macrantha* Endl.: *A* Habitus. *B* Blätter. *C* Kelch. *D* Kelchblatt. — *E, F D. microphylla* Endl.: *E* Habitus. *F* Blüte. — *G—H D. heterophylla* Lindl.: *G* Habitus. *H* Gynaeceum. (Nach DIELS in Pflanzenreich.)

cannot be termed "more or less maritime" as stated by Bentham. This is because it occurs not only over the whole area of the Southwest Province but also extends well inland.

The role of *Cassytha* in the vegetative physiognomy of the south-west should not be under-estimated. *C. racemosa,* which forms great complicated networks like a *Cuscuta*, is very widespread. These masses often hang down a metre or so from the branches of trees and shrubs (Plate XXIX). The small species are parasitic on the bushes of the shrub-heaths. Occasionally they are so numerous that their wiry strands, which run from bush to bush, can appreciably slow one's progress through the area.

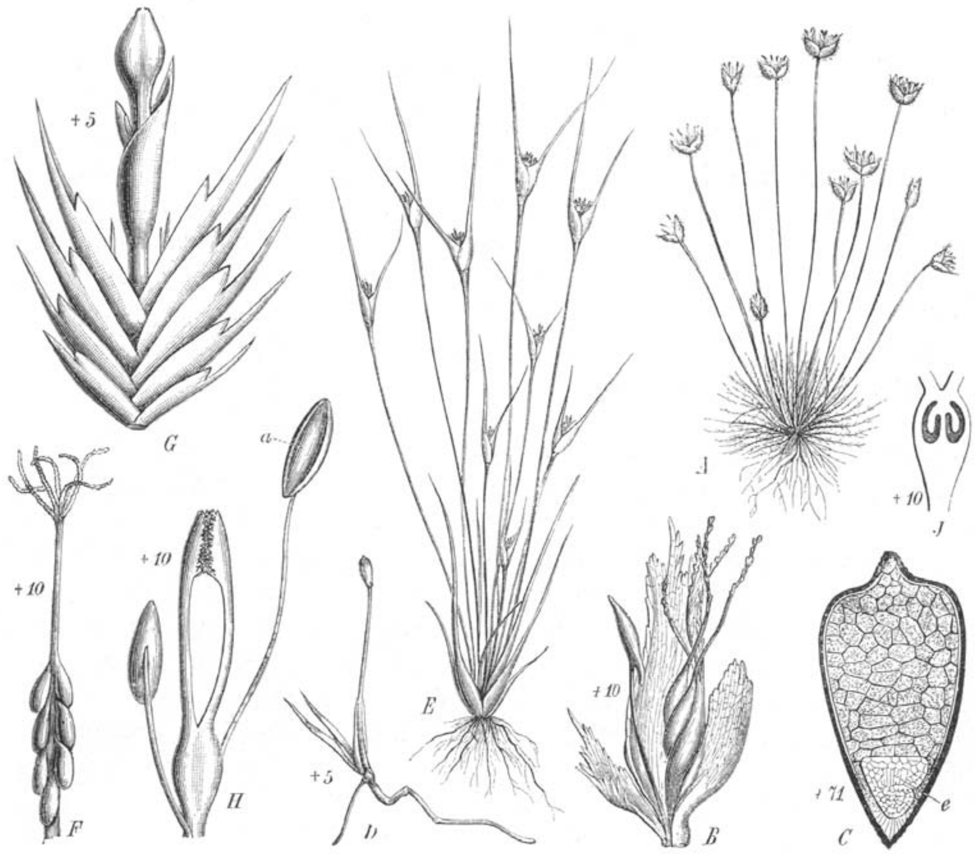


Fig. 31. *A* Habitusbild von *Centrolepis tenuior* (R. Br.) Röm. et Schult. (nat. Gr.); *B* Blüte derselben von den Vorblättern umgeben; *C* Medianer Längsschnitt des Samens: *e* Embryo; *D* Keimpflanze: der Kotyledon trägt noch die Samenschale. *E* Habitusbild von *Centrolepis aristata* (R. Br.) Röm. et Schult. (nat. Gr.); *F* Fruchtknoten von *Centrolepis Drummondii* (N. ab Esenb.) Hieron. — Zum Vergleich *G—J* *Gaimardia australis* Gaudich.: *G* Habitusbild eines Fruchtzweigleins; *H* Blüte: *a* leere Anthere; *J* Medianer Längsdurchschnitt durch den Fruchtknoten. Die linearen Vergrößerungen sind den Figuren beigeschrieben. — (Nach Hieronymus.)

20. Families also common in the Eremaea (Families and genera which are strongly represented and of considerable physiognomic importance in the Southwest Province but which are equally important in the Eremaea.)

Among the important elements of the flora of the Southwest Province there are several which cannot be considered as truly characteristic of the province because they feature equally well in the Eremaea. In fact, in suitable areas, they occur over the whole of central Australia.

The Compositae and Amaranthaceae are the most important families. The Compositae (about 140 species) is a family well endowed with gregarious plants. This is particularly well marked amongst the annual 'Everlastings'. Many of them occur in the south-west, and some, e.g. *Helipterum Manglesii,* with its nodding colourful heads (Fig. 53), is everywhere of physiognomic value. Members of the Compositae develop most strongly where the vegetation takes on an Eremaean facies. Wherever they occur in the south-west they retain certain Eremaean peculiarities. These naturally are more pronounced in the Eremaea itself, where they first developed. On these grounds, the Compositae should be treated as one of the characteristic families of the Eremaea.

The above applies also, and perhaps to an even greater extent, in the Amaranthaceae. About 20 species in this family occur in the south-west.

This situation differs, however, from that found in the Rhamnaceae, in *Pimelea*, and in the Haloragaceae. These groups are too widely distributed and too important in the Eremaea to be considered as character plants of the Southwest Province. It must be noted also that their centre of origin is not the Eremaea, as is the case with Compositae and Amaranthaceae. They are pan-Australian families with the most striking powers of adaptation to different conditions. The number of species present in the south-west lies somewhere between 30 and 40.

Members of the Rhamnaceae are always shrub-like in growth form and vary from tall plants with soft leaves through all stages of reduction to rigid dwarf plants with reduced foliage. The ericoid type of plant, which exhibits many points of convergence with the Epacridaceae (or *Erica*) both in the form of the inflorescence and its white colour, is particularly widespread.

The genus *Pimelea* also consists of shrubs and perennial herbs which are quite variable in height. The most impressive species resemble willow bushes. These range from shrubs 3 to 4 m high, e.g. *Pimelea clavata,* to low perennial herbs up to 30 cm high. In other respects, the general appearance is much more uniform than that of the Rhamnaceae. It is always somewhat variable, but does not develop extreme forms. The leaf also does not show much variation in shape. In certain cases, where due to climatic stress, it is unable to carry on its functions in the summer. Regular leaf fall takes place. This is illustrated by *P. microcephala* and others.

Pimelea is present in all West Australian communities, and because of its gregarious occurrence and striking flowers, its species often become physiognomically important. This is particularly the case on the clayey alluvium. The species present there show a tendency to form obvious communities and to produce a fine decorative effect with their rose-red or white flowers.

Physiognomically, members of the family Haloragaceae are of quite subordinate rank. The 30 species are partly slender annuals and partly small perennial herbs. The versatile genus *Haloragis* is strongly represented in the whole vegetation scene and contains some interesting adaptive forms. Nevertheless it is only of second- or third-rate importance when the overall elements of the flora are considered.

21. Families under represented in the Southwest Province

If one examines the general floristic character of the south-west, a striking feature will be apparent: namely, the relatively few members of the families Graminaceae and Compositae which are present. Strictly speaking, this holds true for the purely south-western part of the area, i.e. that part between the Swan River and King George Sound. In this triangle one finds a flora which, considering the overall importance of the family Compositae in terms of the wider south-west Australian flora, is perhaps the poorest in species of any comparable temperate region.

The same holds good for the Graminaceae. The occurrence of grasses on sandy soils is extremely poor. Griseback's statement, in "Vegetation der Erde" (11, 216) quoting Drummond[1], that the sandy areas of the Swan River Colony are "preferably used as grassland" is absolutely incorrect.

In the drier parts and consequently in the northern and eastern landscapes, particularly on loamy ground, both families are well represented. This appears to be because Eremaean elements have either invaded the district without showing any alteration in form or have become acclimatized through modification.

The rarity of occurrence of members of the and Graminaceae and Compositae in south-west Australia is very difficult to understand. Climatically similar areas, e.g. the Mediterranean area and the Cape region of South Africa, are rich in members of both these families. Moreover, introduced species of both, particularly annuals, do remarkably well in south-west Australia. *Briza maxima,* for example, is at present more common than any of the indigenous grasses.

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1 I have not found such a remark in Drummond's writings. A misunderstanding must have occurred.

CHAPTER 4 ECOLOGICAL CHARACTER

a. *Lifeforms of the vegetation*

The vegetation of the Southwest Province of Australia has lifeforms characterized by woody stems and branches, 65% of its species consists of trees and shrubs.

Trees and Shrubs

Although the ratio of the number of tree species to the total number of plant species is low, it is nevertheless higher than in other winter rainfall areas, eg. the Cape region of South Africa and the true Mediterranean.

In Chapter 2 we introduced nearly all the trees of south western Australia. The Eucalypts took first place, followed by the Acacias and the Banksias, then the Casuarinas. Finally elements of the genera *Callitris* (Pinac.), *Jacksonia* (Legum.), *Agonis*, *Melaleuca* (Myrt.), *Hakea* and *Xylomelum* (Proteac.), which play a more subordinate role within the tree-and-shrub group, may be mentioned.

The concept of a tree as a plant form arises from its late maturity; the trunk of stem grows vegetatively to a considerable extent, and shows strong branching before the flowering stage is reached. In most cases this long period of growth appears to be essential for tree-forming species. However, in the case of the vegetation of Western Australia this relationship does not appear to hold completely. There is a considerable variation here, and trees and shrubs have a very close relationship. All the above mentioned genera not only include shrubby species together with tree species, but the tree species often flower while still in the shrubby stage. They are therefore physiologically ripe to flower without having to attain the stature of a tree. Such close relationships between trees and shrubs are known elsewhere, but it is strikingly common in our region, and it can often be quite deceptive. I have for instance, seen *Eucalyptus occidentalis* in flower as a 20 m tree not far from the Stirling Ranges. But quite close by, one can see the same species in shrub-form [*Eucalyptus sporadica* -mallee] and yet, like the tree, bearing bright yellow flowers. *Banksia attenuata* flowers in the form of a low shrub just as frequently as it does in its tree form. It should be noted that it is not always a question of local races either, for the two forms often grow next to each other. Another striking example is presented by *Agonis juniperina*, which usually appears as a medium to large shrub, but in certain places, as for example, not far from King George Sound it attains tree form. It is similar in height to adjacent *Eucalyptus* species. The same phenomenon holds good for *Melaleuca Preissiana*, for numerous eucalypts and in short, for almost all the species which are met with as trees in Western Australia. This physiological elasticity is of great importance also from the scenic point of view, for it is naturally not confined to the groups in which tree growth forms occur. Amongst the shrubs too, the ability to produce flowers and fruit is not contingent upon the attainment of a certain vegetative mass, or at least there is room for variation in this respect. All sorts of gradations exist between the tall richly-branched shrubs and the low dwarf, simple-structured bushes of the undergrowth. This is not only the case in the same genus, but it occurs even in the same species. Our current terminology is not as yet adequately developed enough to handle these strange occurrences. It is therefore difficult for us to consider as shrubs the single-stemmed dwarf forms present in the Epacridaceae. This is despite the fact that the same process of lignification has taken place in stems as has occurred in the thick branches of the tall shrubby species of *Leucopogon.* The potential for tall growth and strong branch formation is also present. Freedom of growth resulting in a variety of growth patterns is thus an outstanding feature amongst West Australian shrubs. This provides most favourable conditions for development and adaptation to the environment.

Lianes

There are few climbing plants in the south west and none of them are really robust wooded lianes such as are met with in the rain forests. The main stem rarely attains a circumference of more than 2 cm. Most slender shoots of species twine through the maze of the shrubby undergrowth. Lianes never appear to occur on tall trees.

Some leguminous plants belonging to the genera *Kennedya* and *Hardenbergia*, with their characteristic tripartite leaves and bright coloured flowers, are the most common climbers. Two species belonging to the sub-cosmopolitan genus *Clematis* often brighten the undergrowth of the woodlands with their white flowers. The greatest number of climbers, however, belong to the family Pittosporaceae, and they are consequently of great interest, particularly as they are also almost endemic to the region. Among these, *Sollya heterophylla* is particularly widespread. It is also one of the most hardy of Western Australian climbers and flourishes as an undergrowth liane in the eucalypt woodland even in the relatively low rainfall zone of 35 – 40 cm.

High soil moisture favours the climbing habit of growth and as a consequence the strongest development occurs mostly along river banks. Without going into further detail we may here list the following genera of climbing plants to which this applies:- *Dioscorea* (Diosc.), *Clematicissus* (Vit.), *Aphanopetalum* (Cunon.) and *Lyonsia* (Apocyn.). Some genera with the same growth form, such as *Opercularia* (Rub.), *Thysanotus* (Lil.), *Comesperma* (Polygal.) and others, which normally do not require such high soil moisture conditions may, however also be found along river banks.

Epiphytes

There appear to be no epiphytic representatives among the higher orders of the plant kingdom present in Western Australia. Cryptogamic epiphytes are also poorly developed. The lichens are the usual representatives here. In general they are rather widespread and they occur also in the drier parts of the country. They appear to be limited, however, by the fact that they can only establish themselves on certain plants. I have never seen species of *Eucalyptus* bearing epiphytes and it is doubful if they ever carry mosses or lichens. On the other hand many lichens are to be found on the stems of *Casuarina*, on the larger species on the larger species of *Hakea* and on certain species of *Acacia*. Liverworths are to be met with on the rough stems of *Macrozamia* (examples being *Fabronia Hampeana* and species of *Calymperes*). Lichens also favour this substratum. The grass trees are apparently different again. They also are free from epiphytic growths. Apparently Preiss does not mention them in his collection.

Perennial herbs

After the woody plants, the perennial herbs are the next richest species group in Western Australia (about 23%). There is however a big gap between the gwo groups. Perennial herbs never occupy a predominant position in the communities. They have evidently failed to find the most suitable medium for their existence in Western Australia. The genera to which they belong do not as a rule show great diversity of form and they usually play quite a subordinate role in he constitution of associations and communities which determine the character of the vegetation. Naturally some exceptions do occur, eg. *Conostylis* (Amaryll.) the Goodeniaceae and many monocotyledons.

Unfortunately due to lack of time I was unable to devote sufficient attention to the ecology of the perennials in Western Australia - they require detailed investigation. In order to survive the dry season they have developed many special adaptations.

The dormant summer parts are often crowded together in a bud which is specially hardened. The morphological details vary. The buds of the epigeal persisting. Species of *Drosera* may be taken as representative of a large class (Fig. 32).

In other members of the perennial class the subterranean organs are of great ecological importance. To this group belong many Monocotyledons - orchids, numerous lilies, and members of the Restionaceae and Cyperaceae. It is in this group that we find so many truly bulbous and tuberous plants. Several species of *Thysanotus* (Lil.) *Caesia* (Lil.) and the common *Chamaescilla* (Lil.) possess functional bulbs. *Anguillaria* (Lil.) and *Hypoxis* (Lil.) arise from the bulbs and the peculiar genus *Tribonanthes* (Amaryll.) develops similar structures. The hypogeal storage organs of *Dioscorea* are also tuberous and this applies also to a *Pelargonium* (*P. Rodneyanum*) which grows in the district. An endemic western group of *Trachymene* (*Trachymene effusa* (Umbell.) and related forms), possess storage tubers of extraordinary size which is unexpected considering the weak development of the above ground parts. It is to be noted that the hypertrophy of the hypogeal organs has also taken place in purely endemic products of Australia. Thus the tuberous *Calandrinia* (Fig. 33), or the interesting Philydraceous genus *Pritzelia* are good examples.

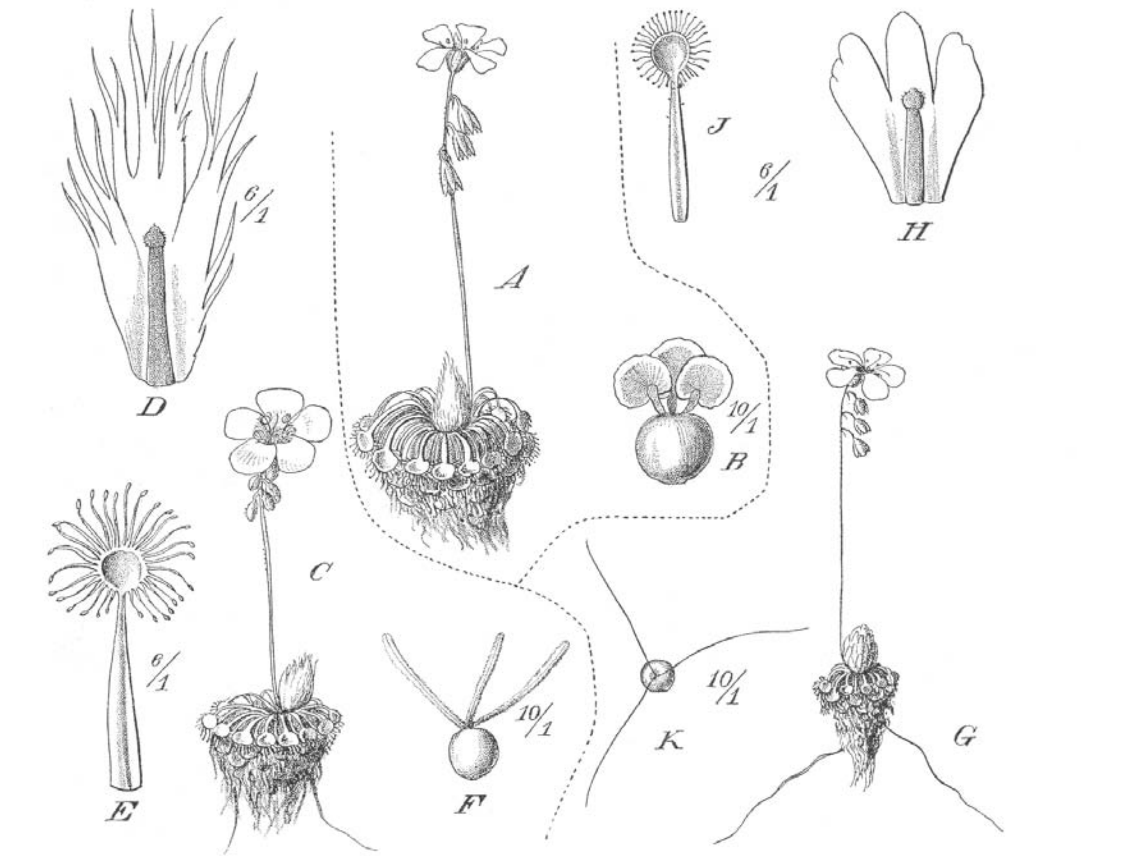


Fig. 32. *A, B Drosera nitidula* Planch.: *A* Habitus. *B* Gynaeceum. — *C—F Drosera paleacea* DC.: *C* Habitus. *D* Nebenblätter. *E* Blatt ohne Nebenblätter. *F* Gynaeceum. — *G—K Drosera pycnoblasta* Diels: *G* Habitus. *H* Nebenblätter. *J* Blatt ohne Nebenblätter. *K* Ovarium. (Nach Diels und Pritzel.)

The tuberous species of *Drosera* (section Ergaleium), are however more diverse in form and wider in distribution. The taller-growing species are illustrated in Fig. 30. In so far as tuber development is concerned they are, however, surpassed by the members of the section Erythrorhiza (some of which are illustrated in Figure 34). Nowhere else are they so common or so varied as they are in Western Australia and nowhere else are they so important from the scenic point of view as in the south west, where their appearance heralds the start of the wet season. The peculiar ecology of these plants is distinctly related to the winter rainfall conditions and in this regard the droseras rank among the most characteristic creations of the country.

When one observes how these types of bulbous plant have been developed in the Southwest Province- out of their own special flora - it is doubly strange to note how comparatively few bulbous plants there are altogether. It seems most unlikely that there is any other region with winter rains, which is so poor in bulbous or tuberous plants as south western Australia. In this respect, so far as plant geography is concerned, there is thus a deep-seated difference between countries with this type of climate. An explanation for this is still awaited. The lower winter temperature of the Mediterranean region can not be responsible for the greater abundance there, since the Cape region of South Africa is equally rich, although the winter is warmer. We shall refer to these conditions later.

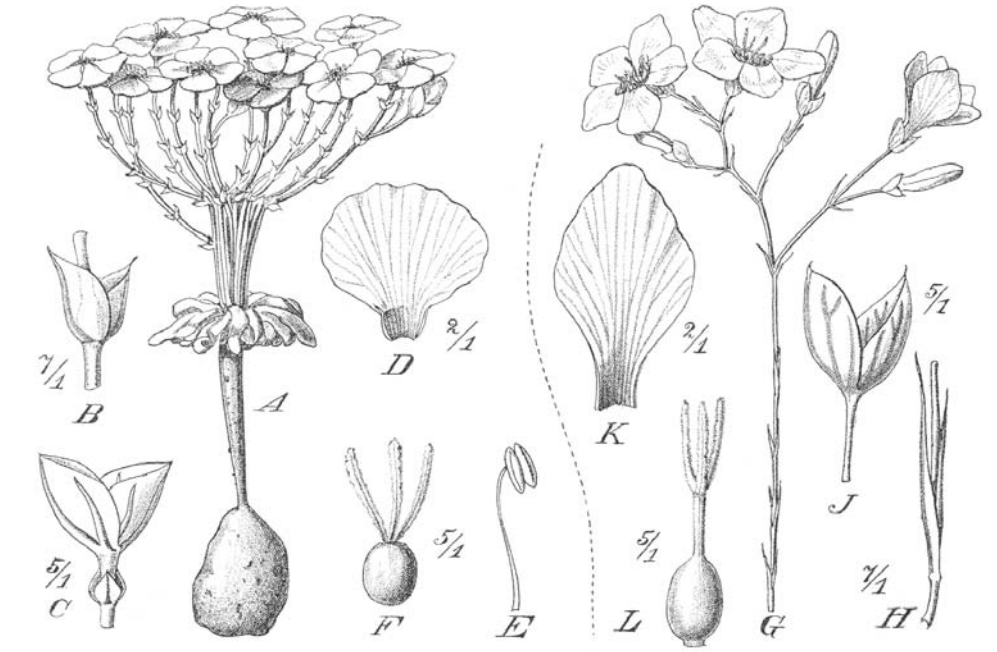


Fig. 33. *A—F Calandrinia primuliflora* Diels: *A* Habitus. *B* Schuppen. *C* Kelch. *D* Blumenblatt. *E* Staubblatt. *F* Gynaeceum. — *G—L Calandrinia Lehmanni* Endl.: *G* Oberer Teil des Stengels mit der Infloresccens. *H* Schuppen. *J* Kelch. *K* Blumenblatt. *L* Gynaeceum. (Nach Diels und Pritzel.)

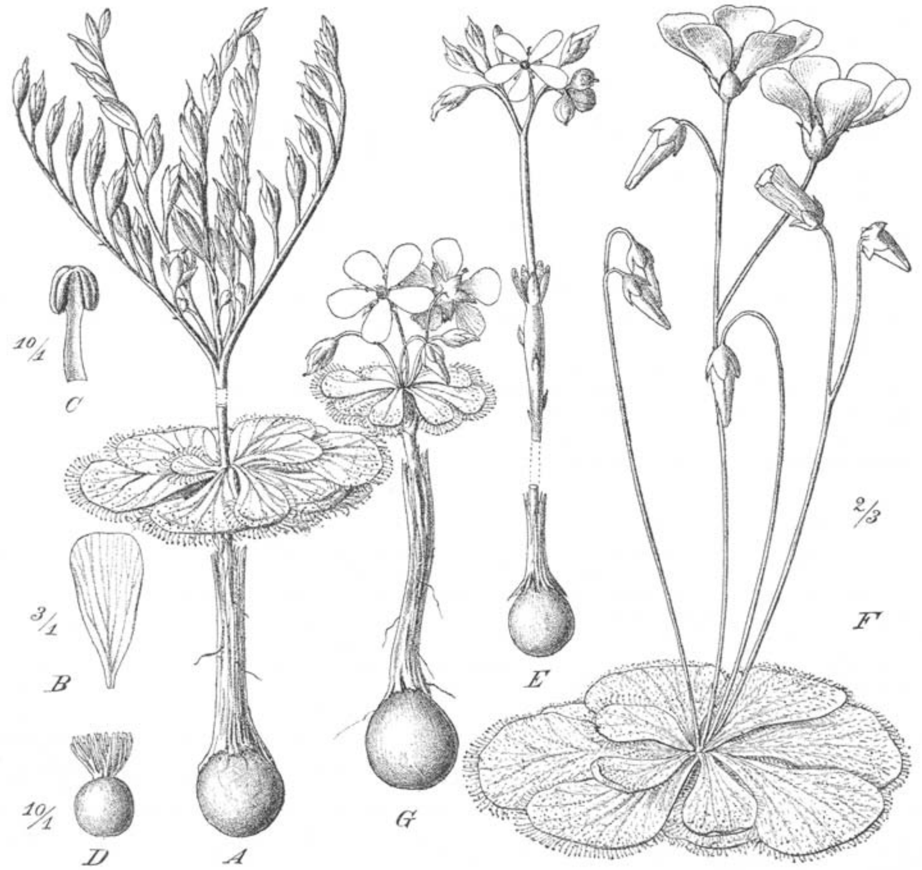


Fig. 34. Zwiebelpflanzen: *Drosera* Sect. *Erythrorhiza*: *A—D Drosera rosulata* Lehm. *A* Habitus. *B* Blumenblatt. *C* Staubblatt. *D* Gynaeceum. — *E Drosera squamosa* Benth. Habitus. *F Drosera macrophylla* Lindl. Habitus. *G Drosera bulbosa* Hook. Habitus. (Nach Diels.)

Annuals

The annuals resemble the bulbous plants in that they play a much less important part in south west Australia than one would have expected from what is known of other regions of the earth. The genera are poor in species (as are the perennials), although there are a few exceptions such as *Hydrocotyle* (Umbell.) *Stylidium* (Stylid.) and *Helipterum* (Compos.)

Fig. 35. Annuelle. *Myriophyllum tillaeoides* Diels: *A* Habitus. *B* Blühender Stengel. *C* ♂ Blüte. *D* ☿ Blüte. *E* ♀ Blüte. (Nach Diels und Pritzel.)

In most communities only very few annuals are present. In the woodlands of the outer parts of the south west region they grow in the shade and protection of the undergrowth. The most important species in such situations are small species of *Hydrocotyle*. Vegetatively poorly developed species of *Monotaxis*, *Poranthera* and here and there one of the Everlastings. On this more open sand heath *Calandrinia* (Portulac.) spp with brightly coloured flowers occur freely. Inconspicuous and small *Tillacea* (Crassul.) spp. together with delicate species of *Stenopetalum* (Cruciferae) and others are present during the rainy season filling in the spaces between the bushes. Yet in comparison with the rich annual flora of the drier types of sandy soil, eg. the western region of South Africa the dearth of annuals in the psammophyllous plant communities of Western Australia is quite astonishing.

The swamp communities compensate to some extent, and as will be shown in the next chapter, the annuals, due to their gregarious character and the number of individuals present, are to be regarded as being amongst the most important constituents of the vegetation. A marked development takes place on poorly drained clay soil, which dries up extensively in the latter part of the dry season only to become ready for plant growth again after the setting in of the rains. It is therefore the shortening of the vegetative period which, on this swampy ground gives the annual herbs an advantage over other growth forms. And from this we may conclude that for the greater part of the south west it is the long continuance of a season favourable to vegetative growth which is unfavourable for annuals. It would be foolish, however, to consider that this hypothesis applied satisfactorily everywhere. It is not clear why, for example, the sandy areas of the zone with over six months dry season should possess so few annuals.

Since the Western Australian annuals are mostly concerned in the constitution of the swamp or alluvial communities (wetlands) further detail is not necessary here. It is included in the discussion in Ch. V. (Sect. D).

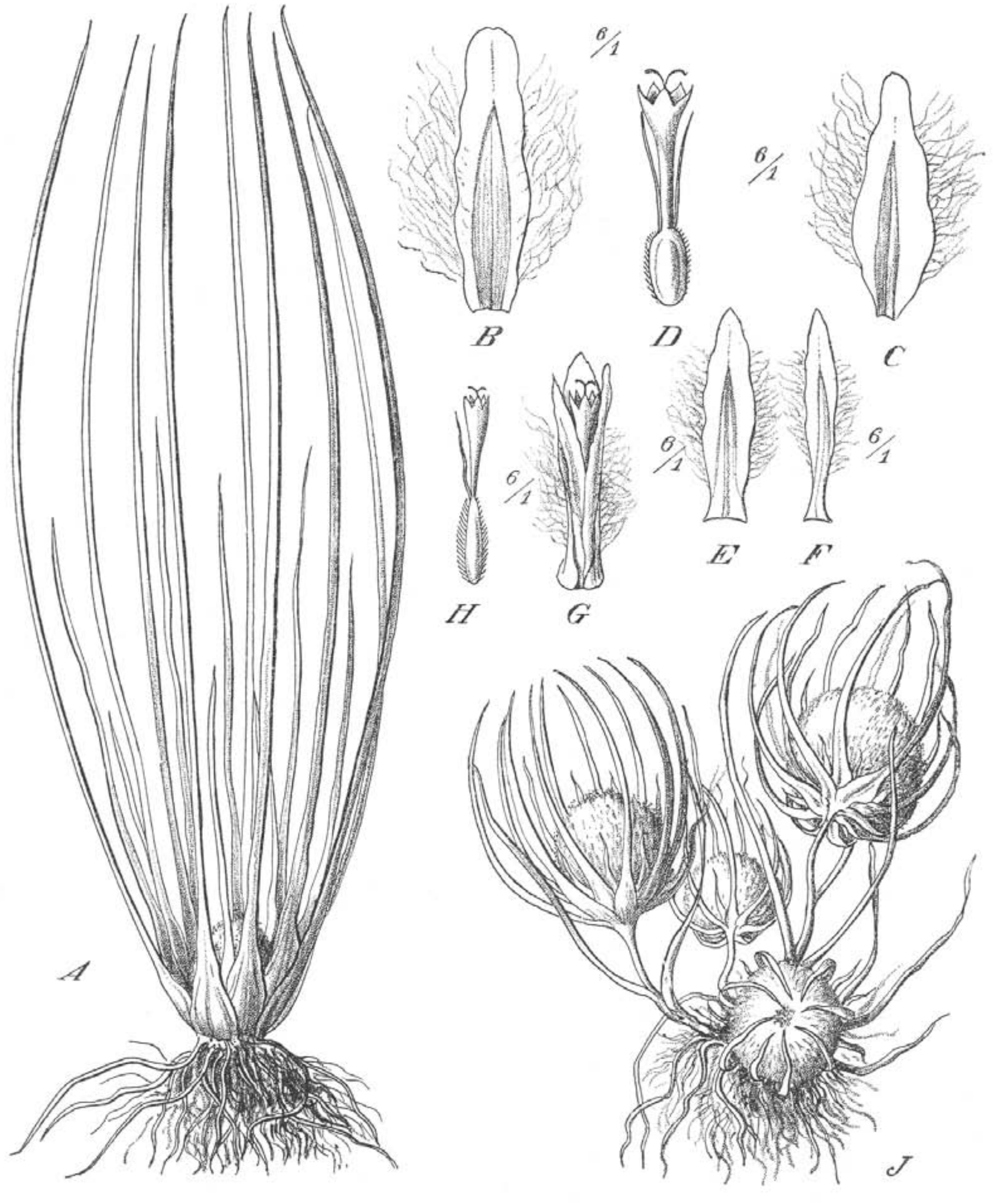


Fig. 36. Hygrophile Compositen als Annuelle: *A—D Myriocephalus isoëtes* Diels: *A* Habitus. *B*, *C* Deckblätter des Köpfchens. *D* Blüte. *F—J Myriocephalus rhizocephalus* (DC.) Benth.: *E*, *F* Deckblätter des Köpfchens. *G* Köpfchen. *H* Blüte. *J* Habitus. (Nach DIELS und PRITZEL.)

Cryptogams

Study of the cryptogams of Western Australia is still far from complete. In spite of this one can state with certainty that the higher cryptogams at least are very poorly represented in the region. Naturally the great length of the dry season in most parts of the country is a real obstacle to their development. But it is difficult to understand why the southerly and much more favourable districts possess such a sparse cryptogamic flora. In particular the number of ferns, mosses and fungi must be considered as remarkably limited, and as a result of my investigations I do not expect that further research will increase the number to any great extent.

Under these circumstances the part played by these higher cryptogams is of little biological importance. I have seen very few places where, through gregarious occurrence, a moss or a *Cladonia* gave character to the vegetation. I can only cite a single case where a really important invasion of cryptogams into a community is to be observed. This is the part played by *Campylopus bicolor* in covering granite rocks. Even this, however, is such a rare case that a detailed discussion may be left to the next chapter. (See Plate XXIII).

The role of parasitic fungi is still unknown. Although our collections contained a series of new species the distribution of these plants does not appear to be extensive. This is also the case with the fresh water algae which are restricted by the limited extent of their habitat. On the other hand several Characeae have already been determined by Reiss, and I also have come across several of them.

b. *Forms of branching*

The branching of a plant depends upon the position where the new growth takes place. The shrubby vegetation of the south west region shows a decided tendency to produce new growths from close under the most terminal "flower regions". This phenomenon which is correlated with the whole economy of the vegetative life in the south west results in the production of characteristic structures. *Petrophila linearis* (Fig. 37A) which was collected towards the end of December in the neighbourhood of the Swan River, illustrates clearly the process in two succeeding shoots. It will be seen that of the new shoots one is placed sympodially as a continuation of the chief stem.

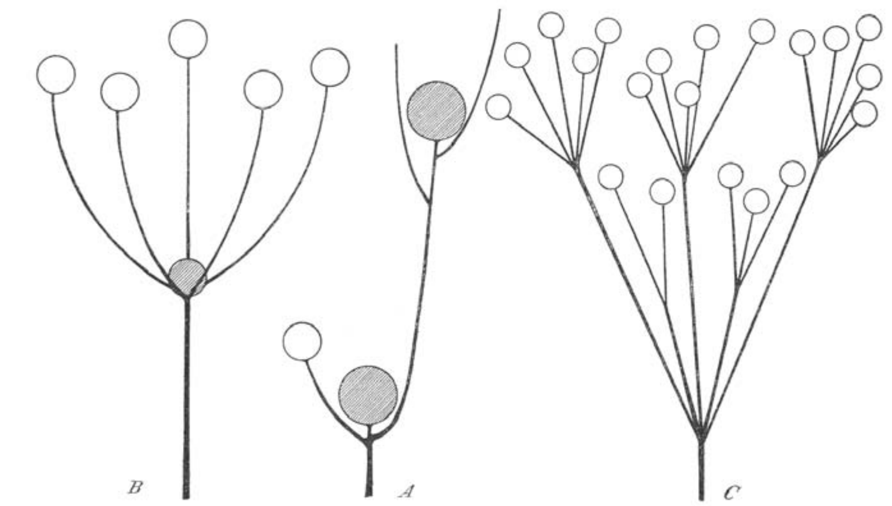


Fig. 37. Schema der Verzweigung von *A Petrophila linearis* R. Br. *B Petrophila scabriuscula* Meissn. *C Leucopogon gibbosus* Stescheg. (Original).

In the more xeromorphic smaller shrubs the arrangement is slightly different in that the new shoots, which are present in greater numbers, are all of somewhat similar length. As a result the entire branch system takes on the outline of an umbrella. Such small umbrella-shaped shrubs are uncommonly widespread in the drier parts of the south west. Typical examples occur in the family Proteaceae, eg. *Isopogon scabriusculus* (Fig. 37B), *Banksia Brownii* and others. The family Epacridaceae is rich in them (*Leucopogon* Fig. 37C), and in the Myrtaceae there are, at least amongst the Chamelauceae, many excellent examples. The genus *Verticordia*, however, probably presents the most complete collection of these forms and in many species, eg. *V. Brownii* the cymose-dichasial type of structure is so dominant that even old plants have the shape of an inverted cone.

In contrast to the above examples where each internode grows to some length there are many groups with a tendency to produce abbreviated shoots. This feature appears to me to be common in the general *Hibbertia* and *Grevillea*, and also in *Logania* (about which I shall have something to say later). Mesophytic species of *Hibbertia* (Dillen.) eg. *H. perfoliata* and *H. amplexicaulis*, bear their foliage on long branches, while the closely related *H. potentilliflora* which grows in exposed regions (and suggests its ecological hardiness by the presence of a silky felt) carries leaves and flowers on short branches. Similar differences are met with amongst other related groups of the genus - the section

Candollea (*H. desmophylla*) the polymorphic series of *H. montana*, and in *H. Huegelii*, and its relations. A similar and instructive variation is presented in the genus *Grevillea* where the western species form an epharmonically very diverse species. Most have long leafy branches as for example in *G. oxystigma* G. *acerosa* and the beautiful *G. Candolleana*. When I followed the genus to the boundary of the Southwest Province (annual rainfall about 30 cm) I encountered in *G. uncinulata* a type characterized by distinct short branches. This points to one aspect of its general xeromorphism. (Fig. 38) *G. uncinulata* is more common in drier areas but it has also been found in higher rainfall regions.

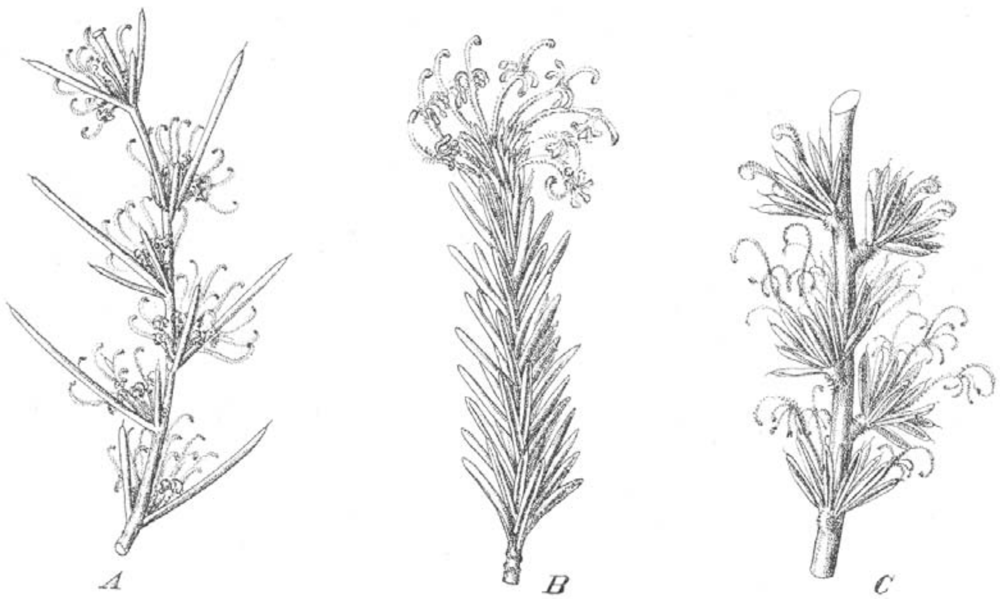


Fig. 38. *Grevillea* mit Langtrieben und Kurztrieben: *A Grevillea acerosa* F. v. M. *B Grevillea oxystigma* var. *acerosa* Meissn. *C Grevillea uncinulata* Diels (Original).

The Southwest Province possesses a number of common species which are characterised by a strong development of plagiotropism. They tend to grow close to the surface of the ground, some even being closely pressed against it. The stimulus for this type of growth is to a large extent due to internal factors, but it is also certain that some external conditions, strongly-favour the induction of this feature. It may be noted that sandy soils are particularly rich in these forms. In these situations one frequently finds mat-like species of *Stylidium*, and the round and firm cushions of many Goodeniaceae (*Leschenaultia formosa*, *Scaevola pulvinaris, Sc. paludosa*, and others (Fig.39). The branches of some members of the Sterculiaceae may be observed to radiate out along the ground. Another plant of very restricted range (but nevertheless import as one of the most peculiar endemics of the south west) which closely adheres to this type of growth is *Emblingia calceoliflora*. This is the only taxon in the Capparidaceae and it is found only in the Irwin district. It resembles in a surprising manner certain species of *Scaevola* having the same type of stem, and covering the ground with its mosaic of leaves in a similar fashion.

Somewhat different in mode of growth but similar in so far as the final form is concerned, are many of the more diffusely growing members of the Proteaceae. Thus, certain varieties of *Petrophila longifolia* (Prot.) become reduced to dwarf bushes by shortening of the internodes, and often at the same time they show a considerable increase in width. The same tendency is present but is more pronounced in the Banksias. Again, in *Dryandra nivea* (one of the most common plants of the Jarrah zone) the stem and all the branches creep horizontally. But even more striking are the prostrate creeping species of *Banksia* itself, particularly as one does not expect to meet such dwarfed plants in a genus of trees and bushes. The much-branched axis in these cases also grows along the ground supporting the bush-like clusters of leaves at intervals. Here and there a club-like inflorescence rises out of the sand and stands there without any enclosing leaves as if it were a separate plant. The apical growing shoot arises from the axils of the top-most leaves and the growth of the axis continues sympodially. The conditions of growth resemble therefore those of our northern rhizomic plants, except that in these warm regions the plant is not embedded in the earth but keeps growing on the surface of the soil. In Australia this prostrate habit of growth results in the vegetatively active parts of the organism developing under more humid conditions since the higher strata of the atmosphere are drier due to the more active air movement. This is at least the conclusion to be drawn from the frequency of such types on permeable sandy soil and in regions of scanty rainfall. They only occur in considerable numbers where the annual rainfall sinks below 50 cm.

Fig. 39. Polsterwuchs bei *Scaevola humifusa* De Vr. var. *pulvinaris* E. PRITZEL (Original).

Similar forms of growth are produced through wind action in coastal areas. A wind-caused more or less horizontal growth form is widespread on the coast of Western Australia as elsewhere on the earth. Branching takes place at the ase of the main axis and the branches remain in a horizontal position close against the ground. Some Westerns ustralian species have permanently adopted this form of growth – e.g. *Grevillea crithmifolia* in the region of the Swan River and a peculiar low form of *Casuarina distyla* species which is common on the dunes about King George Sound. This species is quite conspicuous once its red-brown male catkins appear.

Temperature effects which play a role (in northern countries and in higher southern latitudes) in the creation of cushion mats, turf, and rhizomic growths are not of much consequence in Western Australia. A part of the Wandoo zone is an exception in this respect and I have found that the temperature conditions during the cooler part of the year exert an influence on the vegetation there. These are the regions where marked night frosts are experienced in the winter with quite low temperatures being recorded. Cushion-like forms are particularly common there, examples being *Leschenaultia formosa* and *Scaevola humifusa*. The most outstanding examples are two members of the Leguminosae, *Acacia congesta* and *Kennedya microphylla,* which belong to genera which otherwise show little tendency to this form of growth. The hard cushion of *K. microphylla* will surprise everyone who is familiar with its relations, eg. the slender climbing plants found along the coast. No less remarkable is the effect produced by *Acacia congesta* with its low compressed complicated branches, because it is the only example of this form of cushion-like or low prostrate growth amid the tremendous diversity presented by the western Acacias.

c. *Stems*

The trees of the Southwest Province are mostly characterized by a strong development of bark. Jarrah, *Banksia* and *Casuarina* species all agree in this respect, their trunks exhibiting rough and cracked bark on the surface. They follow the rule, therefore, which holds good in countries with a periodicity in climate, and in particular resemble the trees of the drier monsoon regions. *Eucalyptus diversicolor* is an exception. Here the bark is not retained, to become thicker and thicker every year, but is shed soon after formation so that the cortex is to a great extent freely exposed. One might assume that this condition was determined by the greater uniformity of the temperature in the Karri area. Schomburgh for instance in this connection referred the smooth grey bark of the south Australian trees to the slight atmospheric changes. I consider, however, that this explanation is impossible in the case of Karri. Neither will it account for the smooth cortex which occurs on Eucalypts of the interior of Australia, where extraordinary variations in temperature take place. The formation of the bark does not depend therefore, to any large extent upon the peculiarity of the climate, but is determined by the specific genetic constitution of the species. As a matter of fact F. von Müller has utilised the structure of the bark as a taxonomic character within the genus *Eucalyptus*.

In-so-far as shrubs are concerned one also finds that marked bark formation occurs. Tiny shrubs, only about half a metre high, sometimes show this feature. Thus in the case of *Petrophila media* (Prot.) for instance, a thin greyish-white coloured bark layer is present even in the relatively young stem parts.

A remarkable peculiarity of many plants which grow in sandy areas of south Western Australia lies in the great production of cork at localised places on the axes. Sometimes it is at the axis of the inflorescence as in several Myrtaceae (*Calothamnus* and *Melaleuca* spp.). It is, however, much more common at the base of the shoot at soil level, i.e. at the junction of the root and shoot. Histological details would take us too far here - suffice it to state that the result is always the same, a more or less thick mantle of large-celled cork at the zone of contact between plant and ground. This feature is very wide-spread amongst the small shrubs and subshrubs of the sand heaths. I do not believe that I would be far wrong if I estimated that 75% of the species growing there whether related or not, possess such "basal-cork". Purely to illustrate the systemaic diversity of such cork formation a few excellent examples may be mentioned, eg:- *Daviesia quadrilatera* (Legum.), *Hibbertia conspicua* (Dillen.), *Verticordia grandiflora* (Myrtac.), *Calythrix brevifolia* (Myrtac.), *Logania flaviflora* (Logan.) and *Scaevola restiacea* (Gooden.). There is not the slightest doubt that the above feature is an adaptation to the environment but I do not know how to explain the circumstances. Perhaps the function of the cork may be explained on the "heating up" theory. The surface of the ground suffers enormous heating-up on the completely unprotected sand heaths where trees are lacking. The air temperature reaches a maximum of 45-46°C almost every year, and from this one may assume that the intensity of the heating up, which the loose sand undergoes by direct radiation is very high[1]. It is just that part of the plant between shoot and root which is subjected to this hot soil where the corky layers develop. Perhaps the corky tissue acts as an insulating device to protect the xylem bundles from overheating.

d. *Leaves*

Time of appearance. The origin and development of the vegetative organs is related to the onset of the rainy periods. Being dependent upon the rate of increase in sap flow and thus upon the supply of water to the roots, the formation of leaves takes place earlier in shallow rooted plants than in those with a deep root system. The absolute time of leaf development is naturally determined partly by the specific genetic constitution of a plant and partly by the general climate of its environment. It follows, therefore, that in the north western part of the province, leaf formation begins and is completed earlier than in the southern part. Thus in the Swan River district at the end of May - after about three

1 Measurements are not given. I was not so healthy on extremely hot days.

weeks of opening rain - only the herbaceous types shows any obvious vegetative growth. However, in the Irwin River district at the beginning of June I saw considerable growth activity in many shrubs. Specimens of *Grevillea amplexans*, the psammophyllous bushes of *Acacia aureo-nitens* and others, had developed a rich growth of young foliage by the 9th of the month and the young shoots of *Eremophila Oldfieldii* had reached a length of 10 cm. In the more southern landscapes the vegetative growth only rose to its maximum intensity in the second half of the wet season. In September and October most bushes show a strong development of new shoots. Further south again on the south coast the production of new leaves commences still later and then continues far into the dry season. In November one sees leaf growth well developed everywhere. During this month I found *Hakea trifurcata* for example, with new shoots about 5 cm long. By about the New Year most growths had reached their mature shape and size and with the exception of some in climatically favoured places, had entered upon the dormant summer period. By comparing the two appearances of *Acacia barbinervis* shown in Figure 40, one may get a good idea of the course of vegetative growth.

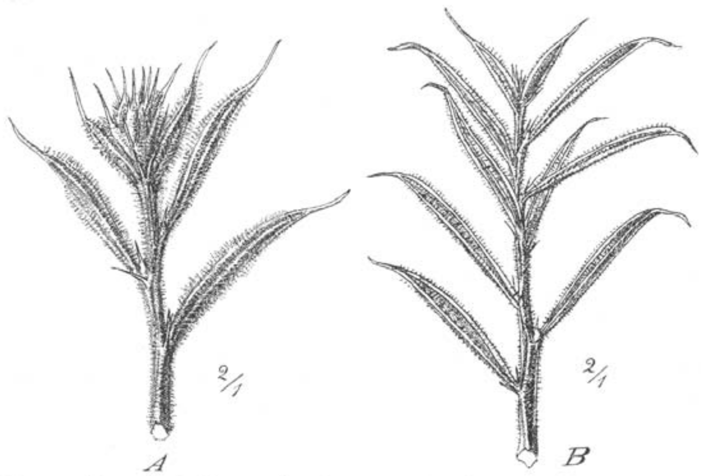


Fig. 40. Entwickelungs-Stadien der Sproß-Spitze eines Zweiges von *Acacia barbinervis* Benth. *A* am 27. Dezember 1900 im Wachstum begriffen. *B* am 6. Februar 1901 mit vorläufig abgeschlossenem Wachstum (Original).

Leaf buds. Ecologically speaking, leaf buds and young shoots are usually well protected, in a very varied form according to their specific morphological type.

When Schimper (Pflzgeogr. 543) emphasized the rarity of a protective envelope of scales on the vegetative buds of sclerophyllous plants his generalization went further than was permissible. He states “The great frequency of scaleless buds is readily comprehensible, for the buds require no protection against drought during winter, seeing that they are formed in summer and may therefore dispense with a hard envelope. The necessary protection is afforded by hairs, coatings or resin, etc.” Neither of these statements is correct. The typical sclerophyllous, “winter rainfall” vegetation of south western Australia provides many examples of scale-covered buds. Thus if one examines in August, *Acacia sulcata* a species found on the south coast, one will find the young shoots sprouting from the axils of moderately thick brown bracts. *Melaleuca uncinata* (Myrt.) and *Hakea ruscifolia* (Prot.) likewise show yellow-brown bud scales. These two examples are mentioned here because they are such common plants of the south western flora. The sprouting leaves consist chiefly of delicate chlorenchyma which is often masked by anthocyanin-like substances. Sclerotic elements which become so important later are almost entirely absent at this stage.

In this sensitive condition the new leaf thrives without any protection, e.g. *Grevillea Wilsoni* (Prot.). This creates a remarkable impression where xeromorphic plants are concerned, the foliage of which is destined to become stiff and almost as hard as wood. There are such plants, however, and I have met this kind of contrast between the early and mature stages of both *Acacia spinosissima* (Legum.) and *Grevillea tridentifera* (Prot.).

In other cases only the anthocyan-pigment is present to shield the tender and soft new leaf. It is to this that the eucalypts owe the bright colour of their crowns at the time of early leaf development. Members of the Leguminosae (*Daviesia crenulata*), and Proteaceae (*Adenanthos cuneatus*), also herald the arrival of spring with bright red colours.

By far the most common character of the young leaf is the covering of hair. These hairs develop early and are actually present before the green tissue commences functioning (See Fig. 40). The acacias (Fig. 40), very many members of the Proteaceae, the hibbertias, and a number of the less gregarious and smaller genera, all exhibit a hairy covering on the newly sprouting vegetative shoots. Silky glancing leaf-tips give the crowns of the acacias their peculiar play of colours in the favourable season of the year. In general, the contrast between the naked and smooth mature stages and the coloured felt-work and wool of the new shoots is very marked. In many forms of *Eremophila Brownii*, the tips of the twigs are snow-white due to the new foliage and one can immediately recognise the new season's growth thereby. Again one form of *Acacia*, *A. alata* R.Br. (*A. biglandulosa* Bth.) has the young shoots so closely covered with stiff white hairs that they stand out sharply from the dark green older branches. Many of the Grevilleoideae (Prot.) are distinguished by the rusty-coloured coating of the young parts. When one thinks of the light colours of the rejuvenated summer woods of our northern home a strange impression indeed is created by the sight of the young foliage of *Hakea*. It is completely covered with yellow silky wool, while the veins and margins are clothed with bright red-brown hairs (*Hakea cinerea*).

If instead of a covering of hairs the indumentum consists of glands then their secretions surround the young leaves and stick the bud together. Also something similar takes place with eucalypts with the new growth is covered in resin.

The full grown leaf. The mature leaf of Western Australian plants functions for several years. The entire sclerophyllous flora is evergreen. Only one or two lianes, which are evidently tropical derivatives, lose their leaves at the commencement of the dry season and regain them when the next rains begin, eg. *Dioscorea* and *Clematicissus* (Vitac.). In this almost complete evergreen character of the flora there is an essential difference from the flora of the Mediterranean region. The explanation lies more in the floral history than in the climatic conditions.

Otherwise the main features of leaf development in south western Australia present the usual characters of sclerophyllous vegetation. These characters have been described more than once so that there is no need to go into detail here. Only a few points require more extensive treatment because our province (on account of the typical nature of its climate) always deserves special attention when reference is made to winter rain regions.

Rob. Brown noted that the position taken up by the assimilative organs in Western Australian plants usually ran parallel to the direction of the sun's rays. His observation has often been repeated and the mechanism which leads to this position has been described. In south west Australia by far the greatest number of species follow this rule but there are exceptions, which show that the plants of Australia have not altogether lost all ability to react. The mesophyllous flora in the south of this province provides many examples illustrating this. The genus *Eucalyptus* itself shows distinctly how the tendency to react is expressed. *E. calophylla*, whose area of distribution stretches across the moderate temperate zone of the province has its leaves directed almost horizontally. Its beautifully flowering sister species, *E. ficifolia*, which grows naturally only in a small area in the extreme south, reacts in a similar fashion. The characteristic species of the southern forests, *E. diversicolor*, also shows by the bifacial structure of its leaves that the upper surface of the latter utilizes more light than the under surface. The same feature is even quite noticeable in the case of Jarrah, although it is not so marked as in Karri. The same tendencies may be observed in the plants forming the undergrowth of the tree layer, and the effects are rather more far reaching. Many Rutaceae (*Chorilaena*), many Sterculiaceae (specifically the genera *Rulingia* and *Thomasia*), and the genera *Tremandra*

(Tremandrac.) and *Hibbertia* (Dillen.) serve in the southern forests as excellent examples of "euphometric" leaves and bifacial leaf structure.

At the same time the leaf area also reaches quite a considerable size. In the rest of the south western vegetation the leaf conforms to the general sclerophyllous type. Occasionally it may be moderately large but usually it is small. "Moderate size" leaves occur in many species of *Hakea* (eg. *H. Baxteri*, *H. amplexicaulis*) and certain species of *Eucalyptus* (eg. *E. macrocarpa* and *E. Preissiana*) These stand out because the size of the leaf appears quite out of proportion in this region and gives the impression of an old inherited character which has not adapted itself to its present environmment. The size of the leaf is usually strongly influenced by the general adaptational effect. Its gradual reduction in size leading to its total disappearance can be followed step by step in very many species in the south western flora. This will be discussed in greater detail below.

The leaf of the sclerophyllous plant is usually considered to be insufficiently divided, and it has been asserted that sclerophyllous leaves are almost never compound. An adaptational investigation of suitable cases, which might throw valuable light on this problem has yet to be made. Judging by the conditions which one finds in the Western Australian scene, the high degree of correlation that has been asserted to occur between leaf segmentation and sclerophylly, does not exist, or at least it is scarcely adequate. Families which in general have the tendency to form complicated branched foliage should undergo simplification in Western Australia. This, however, does not happen. The genus *Clematis*, many members of the Leguminosae, Rutaceae (*Boronia*), Vitaceae (*Clematicissus*), Sapindaceae (*Dodonaea*), and the ferns of the region all possess pinnate leaved species in Western Australia. The other groups, however, never show any tendency towards stronger leaf division.

On the other hand, as already mentioned, limiting factors of all kinds come into play with increasing xeromorphy. This includes that peculiar interference with the unfolding of the leaf which leads to the development of "rolled leaf". Each of the large families of the region contain many examples. The genus *Grevillea* presents many variations in structure. Sometimes the mid-rib on the underside of the leaf is not raised, only a depression being present (eg. *G. oxystigma* var. *acerosa*, Fig. 38B). On other occasions it is well developed and divides the depression into two parallel grooves (eg *G. pinaster*, *G. Hueglelii*). The whole story is repeated again and again in the flora of south-western Australia in the case of both simple and compound leaves, and in the same form as in other floras.

Ericoid and pinoid leaves are unusually widespread (Fig. 41A,B) as will be seen when we come to the descriptions of the communities. The term ericoid is somewhat vague and examples turn out to be rather dissimilar when more closely examined from the genetic point of view. The term is of value, however, in regard to physiognomy and is useful in making a survey of the cases of convergent forms. The ericoid type of leaf is particularly widespread in the Epacridaceae, Myrtaceae, and Rhamnaceae, but there is no important family of dicotyledons in the region in which it is not represented.

A similar and yet to a certain extent divergent direction of evolution leads to the pinoid leaf, which is present in the flora of our province in a rich variety of forms. It culminates in those cylindrical stiff thorny structures which have almost entirely lost their leafy nature and in ecophysiological terms, function as no more than axes. In south-western Australia the genus *Daviesia* shows this condition. In Bentham's section Teretifoliae, there is no longer any difference between leaf and branch except the limited growth of the former. Functionally the assimilatory parts of the twigs and the stiff pinoid leaves are equivalent. In fact the leaves of *Daviesia hakeoides* particularly, as they remain very short, are even less important than the twigs in this respect. The family Proteaceae has developed form counterparts to the thorn-like needle leaves of the daviesias. This is particularly evident in the genus *Hakea* (Fig. 42). The phyllodes of *Acacia* also occasionally take on a similar form. In all cases the extreme reduction of the surface has an effect on the position of the organ, and where no longer any broad surface is exposed to the light, the vertical position is unnecessary. The typical pinoid leaves then tend to arrange themselves at right angles to the axes from which they arise, and to stick out stiffly from them.

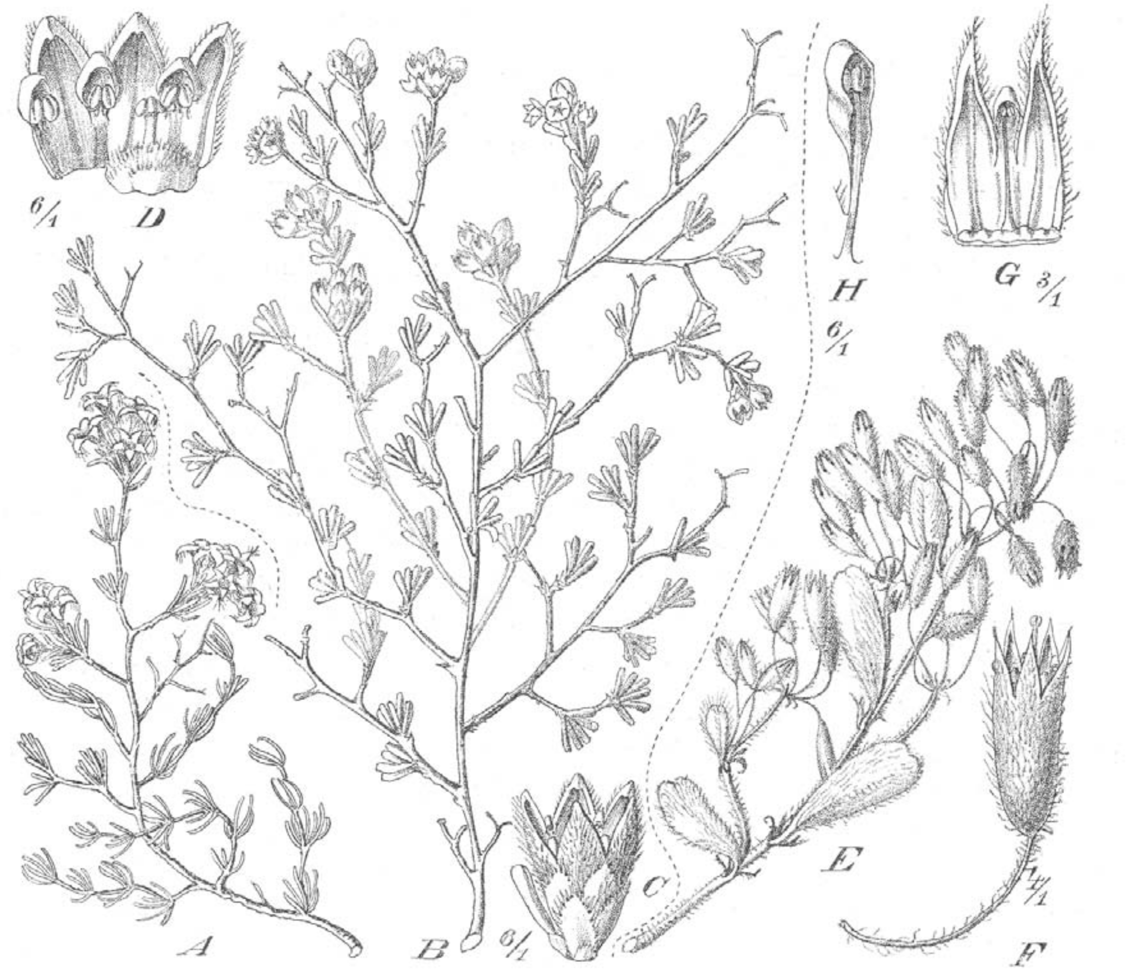


Fig. 41. *A Cryptandra leucopogon* Meissn. Blüten-Zweig. — *B—D Cryptandra polyclada* Diels: *B* Habitus. *C* Blüte mit Bracteen. *D* Teil der Blüte ausgebreitet. — *E—H Stenanthemum gracilipes* Diels: *E* Blüten-Zweig. *F* Blüte. *G* Teil der Blüte ausgebreitet. *H* Blumenblatt.

The physiognomic effect of this is considerable. The strongly reduced leaves which are present in the genus *Daviesia* and other genera are the fore-runners of complete aphylly. The leafless condition is widespread in the vegetation of south Western Australia. This is not leaflessness in the strict morphological sense, but regarded from a physiological point of view, the functions of the leaf have been taken over by the green stalks. There is some interest in knowing the taxonomic diversity of these aphyllous classes and consequently the following list is given of the most important groups or genera in which the feature occurs:-

Restionaceae	*Leguminosae -Acacia*	*Loudonia* (Halorag.)
Corynotheca (Liliac.)	*Boronia* (Rutac.)	*Trachymene* (Umbellif.)
Thysanotus (Liliac.)	*Tetratheca* (Tremandr.)	*Samolus* (Primul.)
Casuarinaceae	*Comesperma* (Polygalac.)	*Logania* (Loganiac.)
Santalaceae	*Calycopeplus* (Euphorb.)	*Anthocercis* (Scrophul.)
Macarthuria (Phytolacc.)	*Psammomoya* (Celastrac.)	*Opercularia* (Rubiac.)
Conospermum (Proteac.)	*Stackhousia* (Stackhousiac.)	*Scaevola* (Gooden.)
Leguminosae - Podalyrieae many spp.		*Hibbertia* (Dillen.)

The degree of occurrence of aphylly in the above list is very variable. Many groups are almost entirely made up of leafless forms, eg. the Restionaceae, the Casuarinaceae, and the genera *Exocarpos* (Santal.) and *Psammomoya* (Celastr., Fig. 43). Others on the contrary consist for the most part of normal leaved species, the leafless examples being extremes which occur only once. Examples are *Hibbertia conspicua*, *Conospermum Eatoniae* and *Boronia spinescens*. There are many groups occupying intermediate positions between these two main types.

The adaptation of complete leaf reduction is also unequally distributed amongst the chief divisions of the south western flora. In some it is frequent (eg. Leguminosae), but in others it is rare (eg. Proteaceae). In others again it is not seen at all, eg. in Epacridaceae, Sterculiaceae and Myrtaceae. What determines such differences still remains an unsolved problem. Notwithstanding this, however, some comment is desirable.

Those groups which have developed only a few or even only a solitary aphyllous form, exhibit their greatest diversity where the conditions are most favourable for mesophytes. This holds good in particular for *Boronia* (Rut.), *Tetratheca* (Tremandr.) *Hibbertia* (Dillen.) and *Logania*. We can here trace the evolution of the aphyllous forms from those with assimilatory leaves. The forms are the most strongly xeromorphically modified types. This, however, does not imply that the opposite direction of development is impossible.

Many species, native to the Eremaea have spread westward and some of these have been altered adaptively. These connections make it possible to explain certain ecological features of the south west flora. E. Pritzel (Fragm. Austr. occ. p. 283) referring to the genus *Acacia* stated that “in the shady mountain forests of the south west are some species which are related to xeromorphic types and are perhaps derived from them. Following the environmental conditions of high moisture and shade these original xerophytes developed either large and flat phyllodes (*Acacia urophylla*, *A. obovata*) an entangled mass of delicate branchlets, (*A. extensa*), or leaf-like winged stems (*A. diptera*, *A. alata*, *A. stenoptera*). The habitat of these species of high moisture and shade along the western side of these mountain forests does not seem to permit any other explanation. Besides, the stem wings mentioned do not possess xeromorphic features.”

I attach similar significance to the occurrence of such peculiar cases as *Acacia insolita* (Fig. 44). This is a “phyllodinous” species which however, also possesses many pinnate leaves. These are an indication of the influence of their environment on them. Examples occur in the forest in the region of the Blackwood River. It is not possible, however, to discuss these occurrences in greater detail here and so they will be further examined later on.

The external appearance of the leaves of the plants of the south west is influenced also by the nature of the epidermis. There are various types. The mesophyll types which have already been mentioned on several occasions may be separated out from the general assemblage first. Apart from certain constitutionally peculiar elements as in many eucalypts for example where the glossy epidermis is uncommon, in the great majority of cases it is the rule that the leaf is enclosed within a single layered, thick, or even very thick-walled epidermis with stomata on both sides. The nature of this wall gives to the leaf its pale dull appearance. This grey or opaque tone of the green which is common to all the winter-rain vegetation formations of the earth, give it a peculiar appearance. This feature is present in the highest degree in the vegetation of south-western Australia. It is responsible for the strongest and most vivid impression its vegetation makes upon the casual visitor.

Relatively rare is the enhancement of the protective nature of the epidermis by wax-like secretions as effective physiognomic means. It is a feature, however, which is seen in many Acacias eg. *A. bivenosa*, and is strongly marked also in *Eucalyptus macrocarpa* and *E. tetragona*. Both are large leaved species of the genus and with their blue-white “frosted” leaves are of considerable importance on the sand heaths of the interior.

There are also secretions of resin-like substances which are of some importance in relation to the ecophysiology of the leaf. The distribution of such plants is, however, much more limited in the Southwest Province than it is in the Eremaea; in fact one meets them essentially only in the landscapes of the interior. These secretions cover the leaves of many species of *Petrophila* (e.g. *P. plumosa*) with a fine coating and they are to be found also on some species of *Acacia*.

Of other epidermal appendages the presence of hair is one of the most common features of the young leaves in south Western Australia The absence of such hairs on the fully grown leaves is therefore all the more striking. It is true that the sclerophyllous plants of other countries show little tendency towards hairiness (see Schimper, Pflzgeogr. p. 542), but the other elements of these floras are still richer in tomentose growths. In south-western Australia on the other hand their number is never important. All of the large families do possess some tomentose forms (*Grevillea*, *Jacksonia*, *Acacia* and *Kunzea* for example), while in the Sterculiaceae they are even more common. Here the undersides of the leaves in particular, are at times furnished with extra hairy growths. But relatively speaking the total is small. It is only in the country bordering on the Eremaean district or on the barren heaths, where the Verbanaceae with true felty plants (*Lachnostachys* and others) are more numerous, and where many strongly haired species of the Goodeniaceae grow, that there is occasionally a situation which is faintly reminiscent of the role played by the felty Tubiflorae of the Mediterranean countries.

Apart from the true mesophytes, the leaves in the Western Australian flora is dominated by the centric type of structure. The isolateral arrangement of the tissues is the rule.

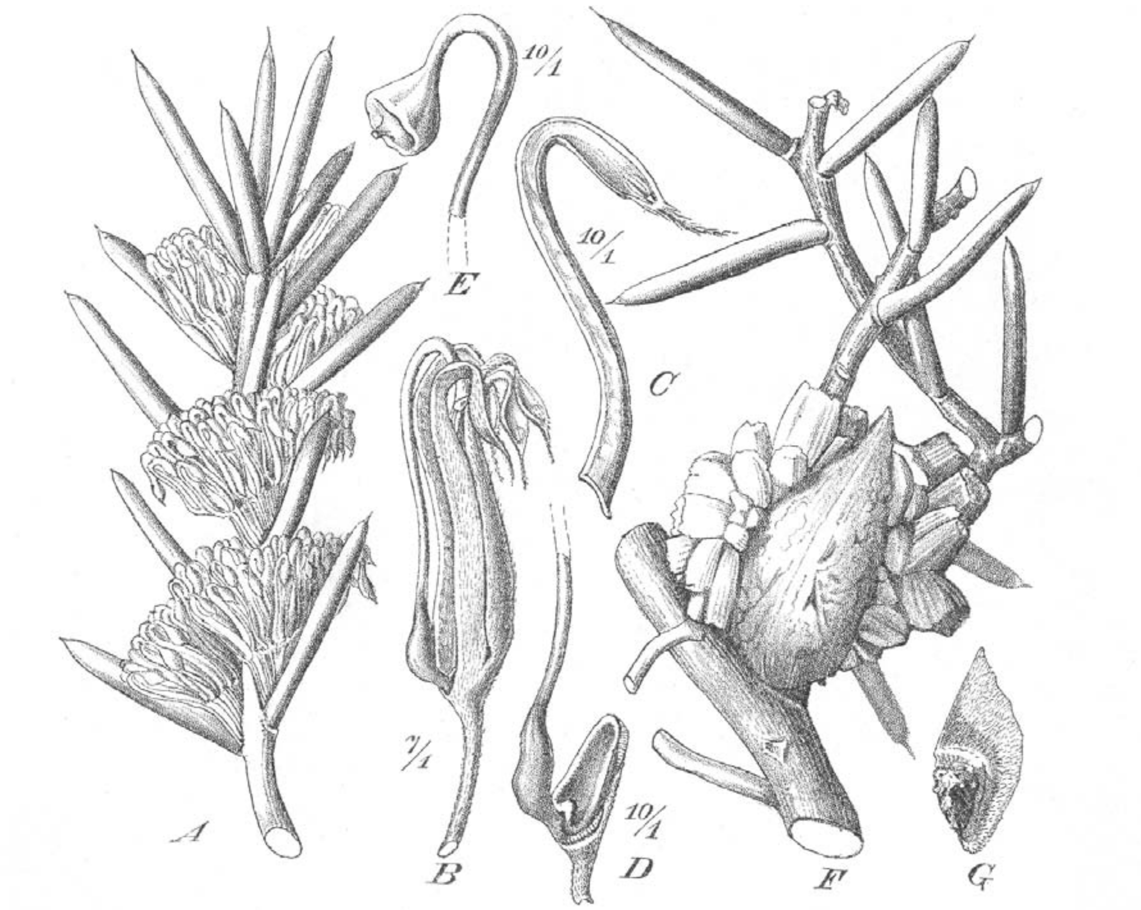


Fig. 42. *Hakea Brookeana* F. v. M.: *A* Blühender Zweig. *B* Blüte. *C* Perianth-Abschnitt. *D* Discus und Ovarium. *E* Oberer Teil des Griffels. *F* Fruchttragender Zweig. *G* Samen. (Nach DIELS und PRITZEL.)

An important plant of the South Western Province, *Melaleuca Preissiana* shows the following arrangement of leaf tissues (Fig. 45B). A single layered epidermis is present with a strongly thickened outer wall. The stomata are sunk to the depth of this wall and little cuticular horns are present. Two typical layers of palisade tissue occur, one against each surface of the leaf and they are separated by a sharply delim-

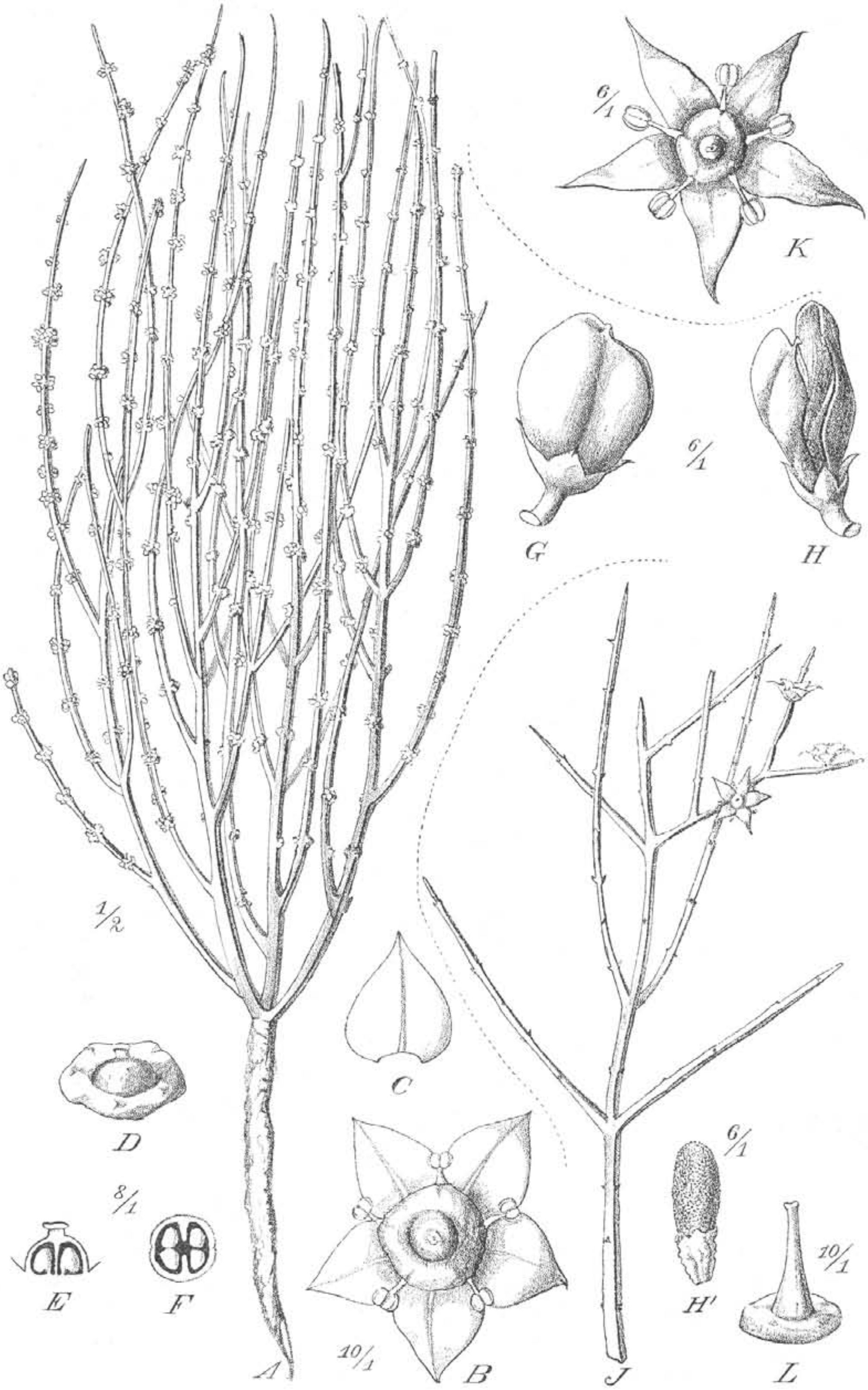


Fig. 43. Aphylle Arten: *A—H Psammomoya choertroides* (F. v. M.) Diels et Loes.: *A* Habitus. *B* Blüte. *C* Blumenblatt. *D* Discus und Gynaeceum. *E, F* Ovarium durchschnitten. *G, H* Frucht. *H'* Samen. *J—L Psammomoya ephedroides* Diels et Loes.: *J* Habitus. *K* Blüte. *L* Discus und und Gynaeceum. (Nach DIELS und PRITZEL.)

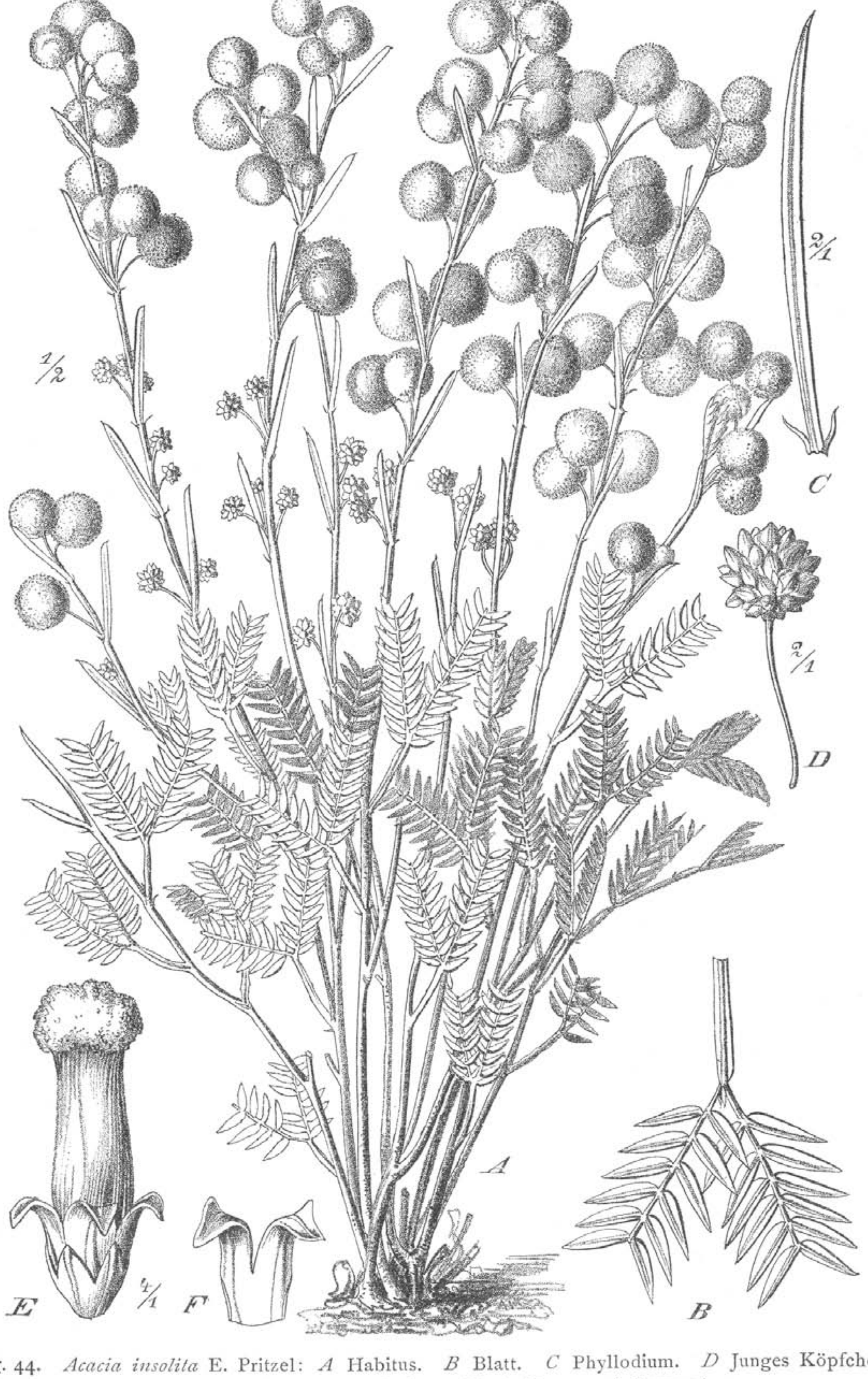


Fig. 44. *Acacia insolita* E. Pritzel: *A* Habitus. *B* Blatt. *C* Phyllodium. *D* Junges Köpfchen. *E* Blüte. *F* 2 Kronabschnitte. (Nach DIELS und PRITZEL).

ited chlorophyll-free middle layer. The vascular bundles are embedded in this middle layer, each with moderately well developed phloem elements.

In addition to this, large oil glands are frequently present. These are also useful as a taxonomic character. Such a type of leaf histology with the exception of the oil glands may be taken as the average type of the south western vegetation. It is found with slight variations in very many groups in the most widely different members of the Myrtaceae. Thus a very similar type is present in the flat-leaved *Calothamnus*, in *Eremaea* and others. It is also found in the phyllodes of numerous Acacias (*Acacia microbotrya*, Figure 45A) and *A. acuminata*, in the leaves of many Hakeas and and other genera of the Proteaceae, e.g. *Stirlingia latifolia*. It is thus found in the most important and most polymorphic elements of the flora.

Naturally owing to the climatic diversity and the species richness in this country, all sorts of variations are to be found. It will suffice for our purpose if only those which are basically important are mentioned and only those tendencies traced which arise from them. The epidermis as a rule remains a single layer and it is really remarkable how seldom a two or more layered epidermis occurs. In some species of *Daviesia* for example I found a double layered epidermis but I have not met with any cases of strongly developed epidermal water-retaining tissue. It is of course a matter of fact that this effect does not occur commonly in other winter rainfall regions. The greatest differences in the epidermal tissues lie in the quantitative development of the strata of the outer wall. However, in hard xeromorphs it reaches a high point, particularly in the Proteaceae (*Hakea platysperma*, Fig. 46B,C) and in the Myrtaceae. Extreme examples in the latter family are represented by *Melaleuca uncinata* and *Eucalyptus Preissiana*. In such examples the stomata come to lie in deep slot-like depressions. This wall thickening is in other respects only an expression of the general cellulose deposition which occurs in xeromorphs.

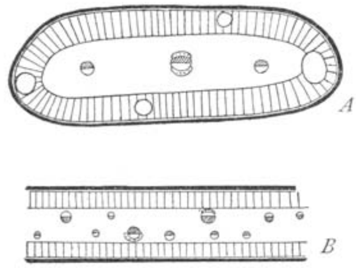


Fig. 45. Schematische Darstellung einer typischen Form des Blatt-Baues in der Südwest-Provinz: *A Acacia microbotrya* Benth. *B Melaleuca Preissiana* Schau. (Original).

The variations in the structure of the internal parts of the leaf are more extensive. In this respect the relation of the chlorenchyma to the "middle layer" is important. In its typical form this "middle layer" is a pith-like tissue. As such it has undergone a particularly far-reaching development in *Daviesia pachyphylla* (Legum., Fig 46A). In this unusually stiff plant it consists of thin-walled parenchyma, similar to the well-known Elder pith cells. It occupies by far the greatest part of the leaf. It is almost certain that it functions here as an internal water storage tissue. This view is strengthened by the fact that the cylindrical pointed leaf has a succulent appearance. A peculiar and similar formation is found in *Hakea clavata* (Prot.), and here also the leaf is swollen, firm and fleshy through the hypertrophy of the "middle layer" which contains no chlorophyll. Such cases show distinctly (on account of the widespread distribution of plants with less strongly developed "middle layers") that we have been in error in denying the presence of water storage tissues in the sclerophyllous flora. Only the epidermal water mantle is rare. An internal water reservoir on the contrary is present often enough. Water storage tracheids are very widespread, their only limitation being due to the frequent change in function of the middle layer, whereby it serves for translocation rather than for water economy.

Very often starch may be found precipitated in this tissue; it is used up later in the growth of the new leaf. In the above type, described as the typical leaf form (Fig. 45) the middle layer is sharply marked off from the green tissue. In other related types, however, the two tissues pass gradually into each other, while in others again there is no middle layer at all without chlorophyll. In these cases one observes only a mass of loose cells with a small number of chlorophyll containing cells in the middle, and on both sides of this the layers of the true assimilatory tissue. *Calythrix* (Myrt.) and *Isopogon scabriusculus* (Prot.) for example, show this feature. On the whole the green tissue consists of typical palisade cells, without any very obvious difference being visible between the various layers of the leaf. This is the case in *Eucalyptus occidentalis* and many species of *Grevillea*. Finally there is a type where the strict palisade-like character of the outer cells is reduced and a loose mass of apparently undifferentiated chlorenchyma comes to exist (as in *Daviesia cordata* (Legum.) and *Adenanthos obovatus* (Prot.).

The relative proportions of chlorenchyma and of tissue not functioning directly as assimilatory tissue are naturally of importance in determining the character of the leaf. Very often in the more xeromorphically altered species a modification counter-productive for green cells occurs in that many of them become transformed into sclereids. Often the green tissue is seen to be influenced *ab initio* [from the beginning] by an intrafoliar reduction of the assimilating area. When the representatives of the polymorphic genera of Western Australia are compared in this respect, all stages in the development of this character are met. In this connection it is not so much the conducting elements as the storing and supporting tissues which relatively show the greatest increase. In extreme cases the vascular bundles rich in sclerid tissue, become crowded so that there are only short distances between them. The whole of the interior of the leaf appears as if divided into chambers. Examples include *Eucalyptus macrocarpa*, *E. pyriformis* (Myrt.), *Daviesia Croniniana* (Legum.) and *Hakea platysperma* (Prot.).

Very frequently the sclerotinization of certain cells expresses itself by the formation of idioblasts. They evidently arise through change of function and transformation of green cells. In *Petrophila* this connection is distinctly seen. Presumably the same applies in the case of other members of the Proteaceae. This family is particularly rich in idioblasts and this histological feature is expressed in the peculiarly firm yet elastic consistency of many species of *Isopogon*, *Hakea*, *Dryandra* and *Xylomelum*. The sclerome elements are also strongly developed in other groups. The fact that no particular mechanical needs are served thereby, but that the development is purely a xeromorphic modification is already known in other regions (See von Goebel, Paramos - Vegetation).

The oil glands of the Myrtaceae also occur under similar circumstances as those which lead to the formation of elements of sclerotic tissue. They also undergo no reduction but take up an increasing proportion of the volume of a leaf which is becoming more xeromorphic. In the pinoid leaf of *Melaleuca uncinata* (Myrt.) for instance they occupy more than one-fifth of the total volume of the leaf.

One of the most striking features of the xeromorphic character which is shown by the vegetation of south western Australia is the accumulation of cellulose in all organs of the plant. It occurs in the majority of woody plants and leads to the firm or rigid nature of all the leaf organs. Following in its train also is the extensive occurrence of thorns on the branches and leaf organs of plants in the drier parts of the country, or in other edaphically suitable localities. Stipules on many Acacias, tooth-like pointed projections on many members of the Leguminosae and Proteaceae, and even whole twigs as in the Santalaceae, Rhamnaceae, *Acacia* species, and others, become converted into thorns. For our region Schimper's statement that "thorn formations are almost unknown" (in the sclerophyllous woodland formations) does not hold good at all. Even on the coast we find bushes of *Hakea*, *Dryandra* and *Acacia pulchella* growing thickly and forming true thorn thickets on the dry limestone. As we go further inland in the Wandoo woodlands and on the sand heaths, impenetrable rigid growths abound. Everywhere the appearance of the vegetation impresses us with the fact that the metabolic workshops of the plant cannot be easily accessible, being strongly protected on all sides.

e. *Flowers*

Position In most of the plants of the south west, the flowers are terminal or situated in the axils of the young leaves. Flowers are not exclusively confined to the old wood. On the contrary in many members of the Myrtaceae, e.g. species of *Calothamnus* and *Melaleuca* etc., the flowers arise from older internodes and frequently at places which are marked by an extensive development of cork. In certain species of *Banksia* there are also unusual inflorescences. For example the flowers of *Banksia sphaerocarpa* often although not always - develop on short lateral branches never more than 2-4 cm long. These are either leafless or possess very few leaves and arise from the base of the older stems or branches. Thus they develop in the interior of the bush, so that the flowers are almost hidden. This reminds one of the condition of many xeromorphic species of *Brachysema*, (e.g. *B. daviesioides* (Legum.) and allied species), which have a very peculiar appearance. Stiff flowerless phylloclades arise from thick woody rhizomes and alongside them grow quite short stalks bearing crowded flowers.

Flowers primordia. As will be described later (Sect. g) the flowering time for the majority of the south-western plants occurs in the second half of the rainy season. Probably in most groups the development of flower primordia occurs during the dry season; often these flower primordia can be observed rather early. Thus one can observe the tiny heads of *Acacia extensa* already breaking through in January, even though the flowers will not bloom until August. The young inflorescences of *Acacia microbotrya* also are distinctly visible in January. They then continue their extremely slow development and do not bloom fully until the end of May or early June. Examination of *Isopogon scabriusculus* (Prot.) towards the end of May showed that the future flower heads were easily recognizable. It was not until the end of October, however, that they commenced to bloom.

Regarding the differences in the time of flowering, further details are given in the section of this chapter which summarizes the vegetative cycle of the year.

Flower buds. The leafy structures which subtend the flowers do not appear to follow any one type of arrangement in the vegetation of the south west. In isolated cases they are normal leaves in whose axils the flowers arise without the interpolation of further protective floral leaves. This is the case in several species of *Hakea*. It appears therefore that no special protective structure develops round the flower buds. A sheath-like expansion of the base of the leaf occasionally serves for protection. In some cases (as in many hibbertias), the nature of the flower stalk itself is protective. It may also be seen in *Hakea laurina* where it is covered with a velvet-like coat.

More frequently the protective scale leaves of the flower are arranged in an imbricate fashion to form a more or less completely bract-enclosed bud. In the plant kingdom this often results in a distinction being made between the general involucre and the floral involucre, although it is not unusual for both types to occur in the same group. The Proteaceae present a variety of arrangements so far as this feature is concerned. In the genera related to *Petrophila* the relation between the bracts of the involucre and the bracteoles of the single flowers varies from one species to another. This also holds good for other genera of the family. Similar conditions are repeated in *Acacia*. Thus each of the tiny flowers has its own protecting scale but there are species in which the whole inflorescence is surrounded by well developed bud scales. (e.g. *A. squamata*. Fig. 47A). In *Acacia scirpifolia* and some other species such a cover completely surrounds a young twig which bears flowers below and leaves above.

The floral bud scales show a leathery consistency in many members of the Epacridaceae (eg. *Andersonia* and *Conostephium*. (Fig. 47H)). More frequently, however, they are thin, scarious, and brown in colour. The very characteristic bud scales of *Hakea* and *Daviesia* (Fig. 47D), and also those in the numerous species of *Cryptandra* (Rham.) and *Hibbertia* (Dillen.), follow this type. The flower bracts of *Verticordia* are hyaline in character and in many species are of considerable size. These protective leaves are frequently characterized by a covering of hair (*Hakea*, Fig. 12C-E)). In *Petrophila*, in *Hakea costata* and others the covering is to be found on both sides of the leaves so that the buds look like willow catkins.

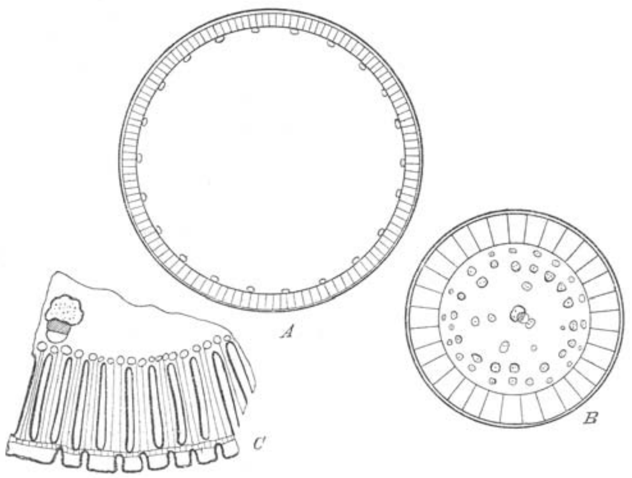


Fig. 46. Schematische Darstellung des Blattbaues bei Xerophyten der Südwest-Provinz: *B*, *C* *Hakea platysperma* Hook. *A* *Daviesia pachyphylla* F. v. M. (Original.)

Very often these protective structures fall off before flowering occurs, but there is considerable diversity here. The quantitative development of these bracts is almost certainly influenced directly by the vagaries of climate. For example I have observed that the buds of *Grevillea* species which occur in the dry interior, particularly on treeless formations, have stronger and more durable scales than do those of their related species which grow closer to the coast. In the case of *Grevillea leucopteris* the characteristic appearance of the shrub is determined weeks before anthesis by the strong development of the bracts. In *G. bracteosa*, which is common in the upper Moore River region, the conspicuous bracts of the inflorescence persist for a long time (Fig. 47E), while those of a related coastal form, *G. Endlicheriana*, remain small and fall off at an early date (Fig. 47F-G).

In more than a few families, however, the enclosing bracts are persistent. The flora of Western Australia is rich in examples where these structures, because of their bright colour or large size, are of service to the plant, not only during but after anthesis (Fig. 48). In the remarkably diversified genus *Conospermum* there is a species (*C. glumaceum*), which presents the most striking and unusual appearance, due to the persistence of large yellowish-white bracts.

A similar condition is also met with in *Johnsonia* (Fig. 48A). Here the flowers are again quite hidden by the large bracts which are white or brownish-red in colour. The strange appearance of some species of *Andersonia*, e.g. *A. colossea* and *A. patricia* (Fig. 48B) is due to a similar feature. Here the bracts are coloured white like part of the corolla. In most cases however, the complete modification of the bracts to look like the corolla is assisted by deep seated modifications to the flower itself. In particular the close association of the flowers to form a crowded inflorescence reduces both the size of the single bracts and of individual flowers to the benefit of the whole. The common envelope becomes more important and takes over to a certain extent the functions which cannot how be properly performed by the reduced sheaths of the individual flowers. The origin of this is clearly seen in the Compositae. Western Australian genera present some good examples. Among these are *Podolepis*, *Waitzia* and *Helipterum*, the “Everlastings” of this country with their splendidly coloured scarious involucres. Since, however, members of the Compositae in other countries have developed similar structures these features alone are of no great importance. But it is much more interesting to see that the same tendency is not only present but even more markedly in purely Australian taxa, e.g. *Pimelea* (Thymel.), (Fig. 48) and *Actinotus* (Umbell.). It also shows in the purely south western groups e.g. *Chorilaena*, *Geleznowia* and *Diplolaena* (Rut.) (Figs 48D, 79, 80) and in *Darwinia* (Myrt.) in particular the involucre both in size and colour has become the most conspicuous part of the inflorescence (Fig. 48D-E).

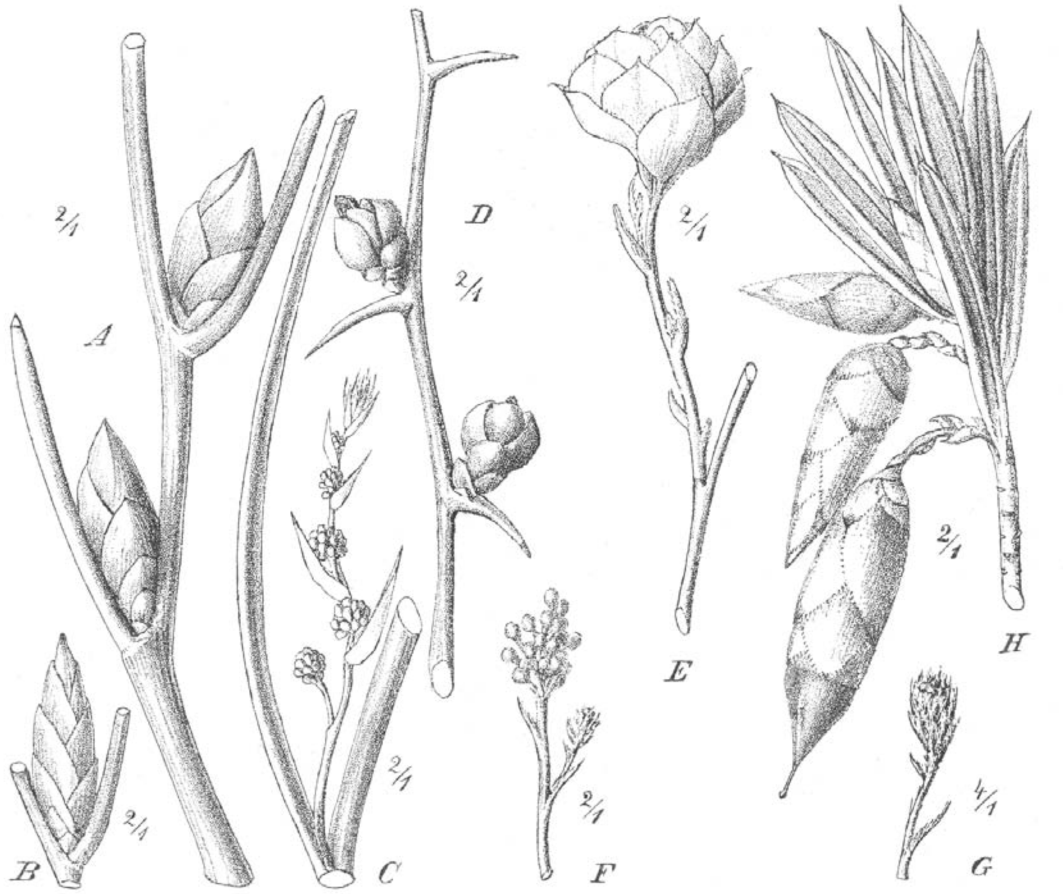


Fig. 47. Knospenschuppen der Blüten in Südwest-Australien: *A Acacia squamata* Lindl. *B*, *C Acacia restiacea* Bth., bei *C* entfaltet. *D Daviesia hakeoides* Meissn. *E Grevillea bracteosa* Meissn. *F*, *G Grevillea Endlicheriana* Meissn., bei *G* die ganz junge, noch bracteate Knospe vergrößert. *H Conostephium pendulum* Benth. (Original).

Reduction of the corolla. In many cases the effects of the above noted gregarious tendency in the inflorescence extend to the corollas of the individual flowers. It is well known how apetaly has frequently developed in the vegetable kingdom as a consequence. This extreme condition however, is seldom reached in Western Australia although a change in emphasis in respect to the functions of the parts of the flower may often be observed. Such a pecularity was strikingly noticeable in the flora of the Cape where reduction of the corolla occurred in favour of the anthers. This same feature may also be observed in south western Australia. While it does not occur in many related families, it is present in two physiognomically very important groups, namely the family Myrtaceae and the genus *Acacia*. It is also most interesting that it occurs in just these groups which in the Cape region are of little or no importance from the physiognomic point of view. It is thus a case of convergence. What external conditions (for they must surely be external) have produced this convergence I am unable to say without making highly speculative statements. However, the abundance of the species concerned, e.g. *Acacia* and *Melaleuca* (which are frequently present in the communities, and in the highly important genus, *Eucalyptus* (which forms all the forests and woodlands) suggest a strong connection with the present dominant environment.

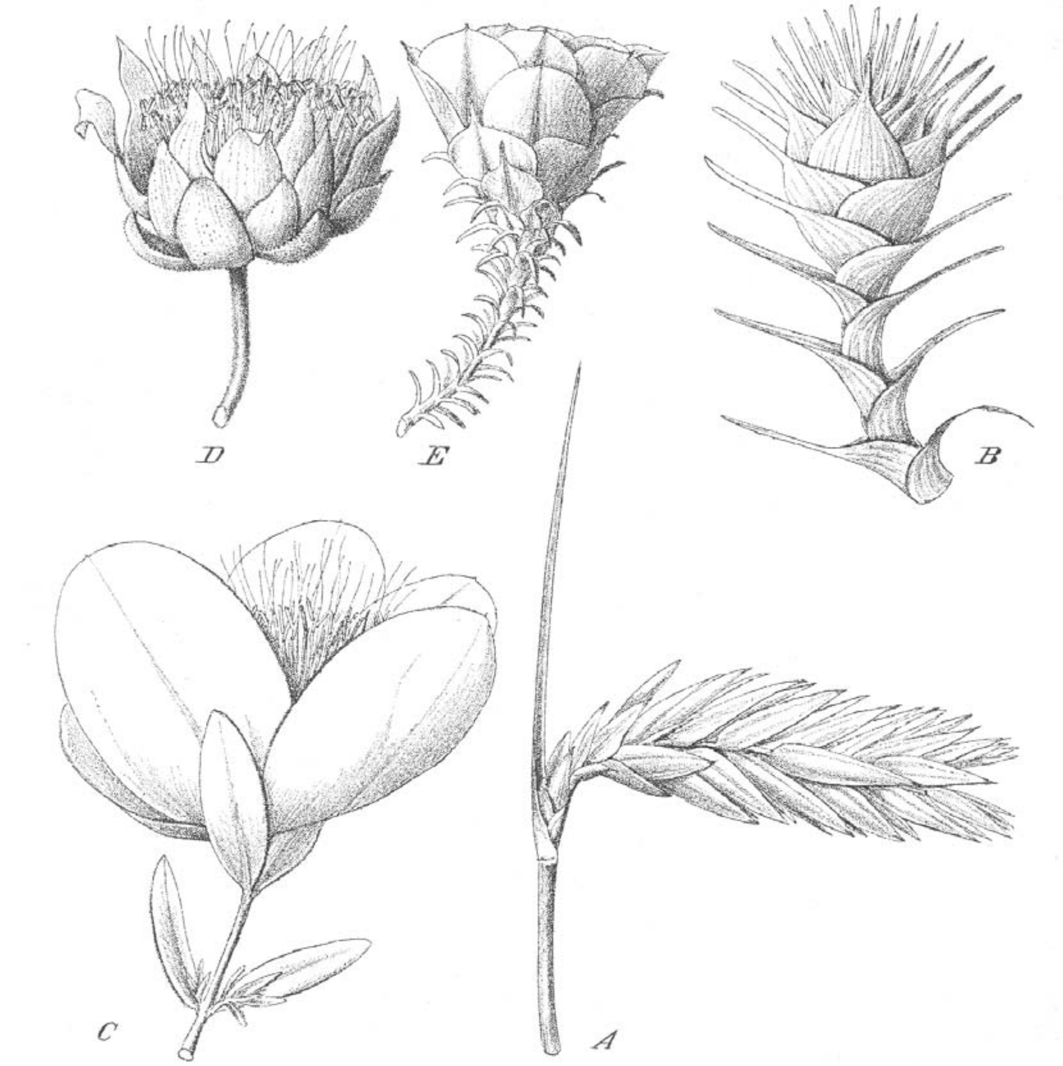


Fig. 48. Corollinisierte Hochblätter als Hüllen der Blütenstände in Südwest-Australien: *A Johnsonia lupulina* R. Br. *B Andersonia patricia* F. v. M. *C Pimelea physodes* Hook. *D Diplolaena Darwinii* Desf. *E Darwinia Meissneri* Benth. (Original).

Flower colour. The colours of the Western Australian flowers are remarkably diverse but they do not all have the same importance from the point of view of overall effect. I do not wish to give any statistics, which inevitably would be very crude considering our present knowledge of flower pigments and their chemistry, but I shall content myself with a brief summary which must be taken as embodying only certain empirical results and which are without physiological pretensions.

Apart from the Restionaceae and Glumiflorae only those elements which are poor in form and less important in the south west Australian flora have weak flower colours, e.g. *Tillaea* (Crassul.), the Euphorbiaceae, and *Cassytha* (Laur.). Most flowers are rich in bright colours. Of the colours present, yellow tones are frequent.

Certain important genera which have many species eg. *Conostylis* (Amaryll.), *Synaphea, Persoonia* (Prot.), *Acacia* (Legum.) and *Hibbertia* (Dillen.) bear only yellow flowers. The group Podalyrieae which is rich in species is dominated by yellow tints sometimes with an admixture of red. In numerous other genera there are yellow flowered species, the following being a few examples representative of this great group – *Banksia* (Prot.), *Drosera* (Droser.), *Calythrix* (Myrt.), *Goodenia* (Gooden.), *Anthocercis* (Scroph.), *Lambertia* (Prot.), *Dioscorea* (Dioscor.) and *Caladenia* (Orchid.).

White is also a colour which is effective physiognomically. It is the dominant colour in the family Epacridaceae. It is also extremely widespread amongst members of the Myrtaceae, especially amongst the gregarious species such as *Leptospermum*, *Astartea* and *Melaleuca*. It is also the colour of many *Eucalyptus* species where, however, it is not infrequently modified by a yellow tint. The family Proteaceae also adds to the army of white flowers, eg. solitary species of *Conospermum*, and a considerable number of *Grevillea* and *Hakea* species. It will be seen from the description in Chapter 5 what an important role in the vegetative scene is played by the white-flowered representatives of these two large genera. In addition to the representatives of these larger families there are many smaller genera and species such as those of the *Rhamnaceae*, and in *Drosera*, *Rulingia* (Stercul.), *Stylidium*, *Logania*, *Burchardia* and *Borya* (Lil.), in which white is either the dominant flower colour or is at least of common occurrence.

The third position in the colour scale of Western Australian flowers is occupied by bright purple or rose-red. This does not dominate whole series of forms as exclusively as does the yellow or white, but it occurs surprisingly frequently in the most different families. It is not widespread amongst the Leguminosae but it does occur. It is of frequent occurrence amongst the Myrtaceae, particularly in *Verticordia*, and all those genera which are related to *Melaleuca*. Other examples where the red colour is present are in *Petrophila*, the Sterculiaceae, *Pimelea* (Thymel.), *Trichinium* (Amarant.), *Tetratheca* (Tremandr.), *Boronia* (Rutac.), *Comesperma* (Polygal.) and *Utricularia* (Lentibul.), and other more isolated forms are also known. They are all important because of the information they supply concerning the relationships of the flower pigments. The well-known variation between purple and blue is to be found more than once in the species belonging to the following genera, *Compesperma* (Polygal.), *Boronia* (Rutac.), *Marianthus* (Pittospor.) and *Thelymitra* (Orchid.) are all genera possessing red and blue pigments in the flowers. The same feature is particularly striking in *Eriostemon* (Rutac.) since the two most common species of the south west bear these different colours. Thus *Eriostemon nodiflorus*, a species of the south weastern heath has bright blue flowers while *E. spicatus* which has a more westerly distribution has rose-coloured flowers.

More important, however, in the south west than this appearance of either the red or the blue colour which is probably controlled by the acidity of the sap, is a less common feature - the relationship of yellow and bright purple. These are two quite constant shades and probably are more or less complementary pigments which appear independently in many groups. In *Trichinium* (Amarant.), in many Myrtaceae (*Verticordia*, *Kunzea*, *Melaleuca*, and in *Pimelea* (Thymel.). In the Proteaceae (*Petrophila* and *Isopogon*) and many members of the Compositae (*Podolepis* and *Helipterum*) they occur constantly together and to a certain extent can reciprocally replace each other. As a consequence of the frequency of the groups named, this anthobiological condition becomes quite important for the whole flora.

At times it almost appears as if these two colours can unite together for in the genera *Eremaea* and *Pileanthus* (Myrt.), brick-red tints are present which correspond exactly to such a mixture.

The colours deep red and blue, which are usually regarded as being of high rank (primary colours) occur in numerous species in Western Australia. *Templetonia* and *Kennedya* illustrate the bright red colour among the Leguminosae. It is considered to be of importance in relation to bird pollination. Similar colours are to be found in the genera *Banksia*, *Adenanthos*, *Lambertia*, and *Grevillea* of the family Proteaceae, in the genera *Cosmelia* and *Astroloma* (Epac.), in *Beaufortia* and *Calothamnus* (Myrt.) and in the case of *Leschenaultia* (Gooden.). While the participation of small Meliphagidae has been observed in the pollination of *Banksia* and the Epacridaceae similar information is still lacking with regard to the other genera. It is very doubtful for instance whether birds could take part in the pollination of flowers which are as small as those of many species of *Grevillea* or *Lechenaultia.*

Just as widespread as the scarlet and bright red of the Western Australian flowers mentioned above, are the blue and violet colours. Some have already been mentioned as accompanying the bright purple. In addition to these one finds many species with bright blue petals amongst the Pittosporaceae (*Sollya*, *Cheiranthera*, *Pronaya* and *Marianthus*, other more isolated examples occur, eg. *Erodium* (Geran.), *Mirbelia*, *Hovea* and *Hardenbergia* in the Leguminosae, together with *Calythrix* and *Llotzkya* of the Myrtaceae, *Solanum*, several genera of the family Liliaceae and the genus *Patersonia* of the Iridaceae. The series of the Campanulatae is also productive. Several annual species of *Lobelia* and many genera of the Goodeniaceae contribute particularly beautiful examples to this group. In these the tendency to have blue flowers is to a certain extent generically controlled. On the other hand it is unusual to meet blue colours amongst the orchids as that colour is relatively uncommon in this group. However, there is scarcely any other flora which is richer in blue flowering orchids than that of south western Australia. This is all the more remarkable because in other respects the region has contributed practically nothing to the evolutionary development for instance of the Orchidaceae. *Caladenia* and *Glossodia* on the one hand, and *Thelymitra* and *Epiblema* on the other, highlight these peculiar colour groupings. Some of the species occur in eastern Australia, but others are exclusively western. This represents a very important fact which has significance for the floral biology of the province.

The above, of course, must be considered only as data for further investigation. I have no evidence which would enable me to establish the anthobiological pecularities of Western Australia on a firmer foundation either geographically or systematically. We find in several genera a colour range through white, yellow and blue, without being able to recognise any determinable external factors. In *Caladenia* rose-red, yellow and blue coloured species occur - often close together in one and the same community. Furthermore there appears to be no law which might apply to the geographical distribution of the individual colours in the Province. The bright red *Calothamnus* grows in both forest and in open country. Members of the Goodeniaceae with intense highly developed blue colours are often found growing close to related species which bear inconspicuous yellow flowers. In all essential details authobiological uniformity dominates the South Western Province. There is not the slightest trace of any differentiation associated with geographical factors, such as is apparently the case in south eastern Australia. Only a certain seasonal arrangement appears to be indicated (Sect. G). There appears to be little or no information regarding relations with the insect world.

The occurrence of such bright splendid colours in the flowers of the south western flora therefore remains as an unsolved problem. One may only speculate, vaguely, that there may be some connection with the hot clear skies and the dry atmosphere of the country.

Scent. Many flowers of the south western flora are distinguished by their strong scent. There is a remarkably widespread belief, however, that the flowers of Australia are almost without scent, but this is quite incorrect. In the plant world of the Southwest Province at least, a district already abounding in aromatic scented foliage, the flowers exude strong smelling substances in a lavish manner. The genus *Acacia* for instance brings forth such an abundance of the most different perfumes with its many species, that few genera can surpass. In many of the best known and pleasing scents such as almond, heliotrope, and others there are analogous perfumes. The same holds good for the Proteaceae. There is no species in that polymorphic company of the south-west Proteaceae whose flowers do not produce a specific perfume. *Hakea recurva* smells like *Philadelphus*, *Petrophila longifolia* produces a malic-acid like substance, while the banksias secrete odours reminding one of pineapple. In the characteristic genus *Daviesia* and in very many of the Myrtaceae the scents of the flowers carry a long way and they are always most intense when the colours of the flowers appear most dazzling. A strain of richness and diversity runs throughout the entire flower world of the south west, and the number of scented plants is another expression of it.

f. *Adaptation and Morphology*.

Critical examination of the elements of the flora of south western Australia shows that they fall into two large classes. The specific factors which determine these classes are not known at the present time. The members of the first group appear to be conditioned by a limited complex of external factors. Their morphology within a limited range appears to be in equilibrium. Members of the second group exposed to the free play of the highly variable elements of the external medium develop a high degree of morphological adaptation. The first class is met with all over the world and is of little help in biogeographical studies. The second group, however, shows stronger development in some floras and less in others. It shows a particularly striking and extensive development in the flora of south western Australia. Our understanding of the biology of this flora depends to a great extent upon our ability to unravel the mystery of the tremendous variation in morphology which has occurred. All the large genera of the Western Australian flora show essentially similarly conditioned self-derived adaptations.

This is, however, very difficult to demonstrate owing to the complicated nature of the whole – i.e. the extensive subdivision in autogenous series of forms. I have, therefore chosen a relatively simple genus, *Logania*, to illustrate these principles. Similar examples could readily be chosen for most other important groups in the south western flora. The following affords us some insight into the operation of the forces which have moulded the evolution of the genera and species in this floristically rich part of the world, and which are still involved in their further evolution.

The subdivision of the genus Logania*, based on its morphological adaptations.* (Fig. 49, 50)

The genus *Logania* consists of two sections - Eulogania and Stomandra, which were separated by R. Brown. They differ in their floral structure in that the anthers in the Eulogania are inserted in the middle of the corolla tube, while in Stomandra they are inserted in the throat. Eulogania differs also from the hermaphrodite Stomandra in its marked tendency to be dioecious. In addition there are considerable differences in their overall vegetative structure, which results in their adaptations proceeding along very different lines. They must therefore be considered separately.

I. Eulogania DC. (Fig. 49)

In this section the flowers are mostly five-partite but occasionally four-partite flowers occur. The throat of the corolla may either be bare or bearded. These are the major differences between the flowers but they are not very important due to the lack of constancy, particularly among the more distantly related forms. The definition of the species therefore depends largely on vegetative characters. The Western Australian species may be defined as follows:-

1. *Logania vaginalis* Labill. var *laxior* Nees - Fig. 49A
(*L. longifolia* R.Br. ex Benth. In Flor. Austr. IV. 361 pr.p. *Logania latifolia* R.Br. ?var *laxior* Nees in Pl. Preiss. I. 367)
A shrub 1.5 - 2 m high without any short branches; leaf area 600 sq. mm; lamina narrow, elliptical and anatomically dorsi-ventral. Upper surface with typical palisade tissue. The under surface shows loose parenchyma with stomata on the surface of the epidermis. Its vascular bundles lack phloem fibres. It grows in shady places among the undergrowth in the Jarrah forest in a rainfall zone of 90-125 cm p.a. Distribution : south coast in the Warren and Stirling Districts.
2. *Logania vaginalis* Labill. var. *longifolia* (R.Br.) - Fig. 49B
(*Logania longifolia* R.Br. ex Nees in Pl. Preiss I. 367; ex Benth. in Flora Austr. IV 361 p.pr.)
Shrub 1 - 1.5 m high without any short branches; leaf area 400 sq. mm; lamina narrow, elliptical or oblong. Its anatomy agrees with that of *Logania vaginalis*. Habitat: - Shady bush in Tuart woodland or limestone. Distribution: - West coast from the Swan River southward, littoral. In a rainfall zone of 75-100 cm.
3. *Logania vaginalis* Labill. typica - Fig. 49C

A shrub 2 - 2.5 m high without any short branches; leaf area 6000 sq. mm; narrow, obovate. Anatomically it agrees with *L. vaginalis*. Found growing on sandy dunes with over limestone. Distribution: - South east coast in the Eyre district, littoral. In a rainfall zone of 60 cm.

4. *Logania latifolia* R.Br. – see Flor. Austr. IV. 361 - Fig. 49D
A shrub 0.5 - 0.8 m high without any short branches; leaf area 320 sq. mm; lamina broadly elliptical or obovate. Anatomically it agrees with *Logania vaginalis*. Habitat : - In bush on limestone soil. Distribution: - South east coast in Eyre District, probably littoral. In a rainfall zone of 60-90 cm.

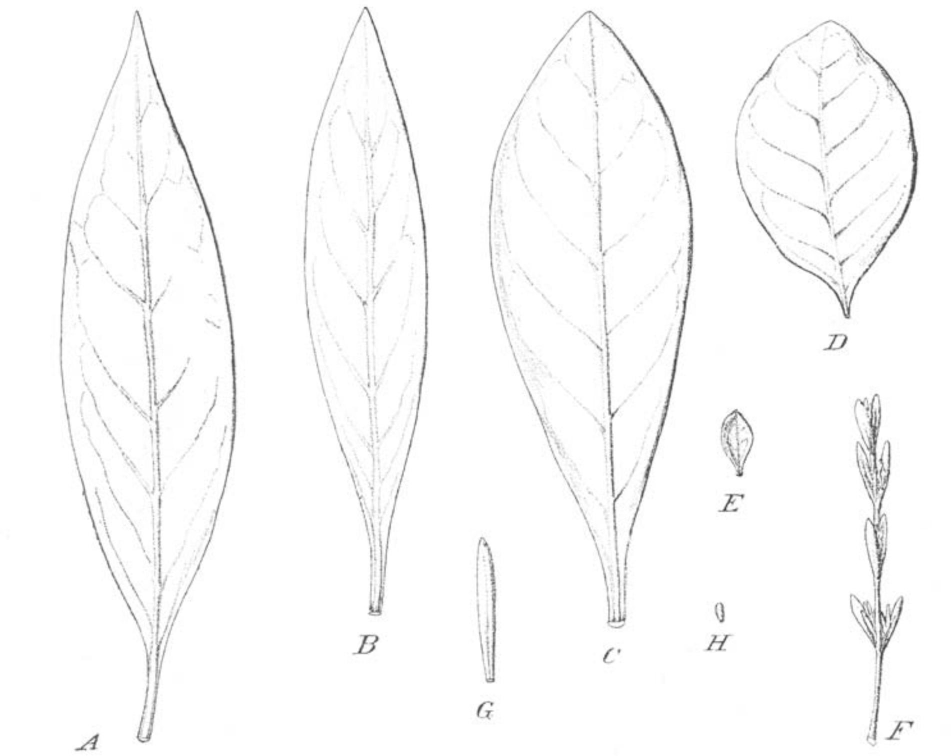


Fig. 49. Epharmose des Laubes bei *Logania* Sect. *Eulogania*: *A Logania vaginalis* Labill. var. *laxior* Nees von Denmark River (DIELS n. 2166). *B Logania vaginalis* Labill. var. *longifolia* (R. Br.) von Fremantle (DIELS n. 3896). *C Logania vaginalis* Labill. typica von Esperance (DIELS n. 5388). *D Logania latifolia* F. v. M. von Baldhead am King George Sound (PREISS n. 1244). *E Logania buxifolia* F. v. M. (DRUMMOND n. 245). *F Logania fasciculata* R. Br. von Esperance (DIELS n. 5362). *G Logania stenophylla* F. v. M. von Phillips River (DIELS n. 4879). *H Logania micrantha* Benth. vom Quellgebiet des Blackwood River (MUIR). — (Original.)

5. *Logania buxifolia* F.v.M. – see Flora Austr. IV. 362. - Fig. 49E
A shrub 0.3 - 0.6 m high without any short branches; leaf area 84 sq. mm; lamina obovate or oblong. Anatomically the leaf is more isolateral than in 1 - 4 above. The walls of the upper epidermis are thicker, while the stomata are more or less sunken projections. Distribution: - South east in the Eyre district. In a rainfall zone of 50-60 cm.

6. *Logania stenophylla* F.v.M. – see Flora Austr. IV. 302 -Fig. 49C
A shrub to 0.75 m high; occasionally with short leafy shoots (dwarf shoots). Leaf area is more or less 125 sq.mm; the shape is linear and margins are revolute. Anatomically itis similar to *L. vaginalis*. Habitat: - In bush on loamy sand. Distribution: South-eastern in Eyre district. In a rainfall zone of 40-50 cm.

7. *Logania fasciculata* R.Br. - see Flor. Austr. IV. 363 - Fig. 49F
A low shrub with numerous small-leaved short branches; leaf area 19 sq. mm; shape, linear oblong or somewhat elliptical. Anatomically similar to *L. vaginalis*. Habitat: - On the coastal cliffs. Distribution: - South-eastern in Eyre district, sublittoral. In

rainfall zone of 50 cm.

8. *Logania micrantha* Benth. - see Flor. Austr. IV. 363 – Fig 49H
Small shrub. Leaf area 2 - 4 sq. mm. Shape, linear, margins strongly revolute; epidermis of the under surface hairy; stomata in hairy depressions. Distribution: - Inner part of the Stirling district. In a rainfall zone from 40 cm.

The adaptations in the Section Eulogania therefore consist of variations in the dimensions of the branch system and in the size of the leaf area through reduction or inrolling of margins. Such reduction sometimes affects the length of a leaf, sometimes the width. It can be compensated only to a certain extent by the correlated development of many leafy short branches. Anatomically as the leaves become more upright they develop a more isolateral character. In the xeromorphic forms the outer walls also become of increased importance. The adaptations lead from the mesophytic type of shrub through the rolled-leaf types to the ericoid dwarfs of the most depauperate nature. The distribution of these is restricted to the 40 cm rainfall zone.

II. Stomandra R.Br. (Fig. 50)

The variation in floral parts is much the same as in the Section Eulogania. The circumscription of the individual is again determined by the vegetative characters.

1. *Logania serpyllifolia* R.Br. - see Flor. Austr. IV 366. -Fig. 50A
Habit:- Semi-shrubs with horizontal prostrate branches, leaf area 170 sq. mm; shape, oval or lanceolate with hairs along the veins. Anatomy: - Dorsiventral, although the chlorenchyma is more or less homogeneous; stomata are present only on the undersurface level with the epidermis. It is found growing among the undergrowth of the Jarrah woodlands in places where humus is present. Distribution: Probably in the whole coastal area of the Southwest Province. Rainfall, 60-125 cm.
2. *Logania campanulata* R.Br. see Flor. Austr. IV. 365 -Fig. 50B
A semi-shrub with erect branches and larger flowers than the preceding species. Leaf area, 165 sq. mm. Shape, linear-lanceolate to linear, with revolute margins, rather more pubescent than *L. serpyllifolia*. The epidermis has a more strongly developed outer wall and the cells of the chlorenchyma are more elongated. Habitat:- Bush on stony loamy soil. Distribution:- from the Darling district to the Stirling and Eyre districts area in the 40-80 cm rainfall zone.
3. *Logania callosa* F.v.M. see Flor. Austr.IV.365. - Fig. 50C
Habit:- A small semi-shrub. Leaf area, 34 sq. mm. Shape, linear with revolute margins, more or less leafless. Epidermis with strong outer walls. Chlorenchyma cells closely packed. Habitat:- bare places on clay-sand. Distribution:- south east in Eyre district. In the 50 cm rainfall zone.
4. *Logania flaviflora* F.v.M. in Victor. Natural. V.165 - Fig. 50D
Habit:- A semishrub to 15 - 25 cm high with leaf area 25 sq. mm. Shape, linear. In anatomy it is similar to *Logania campanulata*. Habitat:- shrubby heaths on sand. Distribution: - Inner Avon district. In the 30-40 cm rainfall zone.
5. *Logania spermacocea* F.v.M. see Flor. Austr. IV. 365 - Fig. 50E
Habit:- A semi-shrub 20-30 cm high. Leaf area 3.6-12 sq. mm. Shape, Linear, usually strongly hairy. Photosynthesis mainly carried on by dwarf branches. These are slightly grooved, the rounded edges (usually six) with single-layered subepidermal bast fibres. Stomata level with the epidermis. Chlorenchyma richly developed. Habitat:- Slightly shrubby heath on sand. Distribution:- North part of the Avon and Irwin districts. In the 40-50 cm rainfall zone.
6. *Logania nuda* F.v.M. see Flor. Austr. IV. 365 - Fig. 50G
A semi-shrub 20-25 cm high; leaf area zero; all photosynthes is carried out by the grooveless cylindrical stem axes. Numerous sub-epidermal bast fibres alternate with chlorenchyma tissue. Stomata are level with the epidermis. Chlorenchyma cells are

palisade-like. Habitat:- Open areas on shrub heaths on sand. Distribution: -Inner Avon district. In the rainfall zone 25-35 cm.

This Stomandra Section commences with a mesophytic type. As we pass to drier regions the leaf surface undergoes marked reduction in breadth, partly offset by the development of hairiness. Photosynthesis by the stem axis becomes increasingly important owing to the reduction in leaf area and finally all assimilation goes on in the stem axes. The adaptation to drier conditions is indicated by the change from soft, broad-leaved plants to small aphyllous shrubs. The adaptational changes appear to allow the species to survive in rainfall as low as 25 cm.

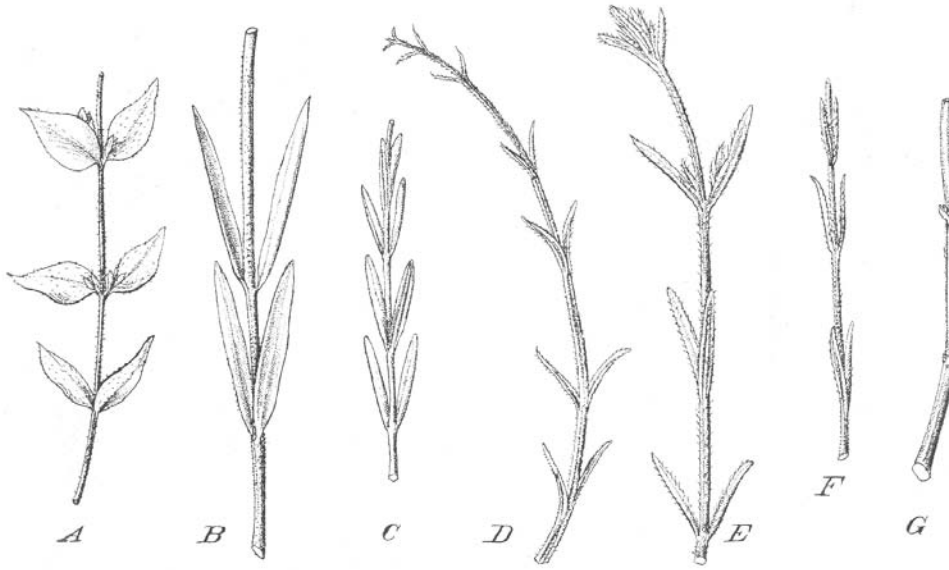


Fig. 50. Epharmose des Laubes bei *Logania* Sect. *Stomandra*: *A Logania serpyllifolia* R. Br. von King George Sound (DIELS n. 4359). *B Logania campanulata* R. Br. von Swan River (DIELS n. 1885). *C Logania callosa* F. v. M. von Esperance (DIELS n. 5401). *D Logania flaviflora* F. v. M. von Tammin (DIELS n. 5068). *E Logania spermacocea* F. v. M. von Geraldton (DIELS n. 4140). *F Logania spermacocea* F. v. M. von Watheroo (E. PRITZEL n. 987). *G Logania nuda* F. v. M. von Tammin (DIELS n. 5061). — (Original.)

We must again emphasize the fact that these adaptations seen in the two sections of *Logania* are thoroughly representative for the Southwest Province. It occurs repeatedly. The Eulogania type is met with again in the genus *Hovea*. Here we have the large-leaved *Hovea elliptica* occurring on the moist slopes and forests of the south west coast, while the extremely small leaved *Hovea acanthoclada*, with strongly developed sclerenchymatous tissue, occurs in the Eremaea. The adaptively regulated reduction in leaf area is also well shown in the genus *Dryandra*. Examination of Fig. 51 makes further comment on this example unnecessary. Similar examples may be found in all the groups of the Western Australian flora. This results in an abundance of morphological variations, but the principal features always remain the same.

The same holds good for the Stomandra type. In this example a very widespread tendency is very precisely expressed. Its climax, the aphyllous condition, is not always reached, but the number of groups tending towards it is very considerable. When the condition of leaflessness is found we often discover that it represents the last stage of a long series of adaptations developed along much the same lines as the Stomandra type. We have already shown how this holds good for a large proportion of the Western Australian aphyllous plants.

The end result, the creation of new species, is common to both examples. A range of new forms has arisen in both which show very great differences. We need to have a clear picture of the situation in order to judge the effective possibilities of the gradations in climate. Too often this is treated in a very summary manner. Many authors have referred briefly to the modifying effect of the Australian climate and have attempted to correlate it with the peculiarities of the native plants. One can readily appreciate the errors into which this may lead us when the complexities underlying a single adaptative series have been investigated. The above exposition in relation to the western *Logania* provides an adequate demonstration of this.

A well-known effect of adaptation is in general the convergence of taxonomically distinct types. The morphological changes involved in the tranfer to aphylly are considerable. The frequency of occurrence of such cases in Western Australia can be seen by referring to the list of leafless plants. Less severely reduced growths also commonly occur. These also agree very closely in their vegetative forms. Species of *Daviesia* with cylindrical leaves and species of *Acacia* with their similar cylindrical phyllodes are often very difficult, if not impossible to separate. *Hakea* and *Petrophila* have extraordinarily similar needle-like leaves. The general resemblance to one another of the ericoid type of plant is so striking that it was referred to at a very early date as a characteristic feature of the Australian “scrub” vegetation. Although usually the taxonomic differences can, on closer investigation, be demonstrated without difficulty, nevertheless striking cases occur in which, even after detailed examination it is still not possible to be sure. *Leucopogon gibbosus* possesses very small (2 mm long at most) arched leaves or ones of circular form, which are reflexed and appressed against the stem (Fig. 52B). Exactly the same form is met with in *Hibbertia microphylla* (Fig. 52A). As is often the case both examples grow in the same district under similar conditions.

This phenomenon of convergence occurs repeatedly in the Western Australian vegetation. It even extends to the tree growth-form. Phyllodes of *Acacia* and leaves of *Eucalyptus* are often deceptively similar.

The number of adaptively flexible taxa in south west Australia is greater than in any other floral area of comparable size. To my mind there is no necessity to invoke some mystical factor, which has just begun to stimulate the Western Australian vegetation into active mutation. On the contrary the process of adaptation to the gradations of the environment has been going on for an immeasurably long time. The overall effect of this has been that the flora has largely come into adaptational equilibrium with its environment.

g. Yearly vegetation cycle.

During March and April the vegetation of almost the entire Southwest Province lies dormant under the influence of the dry period. The figures alongside the drawings give the average rainfall for the areas in which the relevant species grow. There are no flowers present on the shrubs while only one or two of the taller *Eucalyptus* species occasionally bear white blossoms on their dark-leaved twigs (*E. redunca*). The whole undergrowth seems to be lifeless so much is yellow and dead. Everything appears to show tired and discoloured tones. This is further reflected in the entire landscape when the sky is hidden by the livid mist of the oppressive east winds, and the dense smoke of bush-fires fills the air.

The increasing frequency of the cloudy skies and the constant summer lightning at night herald the change. Then by about the last week of April, dark clouds begin to gather in the north western sky and soon the break of season rains begin to fall upon the scorched earth.

In a few days life appears to awaken, and within two to three weeks the whole aspect of the country changes.

Tender green shoots spread out rapidly over the ground so that one soon forgets how such a short time ago the earth lay bare everywhere. The young seedlings sprout in crowded masses particularly where some small groove or channel has retained a little more water. Each shallow depression and each cart track is covered with a green veil. Grass and delicate herbs produce their first leaves while the bulb-bearing *Drosera* shows white flower buds close to the dark sandy soil. In sheltered places the delicate flowers of

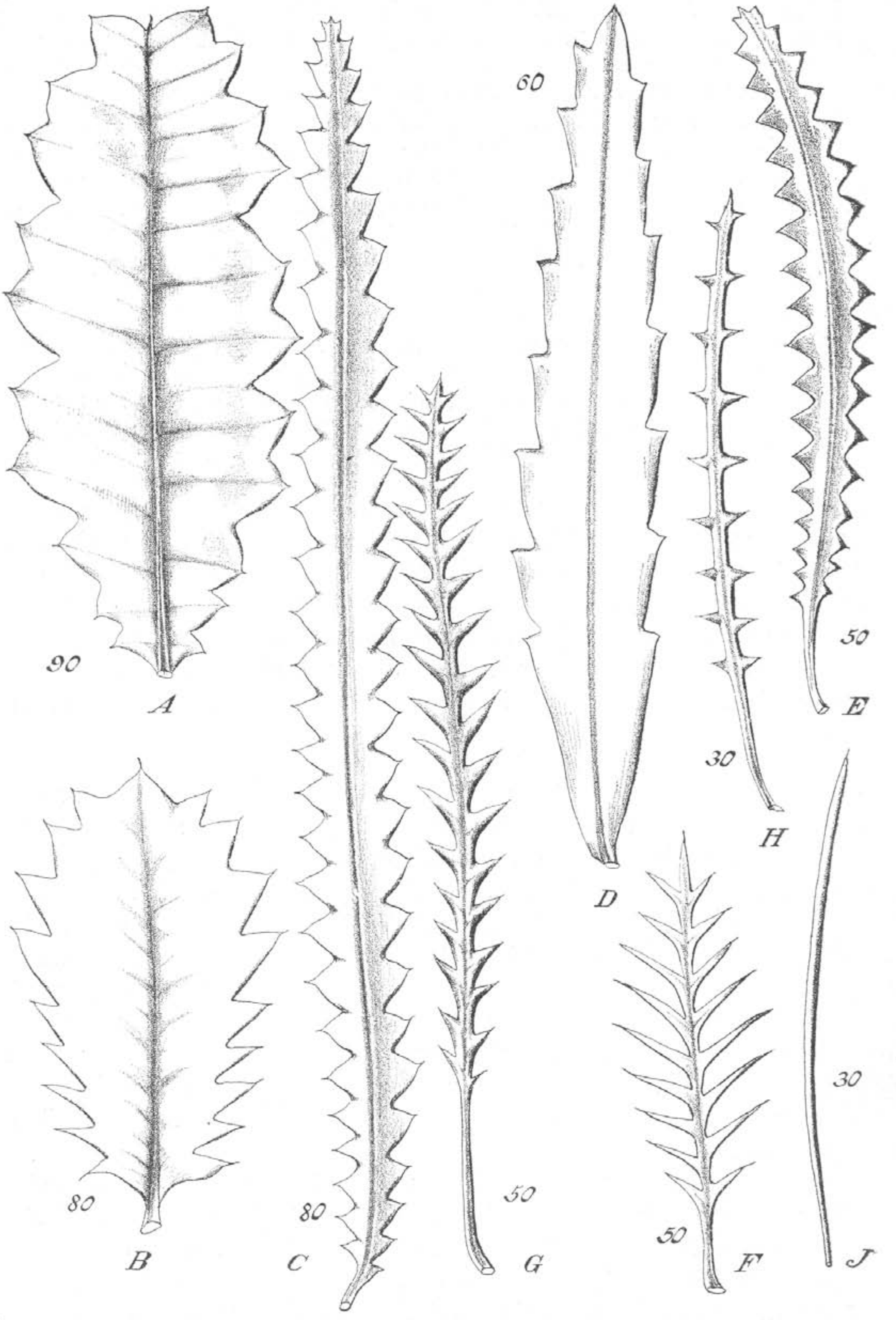


Fig. 51. Epharmose des Laubes bei einigen Arten von *Dryandra* (Proteac.) Südwest-Australiens: *A D. praemorsa* Meissn. *B D. cuneata* R. Br. *C D. serra* R. Br. *D D. carduacea* Lindl. *E D. plumosa* R. Br. *F D. serratuloides* Meissn. *G D. senecionifolia* R. Br. *H D. horrida* Meissn. *J D. speciosa* Meissn. — Die Zahlen geben die durchschnittliche Niederschlags-Höhe der Areale der betr. Spezies. (Original.)

the first tuberous orchids, eg. *Eriochilus dilatatus* appear.

Some of the vegetation damaged by bush fires during the last few months appears to be rejuvenated, but otherwise the leaves of the shrubs show little change. The flower buds, however, unfold from day to day as if they had only awaited the addition of a small amount of water to give them the first touch as it were of spring conditions. The first flowers of *Hibbertia hypericoides* (Dillen.) and of species of *Daviesia* (Legum.) appear, while in particular several species of Epacridaceous shrubs unfold their buds which had developed some time before. About the middle of May when *Styphelia tenuiflora* (Epacrid.) blooms in thousands, the undergrowth bears the snow-white cloak, as it were, of early spring. In the meantime some Acacias are well advanced in their development, and in a short time they brighten the still drab bush with their golden yellow flowers. *Acacia teretifolia* is one of the most effective of these.

Fig. 52. Epharmonische Konvergenz: *A Hibbertia microphylla* R. Br. *B Leucopogon gibbosus* Steschegl. (Original).

Towards the end of May the bush already displays a rich and variegated floral pattern, and in places the open ground in the woodland does not lag far behind in its bright display. It closely resembles what we know and love in our own leafy woodland in springtime at home. It takes quite an effort to absorb the abundance of new plants which are present wherever one turns. Beautiful indeed are the sides of the hills - their slopes upturned to the warm sun. Their soil now with adequate water, while gurgling streams flow over the steep granite slopes. A bright border of scented acacias (*Acacia alata*) accompanies the often hidden courses of the streams. *Olearia paucidentata* (Compos.) with its large and brilliant heads of flowers rises from the stony ground, and the young shoots of *Dioscorea hastifolia* grow strongly in sunny situations. Their delicate reddish leaves are scarcely visible among the masses of bright yellow flowers which give colour to the wide areas. The more woody shrubs on gravel and sand, e.g. *Hakea lissocarpa* and *H. marginata* with masses of white flowers and the small heath-like shrubs of *Leucopogon* (Epacrid.) covered with white bells, also reflect the moist and still warm conditions.

Amongst the taller shrubs many species of *Banksia* (Prot.) will be well in flower by

June. One often sees near Perth the play of colour on *B. Menziesii* whose flower cones change from a dark red colour to a fresh yellow-red as the perianths become fully open. Occasionally isolated branches of *B. prionotes* are likewise often to be seen in flower in the dry wilderness of bush in the interior. These striking forms bridge the gap between the rainy seasons of the two years. When their colours finally fade and their leaves begin to roll inwards because of increasing dryness, the new life has long had command and flowers and colours decorate the fresh and active undergrowth.

To the east of the hills the rains so far will not have been very abundant. They will, however, have been sufficient to produce a similar change to that on the coastal plain. Grass will have appeared on the parched soil and droseras and bulbous plants will have commenced to flower. Amongst the taller bushes, eg. *Acacia microbotrya*, the tiny flower buds having swollen steadily for sometime before the rains came, are now beginning to flower. When in full bloom they scent the air and their pale yellow colours appear from afar as a highly decorative feature amidst the blue-green foliage.

With the passage of time rainfall increases but the temperature falls steadily. This is reflected in the progress of vegetative development which does not proceed as rapidly as during the first few weeks of the rainy season. The buds developed in summer are now all unfolded; further progress in growth is orderly. The development of the vegetative organs becomes of prime importance. The number of flowering species increases less rapidly than in the first weeks of May but does not stop. The bright flowers of the early flowering *Hakea* and *Acacia* species are still dominant but a number of new species have joined them. These include the taller growing species of *Drosera*, eg. *D. heterophylla*. The swampy land with clay and loamy soil, which has been more or less dormant up to the present, has now become sufficiently moist to support vegetation and the drab colours are replaced by the fresh tints of young shoots. Flowers also occur here and there.

Where grasses and herbs already thickly cover the richer soils in the hills, the floral development of the perennial herbs and bulbous plants is at its strongest. In such places the white flowers of *Burchardia umbellata* and *Anguillaria dioica* are so abundant that one is reminded of the beauty of the Liliflorae in the Mediterranean countries and the Cape.

By July the number of the flowering shrubs is already very high. At the foot of the Darling Ranges one can find many vantage points from which to overlook the Swan River plain. The dazzling reddish yellow flowers of the *Daviesia* (Legum.), the dark red of *Hakea myrtoides* (Prot.) and the white bells of *Cryptandra arbutiflora* (Rhamn.), which resembles an *Erica*, are all present in abundance. Among such a wealth of flowers one may easily overlook the fact that some messengers of spring, eg. *Dioscorea*. have already faded. On the south coast where the weather is colder, the unfolding of the vegetation takes place more slowly. But from the end of May under the influence of the rainy season, the vegetation is already showing considerable development. The number of plants coming to the flowering stage increases very gradually. The floral display of the new season here appears even in July to be less striking than that further north.

This is a corollary to the observation that the interruptions caused by the dry season are less severe here than in other parts of the country. In this respect the climate creates exactly the opposite condition in the landscapes of the north-west. There the rainy season reaches its height before the middle of June - the temperature, however, never falls as low as in the Swan River area and it rests again immediately after the solstice. All this results in a much more rapid development of the vegetation, particularly in the relatively warm coastal region. In the Irwin River district by the beginning of June a considerable change in the vegetation has already occurred. The bush in the valleys is green with herbs and grasses and the scented blossoms of *Xerotes effusa* (Lil.) enliven the scene together with the brightly coloured flowers of bulbous plants. The slender *Grevillea* bushes are in flower near the creeks, the *Dioscorea* and *Clematicissus* (Vitac.) with their fresh leaves twine among their branches. These are the only “rain green” lianes in the evergreen vegetation which is so typical of Western Australia.

A few weeks later the plains are at the height of their vegetative beauty and one will rarely see anything finer than the upper Irwin or Champion Bay area at this time. At Mingenew for example, on the upper Irwin River, a small fertile plain extends eastwards to the foot of the low hills. At the end of June it is velvety with grass and delicate herbs. The Acacias grow sufficiently far apart for one to see between them and enjoy from afar the beautiful carpet of soft green. *Acacia acuminata* (Legum.) bears an abundance of yellow flowers and each small twig terminates in silky grey leafbuds which provide a delicate touch of silver to the dark green crown. Many annuals are already in flower and the bright red heads (*Helipterium, Lawrencella)*, often with the yellow and white tints, which adorn the meadow-like areas as with embroidery. Blue skies, mild air, the song of birds and the scent of *Acacia* make this landscape very attractive for most of the beautiful spring days. It shows how similar the picture of awakening nature is in all countries, where its pulse periodically changes.

From this low lying loamy area the land rises gently to the wide-spread sandy heaths. The vegetation still lags in development in July and the numbers of plants in flower is limited. The soil is less retentive of moisture and consequently the plants do not attain so quickly to luxurious abundance, which in the lowlands drives them so strongly to growth, blossom and maturity. In this vegetation zone each step forward is more precise, but the results are more permanent than is the case for the flora of the loamy country which after a short period of glory rapidly withers away.

Towards the end of July another important period occurs. This affects the greater part of the Southwest Province. The temperatures have reached their lowest point, rainfall is at its maximum and the sun has commenced to rise higher in the sky. At this time the pulse of the plant world also begins to beat more quickly. The hitherto smoothly rising curve of vegetative growth and flowering suddenly rises steeply. Entire plains suddenly become yellow with *Acacia* blossom and the ground in the woodland brightened by the colour of the undergrowth, is quickly converted into a colourful garden. On sandy soils, the mass of shrubs in flower forms a single gaily coloured carpet. On the open ground delicate annuals grow close to the moist soil and in the gaps between the rocks on granite bosses, the ephemeral flora now delicately but richly unfolds. In the loamy valleys the banks of small streams are green; in places the red soil is sparsely covered by patches of moss and grass, and the rosettes of ephemeral herbs. Orchids appear here and there and the first everlastings with their brightly coloured bracts begin to bloom.

In August the important woodland and heath communities show the greatest number of colourful species in flower. Swampy areas which are slow to warm up, still lag behind in flowering. Thus in the south western sector, say from the Murray River southward, where flooded areas are common, floral development is slow as compared with the better drained areas further north in the Swan River zone. The same thing applies in the forest areas of the cool southern hill country. There one may see the new green fronds of the Bracken Fern only just beginning to emerge from the tangle of the preceding season's brown and decaying fronds.

In September the intensity and frequency of the rain diminishes markedly in the south west. However, the importance of the effects of the downpours of the preceding months now becomes apparent. The upper layers of the soil everywhere are thoroughly saturated, and consequently the vegetation almost everywhere maintains its growth much the same as in August. Both the annuals and the taller shrubs continue flowering on new shoots whilst other species also begin to blossom. It is only in the extreme north-west where, following the end of August, the rains have shown drastic reduction, that the ripening process has been initiated and fruiting becomes well advanced. The south with its slower tempo of change, however, makes up for this later.

Spring for the south west area really commences about this time. The plants have remained more or less dormant during the cold and inclement weather. This dormancy persists until September when the sun begins to shine more strongly and the temperatures become higher. The early flowering plants of the Wandoo undergrowth, eg *Hypoxis. Tribonanthes* (Amaryll.), together with other bulbous species which have long since flowered further north, now come into full bloom. For instance I have seen *Petrophila* *ericifolia* (Prot.) in bloom not far from the western end of the Stirling Range at about this time, in late September. This is much later than in the more northerly coastal area.

The predominant annual vegetation in alluvial soils of the south-west also reaches its flowering peak in September. Its development is detained because of poor water absorption and slow warming up of its rooting substrate. In social groups members of the Cyperaceae, Centrolepidaceae and Restionaceae flower simultaneously and in between, the colourful flowers of *Stylidium*, Compositae, and other herbs occur, becoming more numerous every day.

In October a wave of falling blossoms, ripening fruit, and the wilting of some annuals, becomes evident and extends rapidly over the country, spreading down from the northwest parts. Occasionally hot days occur in the interior parts and night temperatures become mild. Ripening of the fruit proceeds rapidly particularly on the dryer loamy land. Faded patches begin to appear on the soil where shortly before all was a carpet of green. The sun shines more strongly and cloudy days become less common. Very beautiful, however, are the hundreds of flowering plants of the extensive sand-heath plains. Gradually flowers appear on species of the Myrtaceae which, up to now, have noticeably been held back in development. Soon the abundance of their flowers exceed in colour and brightness everything which flowered earlier. The late flowering Goodeniaceae also brings many new forms into view. The development of vegetative parts strongly manifests itself. Everywhere young leaves emerge, often reddish or light-green in colour. Some are still covered with long and downy hairs, which protected them in their bud stage. In eucalypts the reddish-green of young leaves contrasts with the dark green of older ones and in banksias young shoots, still covered with bronze or copper-coloured felted hairs, show on top of the last season's branchlets. The charm which this diverse display of colour expresses, can easily deceive the observer as to the otherwise ever increasing more and more obvious signs of the decay of this season. Most of the plants have fruited by now and only species of *Lobelia* continue to bloom showing their fresh blue colour in November, and indicating the close of the growth phase of the annual plants. In the north by this time everything is already withered in the dried up valleys. On the sand plains *Lachnostachys* (Verben.) and *Conospermum* (Prot.) still stand out with their soft woolly white fruiting spikes. But the arrival of a windy day results in a rapid dispersion of the light]y hung fruits which are blown across the plains together with the fleeting heads of the Everlastings.

If one visits the sandy woodland of the coastal plain at the end of October, extensive bare patches may already be observed on the ground which a few weeks before was completely covered with green. *Conostylis* (Amaryll.) droops as if tired of bearing its heavy fruit and the panicles of *Stirlingia latifolia* (Prot.) are completely covered with feathery fruit. They look like Composite perennials which scatter their seeds.

Inland in the Avon River region the change is most complete. The wheat is harvested and the once green areas in the Wandoo woodlands or even in the thickets where acacias and York Gums cast their light shadows. have largely disappeared. All that remains is bare ground or the remains of herbs and grasses. A few surviving rear-guard plants still keep their lonely watch here and there. Thus an *Arthropodium* (Lil.), its bulb nourished by the strongly developed foliage in the moist season, now bears its flowers on a bare stem. The much stronger growing and more colourful crowded ears of *Trichinium* species (Amaranth.) are also present. These are the plants which bring the flowering season of the year to a full toned conclusion.

In December the vegetation over the whole country appears generally withered but there are still well-marked differences in the extent of this. On heavy soils practically all the vegetation has dried out. Southern areas where adequate moisture is still present provide an exception. Plants of the sandy woodland have also for the greater part entered upon their dormancy period. A few stragglers such as species of *Arnocrinum* (Lil.), *Jacksonia densiflora* (Legum.), *Scholtzia involucrata* (Myrt.) together with other Myrtaceous genera including *Calythrix* and *Verticordia*, as well as some species of *Acacia* (*A. Huegelli*) are still evident in full flower. The beauty of the flowers persists for a remarkably long time on the desolate heaths, even far into the interior, hundreds of kilometres from the coast. The vegetative existence of these dry communities confirms the statement of Behr with regard to the scrub of south east Australia. “Little can wither where little sprouts”. The short-lived rainy season scarsely affects the growth cycle of these regions. Flowering sets in early (middle of May) and increases quite slowly and gradually, much more slowly in fact than in any of the other plant communities. The same pace is continued until well into the dry season. Nothing is more surprising even in January than the change which is evident when one travels from the withered landscapes of the Swan and Moore Rivers to the great girdle of sandy heaths which extends northwards up to the Murchison River. Here the bright colours of flowers of the Chamaelauciae (Myrt.), of members of the Leguminosae and Proteaceae reveal that not even the heat of the summer can rob these otherwise parched plains of their flowers and colours.

In the other communities it is the tallest growing plants which do not flower until the advent of the dry season. The tall banksias, *B. attenuata*, *B. littoralis* and *B. grandis*, unfold their beautiful yellow flower-cones and *B. Menziesii* its darker cones, only towards the end of the dry period. Christmas time is marked throughout the country by the startling vivid colour of the Christmas Tree (*Nuytsia floribunda* (Loranth.)) which only then begins to open its buds. The contrast between the blossoming trees and the faded undergrowth first becomes really obvious when these bright orange flowers open. At the same time the flowers of *Melaleuca Presissiana* (Myrt.) open to lend for a short time, to the drab and melancholy appearance of the marshy lowlands.

From the beginning of January the number of new flowers is relatively few. There are still some trees amongst them as for example, *Xylomelum occidentale* (Prot.), with its white inflorescences it is a stately member of the western woodland. Otherwise only a few genera take part in the production of this scanty summer flora. *Loranthus* is certainly the most striking of them. Being peculiar to the drab interior its bright colours render it doubly obvious there. The bright crowns of *Pronaya elegans* (Pittospor.), some late flowering members of the Myrtaceae, e.g. *Beaufortia*, *Verticordia* and *Regelia*, together with *Schoenolaena* with its white umbels follow in January or later. The gleaming stars of *Calandrinia Lehmanni* (Portulac.) which sprout without green leaves and apparently without sap, from the tile-like ground between the dried-up grass of the Wandoo zone, also surprise one by their late occurrence. Usually, however, it is a few rare isolated species of the larger genera which attract one’s attention. They seem to choose almost the hottest and driest time of the year to blossom without any relation to their sister species. *Hakea ruscifolia* (Prot.) and *Acacia Meissneri* are two of these and where they occur both are quite unmistakable, so are the flowers. *Hakea ruscifolia* bends under the weight of its floral burden; there are thousands of flowers upon each single branch. *Acacia Meissneri* presents a combination of pale blue-green foliage and deep yellow strongly scented flowers. The *Acacia* species are widely distributed in the Avon Valley. When one visits there on hot January days one sees little but rocks exposed on bare slopes, or dark coloured *Eucalyptus* tops, with withered arable land in the low-lying parts. It is only the presence of *Acaci*a in bloom, or of a vineyard with its vivid green, which give any indication of life in the general exhaustion.

The above picture of the vegetation cycle in the south west portion of Western Australia needs to be modified because of the marked divergence from it in the most southern districts. This largely coastal area is characterized climatically by the very gradual onset of the dry season and by the fact that it is never as extreme as in any other part of the country. The monthly rainfall in November, December and March is of the order of 20 to 25 mm, which is considerably higher than in the rest of the country. This marked blurring of the periodic rainfall pattern correlates with some degree of uniformity with the biology of the vegetation. This as a consequence affects its physiognomy. There are always many plants in flower on the south coast but whatever the season they never show the same abundance or degree of crowding as they do during the peak season in other areas. It is necessary finally to look at flowering phenomena on the south coast at the beginning of the dry period. Near King George Sound towards the end of December, for example, we may note that for the annuals in particular many are only now coming in to flower. The shrubs are, however, further advanced, being well in flower, while the swampy areas appear as if covered with snow due to the crowding together of the white flowers of the epacrid, *Lysinema*. Development continues during January reaching its peak during early February. The famed Albany Pitcher Plant, *Cephalotus follicularis* is rarely seen in flower before mid Janary, while the flowers of *Beaufortia sparsa* (Myrt.) are not at their best before mid-February. Other characteristic plants also show themselves to be remarkably independent of the variations in climate of this temperate coastal region. I have for instance seen *Isopogon formosus* flowering not only in February but also in July and October.

CHAPTER 5 FORMATIONS

A. Littoral Formations

There is little room for the development of a littoral community of the coastal topography of the Southwest Province. Because of the scantiness of the tide, mangrove and mudflat communities are rare. Often the coast is bordered by recent limestone. In numerous places, however, the ocean washes up on and penetrates into granite, the primeval rock of the continent. In both cases maritime edaphic effects on plant formations, which clearly separates them from continental influences, scarcely exist.

Then coastal formations depend more on the climatic effects and, in certain cases, on peculiarities due to civilization. Moreover woody formations of great diversity take over; one group being closely dependent on edaphic factors, the other one, being edaphically more tolerant, gradually blend in with formations of the interior.

a. *Mangrove* (Plate 10)

The Mangrove reaches the extreme southern limit of its distribution on the eastern shores of the Indian Ocean in protected estuaries of the south west. The most southerly point at which *Avicennia officinalis* has been recorded is latitude 33° 30'S, in the neighbourhood of Bunbury. Here it appears to flourish. Quite imposing specimens with trees to 4 m high are present. This community is also in places still quite thick and uniform. The "palaeotronic mangrove" similarly comes to an end in eastern Australia or on the coast of New Zealand. The physiognomy of the mangrove community here does not differ from that of the same in the Eremaean region. Only the floristic poverty is more evident.

b. *Mudflat formation* (Plate 10)

The above mentioned facts also apply to the mudflat formation, which presents a similar picture in the neighhourhood of the Gascoyne River. *Salicornia*, which forms the outer edge is the most resistant of all the halophytes. The less resistant forms are more internally situated. The scene is quite cosmopolitan. Only the greater variability of *Salicornia* brings about a little diversity in the apparently monotonous mass. Some bushes (*S. australis*) are quite fleshy and blue-green in colour, while others (*S. arbuscula*) form strongly woody and irregularly branched miniature bushes, whose short reddish branches cover the dark green ground. Together with the *Salicornia* one may certainly expect the presence of one of the numerous forms of *Samolus repens*, whilst *Suaeda maritima* and *Atriplex* species increase the number of succulent plants just as they do in the coastal areas of the Eremaea.

c. *Open formation of the sandy beaches*

On the loose sand of the outer flat beaches only a small number of plants are present. *Cakile maritima* is one of these being adapted to survive the most extreme conditions. No native Australian species disputes its position. Somewhat higher on the beach occurs the imposing *Mesembrianthemum aequilaterale*. Its extremely thick branches are lying close to the sand. The apparently out-of-place purple colour of its flowers, arising from the exuberant fleshy mass of stem and leaves, contrast with the brilliant whiteness of the sand. The roots of *Spinifex hirsutus* or of *Festuca rigida* may be seen everywhere penetrating the sand like thin strands of wire. Very often they have little trouble in binding the loose masses of sand for this soon comes to rest on the firm bush covered banks of the littoral limestone. The presence of this is indicated by the steeper slope. Where the limestone is absent, and the vegetation alone has to bind the dune sand together, *Pelargonium australe* (Geran.) plays an important part in addition to the grasses. It covers great areas with its thick hairy leaves. It appears to be a pioneer plant since it is only rarely present in the thicker vegetation covering older dunes.

Wherever the dunes have become more stabilized, whether due to the presence of limestone or for other reasons, they rapidly become covered by more or less open growths of dune-vegetation.

The outer zones of the dune vegetation appear very much the same in structure over wide areas. The inner ones, however, vary markedly, both physiognomically and floristically, in the different districts of the country and they must be considered separately.

If one observes the ridge of the outer high dunes from below one will see at the margin of their slope the first representatives of shrubby plants. They appear as compact cushions of rounded form, often almost hemispherical, kept low by the force of the wind. The stalks of the larger members of the Cyperaceae (*Lepidosperma gladiatum* (Cyper.) and *Scirpus nodosus* project above the bushes and one may see their flower heads moving freely in the wind. If one climbs up the dune face one recognises amongst the first and most striking of the shrubs, *Scaevola crassifolia* (Gooden.) and *Acacia cyclopis* (Australian without any doubt!). *Scaevola* is well adapted to strand conditions; its leaf is more fleshy than that of its much-branched relatives. Numerous glands cover it with a shining lacquer which accentuates its bright green colour. The plant makes a pleasant picture when blooming, its bright blue inflorescences gleaming among the fresh green foliage. A*cacia cyclopis* is also a bright green in colour. Close to the edge of the dunes, freely exposed to the winds from the sea, it occurs only as a low bush yet elsewhere in sheltered places it forms shrubs 2 to 3 m high. They occur together in groups separated in the outer regions by bare stretches of mobile sand but further inland they grow closer and closer together until they form dense thickets.

A number of other dune plants occur with *Scaevola crassifolia* (Gooden.) and *Acacia cyclopis*, *Spyridium globulosum* (Rhamn.). *Agoni*s *flexuosa* (Myrt.) and the leafless santalaceous plants (*Leptomeria* and *Exocarpos*) are examples of plants adapted to the extreme conditions on the exposed windy tops of the dunes. Their main role becomes evident in the real coastal-woodland.

d. *Littoral Woodland*

On the land-ward side the communities of the littoral limestone are often found alongside and close to the *Acacia* margin of the strand. This vegetation already shows to a large extent an inland character but the soil peculiarities clearly separate it from the vegetation types found in the interior. Nowhere else in Western Australia is such a decomposed (and so accessible for plant growth) limestone present as in this littoral zone. Wherever too, the vegetation has succeeded in utilizing these edaphic features, it is also helped further by the very favourable rainfall conditions and by the tempering effects of the sea. Such places are present on the shady southern slopes of the steep limestone cliffs, which occur where valleys have been avoided, or along the basal zone at the foot of the limestone ridges where limestone detritus has become heaped up in deep masses.

In these places the vegetation of Western Australia, from the vegetative point of view. reaches its peak of achievement. Locally this plant development differs and may be subdivided into three zones.

Thus the greatest number of forms is found in the Irwin District and also the sharpest, floristic configuration. This may be spoken of as the northern zone. Further south on the west coast the corresponding formations are distinguished by the *Eucalyptus gomphocephala* / Tuart zone. Finally eastwards of Cape Leeuwin they show another special form; this is the southern zone.

1. *Northern Zone*

The greater warmth of the climate (including that of the rainy months), as compared with the southern districts has a very marked effect upon the development of the woody coastal communities in the north. In quantitative terms almost all the components of the vegetation exceed by far that present in the south.

The zone facing towards the sea again consists of *Acacia*, *Acacia rostellifera* (Legum.) for instance with its conspicuous blue-green phyllodes dominates the soil in places to the exclusion of other vegetation. In more sandy areas *Melaleuca Huegelii* (Myrt.) oc-

Mangrove und Watten,
mit *Avicennia officinalis* L. und *Salicornia australis* Sol. (vorn).
Distr. Darling, unweit von Bunbury. — E. Pritzel phot. November 1091.

curs alongside the *Acacia*. In dune areas the *Melaleuca* develops thick stems while its delicate leaves cover the ends of the branches and its beautiful white flowers still cover the small trees up to the beginning of the dry season. Later on *Melaleuca cardiophylla* (Myrt.) which still bears white flowers on its numerous thin twigs in January, keeps up the flower succession. *Acacia* in the first instance and then *Melaleuca*, are undoubtedly the most important plants of the northern dunes. All the other elements can only be considered as being of secondary rank. Amongst these is *Fusanus acuminatus*, (Sant., Fig. 67) which grows to tree size up to 4 to 5 m high. Its pale coloured leaves mingle with the deep green of the myrtaceous trees. *Gyrostemo*n *ramulosus* (Phytolacc.) is another plant which one often sees in tree-like form. The contrast of its soft bright stem against the dark net-work of foliage ensures the attention of the observer. Its cylindrical leaves are of fleshy consistency but this is not surprising in one of the Phytolaccaceae. Yet one observes this tendency also on other dune plants. Thus *Fugosia hakeifolia* possesses succulent cylindrical leaves which have little in common with the usual ecological characters of the Malvaceae.

It is directed vertically and this upright habit of growth dominates the whole formation. The rounded crowns of the acacias and melaleucas are softened by it. A close mass of delicate branches and foliage is developed but the vertical rays of the sun pass through almost without hindrance. consequently as soon as the soil is moistened by rain one finds a diversity of life under what, from afar, looks like an almost impenetrable black crown. Some low semi-succulent plants are among the first to start active growth. Tender leaved *Pimelea* shrubs (*P. microcephala* and *P. Gilgiana,* Thymelacea.) give the bush a fresh green look. The vigorous climbing shrubs appear prominently in their characteristic forms; the soft arrow-shaped leaves of *Dioscorea hastifolia* (Dioscor.), the delicate leaf mosaic of *Clematis microphylla* and the bright green of *Zygophyllum fruticulosum* are noteworthy. Soon these climbers show their numerous flowers in delicate garlands well before buds open in acacias and melaleucas. When the rainy season ends they rapidly fade. By about Christmas time only the dry capsules of *Dioscorea* are to be seen, while the feathered fruits of *Clematis* have long since vanished. Both remain leafless until the next rainy season arrives - they are real tropophyllous plants and are amongst the very few woody growths of Western Australia which possess leaves only during the rainy season.

Where the decomposition of the litter and substrate has progressed the furthest and the products have collected in the moister hollows, the vegetation of the littoral limestone shows it vigour and beauty at it best. Amongst its most typical elements are some of the advance guards of the more inland vegetation. The light crowns of *Eucalyptus loxophleba* and *E. rudis* project above the impenetrable dense bush. The taxonomically distinctive *E. erythrocorys* has its place near them. *Acacia rostellifera* (Legum.) still remains the dominant species. Individual plants, however, occur closer together, attaining a height of 5 to 6 m whilst leafy branches meet to form a shady roof. In this wilderness it is often difficult at first to find one's way. Gradually, one learns again, to recognise *Melaleuca Huegelii* (Myrt.) and *Gyrostemo*n *ramulosus* (Phytolacc.) which show here a more stately and vigorous growth than on the outer dunes. *Pimelea microcephala* (Thymelae.) has become surprisingly tall in its growth and *Clematis microphylla* (Ranunc.) has developed from a delicately leaved climbing shrub to an impressive liane, shooting up to heights of 3 and 4 metres. The slender forms of *Hibiscus Huegelii* (Malv.)which look almost like trees and yet still have that indefinable shrub-like appearance. Leaves are abundant and freshly coloured with soft tissues. They form a strange contrast with the shiny dark green of *Grevillea argyrophylla* the only really tree-like *Grevillea* of the series Occidentales. The undergrowth is floristically a treasure-trove. It consists of a collection of interesting endemic species of peculiar subtropical stamp. Both species of *Stylobasium* (Rosac.) grow close together there. The white inflorescences of *Jasminum calcareum* (Oleac.) give off a sweet scent. Lianas creep through the bush and fill the spaces with a tenacious network. They include *Aphanopetalum* (Cunon.) with its green flowers, *Marianthus ringens* (Pittospor.) with its beautiful red corolla and *Anthocercis intricata* with its intricate flexuose branches covered with delicate white flowers. In the diffuse light. beneath this vegetative canopy a soft herbaceous growth covers the soil. *Briza maxima* flourishes here more vigorously than anvwhere else in the country. Rich humus collects in the hollows. *Caladenia latifolia* (Orchid.) adorns the shady ground with its delicate rose-red flowers, and where it is more open, crowds of annual Composites give colour and life to the scene. Different species with diverse requirements are present and according to the light intensity of the locality they interchange with one another.

2. *Tuart Zone*. (Plate XI)

Near the Swan River the nature of the limestone zone remains unaltered but the physiognomy of the vegetation gradually takes on a new face. The hills with their sandy covering, but which are basically formed of limestone, are frequently indistinguishable from pure dune formations. In some places no vegetation at all is present - they then appear blinding white as far as one can see, except for green spots in the hollows and valleys. In other parts, however, they are covered by a richly mixed woodland growth. Only here and there do bright sandy strips break the continuity of the bush. In these wooded areas tree-like forms are present and in particular the character plant of the whole community, *Eucalyptus gomphocephala* (Fig. 5). If the Southwest Province is entered from the west coast this is the first *Eucalyptus* observed - it is one of the most beautiful and yet most strongly developed. Already the old settlers knew it as Tuart and clearly distinguished it from the other important species of *Eucalyptus*. Taxonomically it is rather isolated among the *Eucalyptus* species of the West, like its beautiful flowering relation of the northern coastal zone, *E. erythrocorys* its distribution is similarly restricted to the narrow band of coastal limestone.

The woodlands which it forms are somewhat open and individual trees have room to develop. At a relatively low height stem branching begins giving wide branches. The foliage is rather dense and the bright colour of the pendant leaves is enhanced by a beautiful gloss. The trees reach 40 to 50 m in height, particularly in the region of Geographe Bay which represents the most southern area of its distribution. The tree there appears as the most dominant feature of the entire coastal woodland, rising, as it does, from the undergrowth and crowning the bush ridges of the dune landscape. Another very important member of the Myrtaceae, namely *Agonis flexuosa* also occurs here. It is more a giant shrub than a tree. Frequently it fails to develop a main stem but produces a number of equivalent stems. In this respect it is like *Pterocarya* (Jugland.) of our parks. Its appearance is thus quite different from that of the Tuart which gives an impression of strength and robustness. In *Agonis* everything is delicate. The pendant branches and leaves give *Agonis* somewhat the appearance of the weeping willow. The leaf is much thinner than that of *Eucalyptus gomphocephala* in whose shadow *Agonis flexuosa* flourishes best.

In more open areas the coastal woodland attains a greater diversity, floristically as well as ecologically. One is reminded most strongly of the Mediterranean Macchia [Maquis]. Perhaps no other community in Western Australia resemble more closely the bush of the Mediterranean coast than the south-west coastal woodland. Shrubs about 2 m high grow close together, and *Acacia cyclopis* is again abundant amongst them. *Spyridium globulosum* (Rhamn.) resembles in its habit of growth and its adaptation, the smaller forms of the “evergreen oak”. The hard leaves with their fine felt on the undersurfaces are quite similar. *Alyxia buxifolia* (Apocyn.) stands out because of its shiny leathery leaves while *Hibbertia cuneiformis* (Dillen.) (the most stately West Australian species of this large genus) is an arresting element of the community because of the fresh green of its crowded leaves. It contrasts vividly with the dull colours which otherwise are so dominant amongst the somewhat smaller shrubs of the dune country. The glabrous leaves of *Fusanus acuminatus* appear pale and glaucous. The whole vegetation often appears greyish due to the dense tomentum covering leaves and shoots. The rigid silky silver-grey branches of *Jacksonia furfuracea* (Legum.), the succulent, mealy leaf branches of *Rhagodia Billardieri* (Chenopod.), and the soft woolly felt of the low-growing Composite shrubs (*Olearia candidissima* and *Calocephalus Brownii*) combine in the coastal woodland to produce an effective colour contrast to the fresh green of the taller growths. The stronger influence of the aridity which is expressed in these features is reinforced still more by the blinding intensity of the light on these dunes. Once hairiness is developed it seems to be doubly accelerated on these sunny areas. Although the Angiantheae and *Olearia* show great adaptability wherever they grow in Australia, it is only in western littoral communities that they occur as felted shrubs.

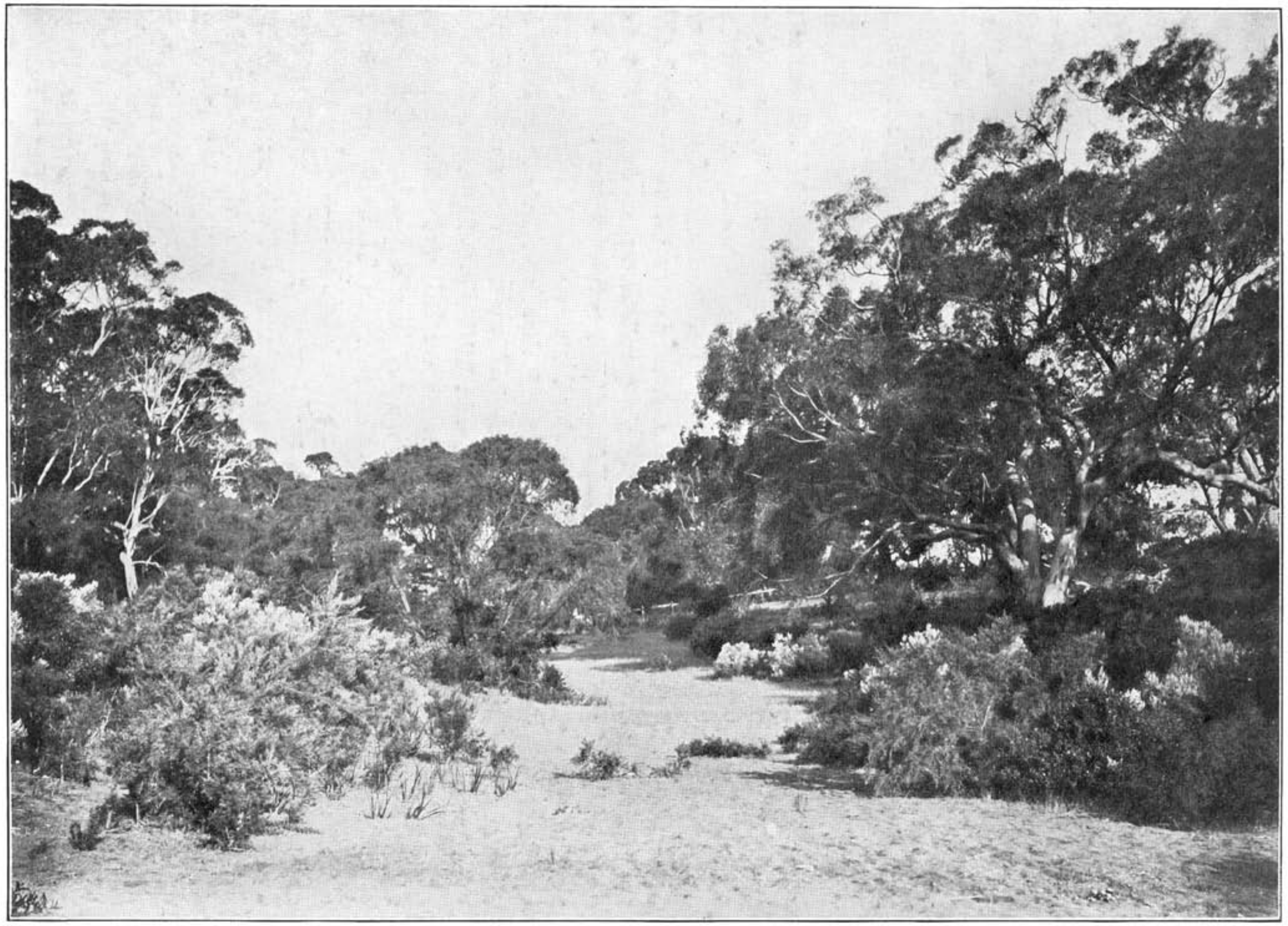
Compared with the northern facies the southern coastal woodland is poor in lianes. *Clematis* and *Dioscorea* are still present, but seldom as common as in the more northerly areas. The other climbing plants so common in the north are not found in the south.

In the rainy season the Tuart zone does not experience those damp humid days which occur in the north. Its summer period is also longer and dryer than it is on the south coast. As a result the scenes of lush vegetative growth which occur on the lower parts of the Greenough River or to the east of the Leeuwin are not to be found. Only in places where the situation is particularly favourable does a comparable abundance develop. An ideal example of such well-endowed places occurs on the Swan River at the well known Osborne Cliffs (Plate IV). At this place the wall of limestone descends almost vertically to the river. Thick dark woody vegetation covers it. Only at the steepest places is it bare. retaining ;.ts bright grey, almost white tone. Even there a thin coating of moss often grows as a green veil over the rock. Colossal Tuart trees, with their broad widely spread crowns form the upper groves while trees of *Callitris robusta* (Pinac., Fig. 61) whose foliage is darker green even than cypress, stand out most distinctly in the dense bush. On closer examination, growths often seen as low bushes appear almost of tree-like size. *Templetonia retusa* (Legum.) and *Acacia cuneata* (Legum.) are among the most common. Ecologically, however, it is *Logania vaginalis* (Logan.) and *Beyeria viscosa* (Euphorb.) which engage the attention. They appear somewhat unusual on the Swan River where they stand isolated in this flora accustomed to bright. sunlight. It is as if they had found a sanctuary as shade plants on the steep south-facing cliffs, never being exposed to the most dazzling sunlight.

The undergrowth of the coastal woodland naturally varies considerably according to local conditions. On the shady slopes of dunes dominated by *Eucalyptus gomphocephala*, tender, almost ombrophyllous plants can flourish. In such places one may collect *Carex Preissii* (Cyper.) with its soft leaves, or *Parietaria debilis* (Urtic.) with its thin leaf surfaces - a typical shade plant. A large number of herbaceous annuals are also present in the wet season. They are not, however, specific to the strand woodland. Herbaceous development in the more exposed bush formations of dune landscapes is more limited. Nevertheless in the wet season many different species develop here and quite a number of introduced plants can thereby mix with the indigenous herb flora. Thus *Anagallis arvensis* (Primul.). *Melilotus parviflora* (Legum.), *Trifolium tomentosum* (Legum.) and *Cynodon dactylon* (Gramin.) are often present in considerable numbers. These testify to Mediterranean influences, while *Heliophila pusilla* (Crucif.) and *Cyrptostemma calendulaceum* (Compos.), show that of the Cape. Many are common in the wet season but have already faded by the time the native everlastings and *Calandrinla* (Portulac.) form delicate patterns in the spaces between the bushes. By the middle of the dry season all is bare; only *Helichrysum cordatum* (Compos.) still develops its closely felted inflorescence even though its leaves have long since withered and dried.

3. *Southern Zone*

The Tuart is missing from the south coast despite the fact that the coastal limestone margin is present here and in fact in certain areas is well developed. Otherwise the vegetation retains an externally similar facies although it gradually takes on a new floristic structure. A rank growth predominates in these areas and the vegetation often equals in richness that of the northern coast. What is attained in the north through the optimal conjunction of warmth and moisture in the rainy season, is here created by the uniform duration of both factors. The effect is equally striking. *Eucalyptus* trees of the interior are again present in the formation. Karri, *E. megacarpa* and *E. cornuta* (which are met



Strand-Gehölz der Tuart-Zone.

Eucalyptus gomphocephala DC. (Bäume der beiden Ränder); *Agonis flexuosa* DC. (Myrtac., kleine Bäume hinten in der Mulde); *Olearia candidissima* (Steetz) F. v. M. (Compos., stark weißfilzige Büsche); *Jacksonia furcellata* DC. (Legum., Gebüsch links vorn); *Hibbertia cuneiformis* (Lab.) Gilg (Dilleniac., kleiner Busch rechts vorn). — Distr. Darling, Bunbury. — E. Pritzel phot. November 1901.

with together here and there), all join in. Interspersed with them is high-growing, rich almost impenetrable undergrowth. *Pteridium* fronds for instance sprout year after year. Deciduous trees are absent as are also the most interesting ecological types of the north. Many new species are present. The habit of the genus *Pimelea* (Thymelaeac.) is quite familiar. *P. clavata* is recognised by its slender supple branches which rise to a height of 2 to 3 m, and *P. sylvestris* by its nodding heads of white flowers. The yellowish pendant compound heads of *Chorilaena quercifolia* (Rutac.). however. appears quite unusual. The shrubs are 3 m high and almost disproportionately slender in the crowded conditions of the bush. The leaf is soft and has a broad blade and its characteristic form is not easily forgotten. This peculiar leaf form is also developed in *Thomasia solanacea* (Stercul., Fig. 24), a gigantic species of its group, which occurs well ramified all over Australia. Along the equitable coast, not far from King George Sound, one finds this plant, often being 4 m tall. In this respect it is comparable to the tall *Hibiscus*, a coastal plant near the Greenough River. Strong growth also characterizes *Trymalium Billardieri*, which attains heights of up to 6 m, only exceeded by the eucalypts.

The fact that numerous lianes occur in this community is expected, since its overall biological character is in part analogous to that of the north. *Aphanopetalum* (Cunon.) and *Dioscorea* (Dioscor.) are, however, absent. One misses also the crowns of *Marianthus ringens* (Pittospor.). They are replaced, however, by the small deep blue flowers of *Sollya* (Pittospor.). *Hardenbergia* (Legum.) forms a network through the bush, and a twining *Opercularia* (Rub.) climbs from branch to branch. It belongs to the endemic forms found in this restricted home. It is as unusual in this southern coast margin as *Chorilaena* or *Pimelea clavata*. From our point of view it is more important than any of the others since it is an autochthonously developed liane in this landscape, a real badge of its shady coastal woodland and its almost overburdened abundance of plants.

Transition zones between the coastal woodland and the vegetation of the interior are very variable. Very often the boundaries are hard to define. In the limestone zone of the littoral region shrub-heaths which, when their nature is considered as a whole, show traits characteristic of inland plants. However they often encroach upon the coastal woodland formation and are closely identified with it. The line of demarcation between the mesophytic strand associations and those of the true alluvial areas is also no less difficult to trace.

B. Woodland Formations

a. Eucalyptus forest and woodland

A very important part of the Southwest Province, perhaps a third of its total area, is covered by closed woodland in which *Eucalyptus* species are the dominant trees. *Eucalyptus marginata* (Plate I) is the most important of these forest species, extending in a strip of varying width from Moore River to Two People Bay (east of and not far from King George Sound), it covers the margin and slopes of the table land. To the west the zone is bordered by the mixed woodland of the littoral region while to the east it is surrounded by the area of *Eucalyptus redunca*. To the south it adjoins the Karri area (*Eucalyptus diversicolor*) which extends from Cape Leeuwin to King George Sound along the coast.

The distribution of these three species of *Eucalyptus* is considerably influenced by climate - in particular by the rainfall. Their zones of occurrence reflect the course of certain isohyets.

The equal graduation of the amount of rainfall expresses itself in certain properties which are typical of all these forests irrespective of the lead species and the general physiognomy of these forests.

Thus the following properties occur in all these *Eucalyptus* forests of the Southwest Province:-

1. They are almost pure formations - the leading species is unmistakeably the dominant species.

2. Eucalyptus trees of similar status do not occur with them, with the exception perhaps of Eucalyptus calophylla, which is only found in certain places. It does occur

in all the above mentioned forest and woodlands but only rarely forms independent associations.

3. The tree-like understorey is very uniform. It is entirely composed of the young growths of these eucalypts - only a few tree-like Proteaceae occur with them.

4. The shrubby undergrowth on the contrary is variable and often very diverse indeed.

1. Jarrah forest (Plate I)

Eucalyptus marginata (Fig. 3) as already indicated, plays an essential role in the mixed woodland of the littoral region. It is recognized there as a broad crowned imposing tree. It is an important element of the woodlands but usually only as *primus inter pares* [first amongst equals]. When one crosses the coastal plain and begins to ascend the slope of the plateau where the sand of the plain is replaced by the conglomerate [lateritic] soils of the granite hills, the general appearance of the tree undergoes a gradual change and its role also alters. The number of individuals in a given area increases while other species play a less important part and often disappear completely. The Jarrah trees tend to grow closer and closer together. As room for the single tree becomes less, the trunk elongates and the crown becomes smaller. Finaily on the summit of the plateau the picture of the Jarrah forest is complete. It assumes the form in which it extends virtually unchanged over the whole margin of the tableland through almost four degrees of latitude.

This pure *Eucalyptus marginata* forest is confined strictly to the region where the annual rainfall exceeds 75 cm. The area is consequently narrow near the Swan River and increases in breadth up to the neighbourhood of the Blackwood River. From there to the east it gradually narrows again to end rather suddenly east of King George Sound.

From the point of view of soil and climate few parts of Western Australia are more alluring to the settler than the entire Jarrah region. The thickness of the timber however renders clearing costly and this is a serious barrier to settlement. Thus one finds only a few cleared areas today in this lonely forest. This is highly important for it allows us to investigate the Australian forest in its completely original state. One's first glimpse of the Jarrah forest reminds one of the conifer forests of the Northern Hemisphere.

Nothing interrupts the uniformity of endless columns of trees with their tall trunks and grey-coloured stringy bark. The taller undergrowth too, consisting almost exclusive]y of younger generations of Jarrah, repeats the picture on a smaller scale. The crown canopy is fairly open but the trees grow so close together than the ground receives quite a lot of shade. In this fashion the forest extends over miles and miles, over hill and valley, being interrupted only by narrow bands or by more rank growth in the hollows and by the swamps of the marshy alluvial country.

The monotony of the tree growths is compensated for however by the diversity of the undergowth. The stately crowns of *Macrozamia Fraseri* (Cycad.) and the well known form of *Xantorrhoea Preissei* (Lil.) rise efficaciously above the maze of low shrub growth. This is made up of small plants rarely more than 1.5 m high. They are all evergreen and their leaves show a general similarity in shape and texture, so that they cannot easily be distinguished during the flowerless dry season. It is only the flowering season that the diverse nature of this undergrowth becomes apparent.

Most of the characteristic genera of the Southwest Province occur here and they are often represented by the species most highly developed vegetatively. This condition is already visible in the vegetation of the Darling Ranges to the east of the Swan River. Excellent examples occur amongst the Leguminosae - Polalyrieae. For instance the largest leaved species of the polymorphic genus *Daviesia* (i.e. *D. cordata*) occurs everywhere. It is a stately plant with contrasting blue-green leaves and yellowish bracts which surround the inflorescence. Of the Proteaceae, *Hakea* is best represented and appears in several vegetative types. In *H. amplexicaulis* and *H. cristata* the branches are clothed with sinuate toothed leaves, while *H. ruscifolia* bears thicker foliage but the individual leaves are smaller. Finally in *H. erinacea* the leaf is divided into a mass of thorn-like pinnae. All these species bloom very freely and the bright colours of their inflorescences colour the thickets of the forest in a similar fashion to the way the shrubby members of the Rosacea do in the Northern Hemisphere. One of the most delicate forms of *Acacia pulchella* with well-developed pinnate leaves and relatively few thorns is commonly present here. Tall growing *Pimelea sylvestris* (Thymel.) with white pendant heads forms entire hedges. Near it one finds *Leucopogon verticillatus* (Epacrid.) much more like a stiff type of *Polygonatum* or *Lilium* rather than as a xerophytic heath plant, which is the usual form of this genus.

Lianes in the strictest sense, that is to say plants which while rooted in the ground only produce foliage and flowers in the tree tops, are not present in the Jarrah forests. On the other hand, climbing plants, twiners etc., play no small part in the undergrowth. They are usually plants with moderately woody axes, imposing leaves and ornamental flowers. Representatives of leguminous genera, e.g. *Kennedya* or *Hardenbergia* occur almost almost everywhere on the floor of these forests. The most striking ones are the numerous forms of *K. coccinea* (Vent.) because of their bright coloured corollas. Twining members of the Pittosporaceae also enliven the undergrowth with blue, red and white flowering species. *Marianthus candidus* is a real companion of Jarrah and is without doubt the most beautiful with its rich corymbs of white flowers.

On the other hand epiphytes are more or less lacking in the forest, even the cryptogamic forms being rare. The trunks of many trees are quite free from them and the branches only show unimportant traces of the smaller plant forms.

The free spaces in the undergrowth are colonized by semi-shrubs and even smaller forms. *Dryandra repens* (Proteac.) is present everywhere on the ground with its strange looking leaf arrangement reminding one of fern fronds. The effect of the perennial herbs is most impressive. Representatives are provided by all the best known genera of the Western Australian flora. *Conostylis* and *Anigozanthos* (Amaryll.) with bright colours, *Tetratheca* (Tremandr.) and *Boronia* (Rut.) in brilliant red and remind one of the *Epilobium* of our mountain forests. *Scaevola* (Gooden.) with soft large leaves and deep violet blue corollas are commonly seen. *Stylidium diversifolium* (Stylid.) occurs on the rocks like many of the Saxifrages. Other free spaces are clothed by *Cassytha* or in the rainy season by delicate members of the Liliaceae (*Burchardia*) pretty ground-orchids and later by delicate annuals (*Stylidium calcaratum* (Stylid.) and *Poranthera glauca* (Euphorb.).

As one proceeds further south where step by step the dry season loses in strength and duration, the mesophytic features of the woodland become more apparent. More conspicuously leaved species replace the scanty-leaved forms of the north. *Acacia nervosa* with broad phyllodes occurs frequently and thicker bushes of *Leucopogon australis* (Epacrid.) appear in the undergrowth. Perennials with delicate foliage grow in between such as *Ranunculus lappaccus* or the softer species of *Tremandra* (Tremandr.), *Haloragis* (Halor.) and *Xanthosia* (Umbell.). Tree-like Proteaceae are more common in the undergrowth, examples being *Banksia grandis*, *Hakea* and *Persoonia*. This latter genus with 3 - 4 species reaching some metres in height is particularly worthy of note. Amongst the smaller growths *Pteridium aquilimum* is of more frequent occurrence. The bare places on the ground are covered by mossy growths (*Funaria hygrometrica*, *Rhaphidostegium homomallum*, *Campylopus inflexus* and others). Also on the fallen tree trunks cryptogamic growth occurs. Moss colonies appear as green coverings and the fruiting bodies of tall gill and pore fungi raise aloft from rotten wood.

Exposed stones and rock in the woodlands are colonized by mosses and lichens, eg *Stricta Billardieri*, *Cladonia verticillata* and others. The overall effect gives the forests of the south their own special physiognomy. The picture is perhaps most characteristically developed in the Blackwood River area where the virgin Jarrah forest covers the hilly country more densely than it does on the Swan. The trees grow close together and in this deep shade *Persoonia longifolia* (Prot.), *Hakea oleifolia* (Prot.), and *Banksia grandis* (Prot.) develop into imposing trees, often forming a kind of lower storey in the forest. *Banksia grandis* (Fig. 8) grows particularly well in these areas. Its trunk is much more slender here than anywhere else and its seedlings often cover the ground as closely as ferns. Above all we find that gregarious growth is widespread. The increasing moisture appears to favour the distribution of certain species, while diversity and abundance of form, features characteristic of the northern vegetation, are lost. *Podocarpus Drouyniana* (Taxac.) predominates over wide areas while in other places the same is true of *Pteridium* (Plate XII). *Xantorrhoea* which occurs in all parts of the forest has strongly developed foliage and forms unusually large leaf crowns. *Macrozamia*, also is commonly present. A fresh bright green is dominant everywhere but other colours are wanting and this lack strengthens the impression of uniformity (and monotony) which the low growth of this region presents in contrast to the rich associations of the north- and south-east.

In the south east of this area the decrease in rainfall again results in a richer development of the undergrowth. The Jarrah forest north of King George Sound is in no way inferior to that of the Darling Range. In many places the shrubby undergrowth is almost impenetrable. The broad phyllodes of *Acacia myrtifolia* are strikingly conspicuous and the delicate perfume of its flowers fills the air in the wet season when the dark violet flowers of *Hardenbergia Comptoniana* (Legum.) appear everywhere amid the branches, and numerous white flowers of *Clematis* festoon the shrubs. These violet and white tones dominate the bush for a long time for after *Hardenbergia* and *Clematis* have bloomed and withered, the flowering period of *Hovea elliptica* (Legum.) and *Logania vaginalis* (Logan.) commences. Both must be included amongst the most imposing shrubs of the Western Australian forests. They both belong to genera rich in species and these in their varied habits of growth reflect the climatic nuances of the country. Both species also are the most richly developed vegetatively in their groups. (Fig. 49A). In the protection provided by the bush mesophytic perennials flourish. The Restionaceous plant characteristic of the formation is *Loxocarya densa*. This is the most delicate species of this family in Western Australia. As in the case of *Petrophila diversifolia* (Prot.) the pretty leaf appears larger and less hard and stiff than is usual in this real western genus. There is a good development of some species of ferns in these woodland localities - as for example *Lindsaea triquetra* whose fronds are often grouped in the shade of the shrubs. On the whole, however, ferns are poorly represented and the sparsity of equally favourable localities as the above remains one of the very note-worthy peculiarities of the Western Australian flora.

On the whole therefore the undergrowth of these southern Jarrah forests is dominated by an unmistakeable mesophytic character. This is of prime importance in understanding the Western Australian vegetation, since in this locality it appears less subject to limitation by the water economy factor. It presents many new species which owe their origin and existence to this freedom.

In depressions and valleys of the country where the water tends to accumulate and moisture is retained longer, the undergrowth becomes more luxuriant. The shrubs occur closer together and grow to a considerable height, Some entirely new species are also present, perhaps under the influence of edaphic factors. The soil is more finely granular and has a marly - or clay-like nature. In such places in the Darling Range attractive vegetative features occur. The stately *Banksia littoralis* is frequently present being most impressive. Often one finds close to the young *Eucalyptus* trunks, fine examples of *Xantorrhoea Preissii* and of *Macrozamia*. As a further characteristic plant of these moist depressions we find *Viminaria juncea* (Legum.). It plays an essential role being quite unmistakable with its numerous pendant bright green branchlets. Lianes of various species occur very commonly. In the central Darling Range, in quite a restricted area, one meets the following climbers, *Kennedya coccinea* (Legum.), *Gompholobium polymorphum* (Legum.), *Marianthus coeruleopunctatus* (Pittspor.), *Comesperma ciliatum* (Polygal.) and the much smaller and more delicate *Opercularia apiciflora* (Rub.). All of these show a strong development of their vegetative organs, in particular a striking tendency to elongation in the internodes. Closely interwoven, they twist themselves up into thick green masses. As a natural accompaniment of the twining habit, the undergrowth appears looser. The tall *Thysanotus Patersoni* (Liliac.) forms a straggling tangled mass with its delicate stems, while *Scaevola fasciculata* (Gooden.) supports its flexuose shoots on the more rigid branches of the undergrowth.

Close to the margins of the gullies (which often contain running streams during the winter) *Grevillea bipinnatifida* (Prot.) unfolds its beautiful leaf mosaic from which the dull red terminal panicles arise. *Trymalium Billardieri* (Rhamn.) also develops here, although it's branches with their imposing foliage do not develop to quite the same luxurious extent as they do further south. It is a typical mesophytic forest plant as are many others in the area. *Grevillea glabrata* (Prot.) with its slender flexible branches and willow-like leaves is of special interest amongst the Western Australian species of the genus because of its strongly mesophytic adaptations. Of similar interest in this respect is *Acacia alata* (Leg., Fig. 18). Because of its leaf-like broad winged stem it is one of those species which Pritzel[1] considers as being originally xerophytic but now adapted to a moist and shady habitat. It is these soft and delicate Acacias which are amongst the most common and essential constituents of the shrub-like growths in the moist gullies of the woodland. They provide a fine decorative effect when their pale yellow inflorescences open at the commencement of the wet season.

The further south one goes the mesophytic character of the shrubby undergrowth becomes more apparent. In places *Albizzia lophantha* (Leg.) becomes the dominant feature of the moist lowlands. This attractive small tree with its gracefully poised branches and sensitive delicate leguminous leaf is most surprising to come across in Western Australia. Only *Acacia pentadenia* (Fig. 18A) and *A. nigricans*, characteristic plants of the Karri zone, can be compared with it, and they seldom reach the dimensions of *Albizzia*. These are also representatives of the type of arborescent pinnate-leaved Acacias otherwise lacking in the State.

In the most environmentally favourable areas of the Jarrah zone the gully vegetation reaches its finest development. *Acacia nigricans* is associated with the community, and the round-leaved *Hypocalymma cordifolium* (Myrt.) is typical. Delicate angular stems of *Acacia urophylla* and strongly developed specimens of *Leucopogo*n *verticillatus* (Epacrid.) are conspicuously present, and in the centre of the whole stands *Trimalium Billardieri* (Rhamn.). This species grows to a height of 3 m. It is of slender growth, with soft leaves and is crowned with extensive panicles of strongly scented blossoms. At its base a dense growth of *Pteridium aquilimum* covers the ground while nearby one may see the delicate fronds of *Adiantum aethiopicum* growing in abundance. It would be difficult to find a more instructive indicator of this shade loving mesophytic community.

Where the forest becomes more open and the loamy soil increases in depth and extent, the fringing vegetation passes into the formation of the real swampland.

2. Karri forest (Plate III)

Pure Jarrah stands do not occur on the south coast. Instead one finds the still finer Karri forests (*Eucalyptus diversicolo*r) (Fig. 4).

This grand tree follows the coast as a narrow border over three degrees of longitude from 115° to 118° E. It commences about 60 km north of Cape Leeuwin and to the east of this Cape it increases somewhat in breadth so that the northern boundary runs about 100 km from the coast. From the Frankland River eastwards it becomes gradually narrower until it ends in a protecting spur south of King George Sound.

The district in which *Eucalyptus diversicolor* grows has the highest rainfall in south Western Australia and it is in fact the most temperate and climatically equable area of the country. The annual rainfall averages about 100 cm while in many places this amount is exceeded to over 125 cm. This high rainfall explains why the tree occurs on the southern slopes of the Perongerup [Porongurup] Range where beautiful woodland form a north-eastern outline of the Karri zone.

The characteristic peculiarities possessed by the Karri forest as a formation are at present unknown. I had unfortunately no opportunity to visit the typical Karri regions on the Warren River and further eastwards. Communications are still very difficult and these areas are still amongst the most inaccessible ones of the southern half of Western Australia. People familiar with the Karri country informed me that its forests were the

1 Diels and Pritzel Fragm. Austr. occ. p 283.

Waldsaum im Distr. Warren.

Eucalyptus cornuta Lab. (links); *Banksia verticillata* R. Br. (Zentrum); *Pteridium aquilinum* (L.) Kuhn (Haupt-Bodenwuchs); *Macrozamia Fraseri* Miq. (Vordergrund).

Distr. Warren, Wilson's Inlet. — E. Pritzel phot. März 1901.

most imposing possessed by Western Australia and that its flora was characterized by many special features. A closer study of these conditions must be left to the future. At present I must be satisfied by presenting what can be observed from what are in effect the outer margins only of the Karri forest.

To the North of Cape Leeuwin, *Eucalyptus diversicolor* appears first somewhat south of Margaret River as a companion of the Jarrah and *Eucalyptus calophylla* - at first in small numbers but at the same time of dominating stature. Despite the stately size of both the eucalypts just mentioned, they are always overtopped by the Karri. Its smooth clean trunk rises to an imposing height before branching begins. This branching is also almost horizontal. The crown appears more open than one would expect of an almost hygrophytic species. The undergrowth shows little which is peculiar to this transitional zone (Plate VII). It appears as the same mesophytic undergrowth which accompanies the Jarrah throughout the south. *Macrozamia* (Cycad.), *Podocarpus Drouyniana* (Taxac.) and *Pteridium aquilimum* are perhaps the most common and most conspicuous plants of this undergrowth at Cape Leeuwin. Large numbers of members of the Myrtaceae accompany these genera and everywhere between the shrubs a close turf of leaves of Iridacean form is present. This is overtopped by the tall growing flowering stems of *Anigozanthos flavida* (Amaryll.) which is easily recognized by its flowers, here green, there red in colour.

Another species frequently observed in these woodland is *Acacia pentadenia* (Legum.). It is an imposing shrub with delicate pinnate leaves and is the tallest representative of the Bipinnatae which Western Australia has produced (Fig. 129). It tends to occur in close stands and large areas of the forest ground are often covered with it. In such places the richness of the soft foliage gives a scenic impression of delicacy to the vegetation. This is a very rarely suggested feature in Western Australia.

The picture of the Karri forest at the eastern limit of its distribution in the neighbourhood of Denmark River is similar to the above. The tree together with Jarrah, is worked there to a considerable extent by the timber workers and the smoke of many mills rises in the forests. Where it has not been touched by man the undergrowth and the bush present almost the same species as are present in the Leeuwin area. The undergrowth is very dense. The soft Acacias, the leafy shrubs of *Logania vaginalis* (Logan.) and *Hovea elliptia* (Legum.), *Anigozanthos flavida*, and *Pteridium* occur generally in the foreground. *Xanthosia candida* (Umbell.), *Tremandra diffusa* (Tremandr.) and *Haloragis rotundifolia* (Halor.) are almost always certain to be present in the make-up of the herbaceous carpet which covers the ground.

There is little doubt but that the heart of the Karri regions will present many divergences from this picture which is only typical of the marginal districts. Further information, however, about this central part is lacking. It is one of the important gaps in our knowledge of the Western Australian formations, which has yet to be filled.

3. Wandoo woodland (Plate XIII)

The Wandoo, *Eucalvptus redunca* (Fig. 6), is a species which is considerably more variable than either Jarrah or Karri, and so is the area that it inhabits, since climate and soil show large differences. Because of this the total area inhabited by Wandoo does not present the features of a uniform woodland formation as is the case for Karri and Jarrah areas. It appears rather to consist of several associations in which the Wandoo tree is a more or less important part. It is most important and most dominant in the western parts of its area of distribution. It is only in those parts that Wandoo occurs as pure forest and can replace the Jarrah and Karri. This zone lies within the 70 to 45 cm annual rainfall belt. The dry period is of longer duration and the winter rains less heavy than further west. Diurnal temperatures are more extreme and the cold nights experienced in the southern parts are in particular climatically important. Edaphically, however, the conditions in this zone correspond to those of the Jarrah region - strongly weathered conglomeritic [lateritic] derivatives of the granite massif make up the soil.

The main roads of Western Australia give easy access to the Wandoo woodland. One encounters *E. redunca* on the old road from Perth to York even on the western coastal plain. The tree occurs in small groups, but becomes more numerous at the western foot of the escarpment. On the higher slopes of the plateau margin the tree disappears almost completely, leaving the field to Jarrah. About 75 km further on from the coast, however, on the other side of the Darling Range, Wandoo reappears and soon becomes the dominant eucalypt. Along a stretch of about 15 km *E. marginata* and more particularly *E. calophylla* still show a tendency here and there to compete with the Wandoo. An interesting picture is provided here by the peculiar colour contrasts of the trunks. From this narrow transition zone to the east, *E. redunca* is the dominant tree, however, for only a relatively short distance, since numerous other tree species become obvious as well.

The typical Wandoo woodlands (as seen in the Darling Range in the vicinity of Baker's Hill or Newcastle [Toodyay]) show the same essential features as the Jarrah forest, except that the undergrowth is poorer and its elements rapidly exhibit more xeromorphic features.

Superficially the characteristic traits of the formation are due to the peculiar appearance of the Wandoo itself. The white bark, the compact or squat growth and the light appearance of the whole formation combine to produce a scenic effect which has no parallel in the vegetation of Western Australia.

The undergrowth still contains numerous species which are common in the Jarrah forests. The growth, however, is much less dense and the bushes more widely spread. In many places one can see considerable areas of bare gravelly ground. The rigidity of the shrubs increases, the herbaceous components diminish, while annual plants become more common. As the rainy season nears its close they cover the floor of the woodland in gay profusion.

Acacia species constitute an important element of the low undergrowth. In the Darling Range, *Acacia urophylla* is widespread and most beautiful. *A. nervosa* also occurs frequently being easily recognized by the obtrusive scent of its bright yellow flowers. The deep blue crowns of *Sollya heterophylla* (Pittospor.), *Leschenaultia biloba* (Gooden.) and the bright red flowers of *Leschenaultia formosa* (Gooden.) are all indicators of the Wandoo wood. They form an attractive pattern on the ground when in bloom during August and September.

As already remarked, xeromorphic forms become more and more distinct in the undergrowth. Members of the Leguminosae are well represented. Of these *Mirbelia spinosa* and *Gastrolobium obovatum* are amongst the most commonly occurring species of the Wandoo zone, but a large number of less widespread types also grow well here. In all these one finds much sclerenchymatous material participating in the structure of certain organs - hard leaves and rigid branches are the rule. Similar to these leguminous plants several *Hakea* species, eg. *H. lissocarpha* and *H. marginata*, are present. These are of considerable importance because of their frequent occurrence and the abundance of their white blossoms during the rainy season.

The charateristically wide open spaces between shrubs of the Wandoo zone are occupied not only by herbaceous but also by bulbous species of the families Liliaceae and Orchidaceae and by members of the genus *Drosera*. The curious flowers of the genus *Caladenia* (Orchid., Fig. 140) are as numerous in the Wandoo woodland as in the Jarrah zone. The species are different, however, the most common being *Caladenia hirta*, a modest looking plant which is so common in September that it may be taken as a character plant of the Wandoo zone.

Because of an increased periodicity in climate, annuals are certainly more important in the Wandoo zone than in the Jarrah forest. Amongst them the Compositae are most numerous. In their gregarious growth and effective massed occurrence no other group approaches them. These unusual formations which are closely related to the Eremaea, the northern part carries a taxonomically more diversely constituted Composite flora than the southern part and many more unusual species are present. Yet the general distribution of *Helipterum Manglesii*, *H. Cotula, Millotia tenuifolia*, *Waitzia acuminata* (Fig. 53) and others, extends in a uniform manner over the whole Wandoo zone. The bright colour of the involucres is responsible for important physiognomic effects during the flowering season but even in the dry months the faded remains of these everlastings are an unmistakable feature of the Wandoo woodlands. They are scarcely less important there than in the grassy formations of the Eremaea.

The composition of the Wandoo woodlands still requires further study, wide stretches between the Swan and Blackwood River have scarcely been examined botanically. The old Post Road from Perth to King George Sound and the Great Southern Railway track show, however, the changes which the formation undergoes from north to south. There are two essential points the increasing floristic poverty of the central part of the area and the occurrence of new and important constituents in the southern section.

The impoverishment of the central part of the Wandoo region is evident even from a casual visit. The change is most marked between about 33° and 34° S. The causes must be sought in the temperature conditions of this district - it is exposed to the extremes of the interior and belongs to that strip which in the cool season of the year suffers the most marked depressions in temperature. As a result a good part of the rainfall (50 - 60 cm per year) is not as effective as in the coastal landscapes or in the northern where the cold is never so intense. The result is a very marked influence on the vegetation. Even in August the undergrowth has an almost winter-like appearance, and later also the bush remains of lower stature and more stunted than usual, the annuals are small and dwarf-like.

An important alteration in the picture of the woodlands takes place in the south due to the appearance of another *Eucalyptus* species, *E. occidentalis* (Plate XIII). Usually it is taller than *E. redunca* and the branching of the stem commences at a greater height. The branches then project straight and uniformly upwards so that they end at about the same height. The crown thus has the shape of a narrow funnel. This habit of growth, which resembles the type of the Eremaean eucalypts has led the colonists to tall it the "Flat-topped Yate". It is easily recognized. Its black-grey bark also contrasts strongly with the white stems of the Wandoo. The graceful pendant cymes of bright yellow flowers, seen on closer examination. are equally characteristic - they indicate its close relationship to *E. cornuta*.

The extent of participation of tree forms in the Wandoo woodlands changes in the different parts of the formation. It is high in the plains to the west of the Stirling Range where mixed woodland with *E. redunca* are produced. The undergrowth, however, still shows the typical Wandoo character, which is expressed partly in the reduced stature of the vegetation in the more central winter-cold districts referred to above. This is particularly noticeable in the frequency of occurrence of cushion-shaped growths. *Leschenaultia formosa* (Gooden., Fig. 20A) which always shows this tendency, is very frequent here. Extremely condensed forms of *Scaevola* also occur, eg. *S. humifusa* var. *pulvinaris* (Fig. 39). Particularly remarkable, however, are *Acacia congesta* (Legum.) and *Kennedya microphylla* (Legum.)

4. Transition to the woodlands of the Eremaea.

As we move eastwards we see the typical elements of the pure Wandoo woodland or the mixed Yate-Wandoo woodland formation gradually being reduced and replaced by new types. These provide unmistakable links with the adjoining Eremaean area. In this process the most important species concerned are the tree-like acacias (*A. acuminata* and *A. microbotrya*). Certain *Eucalyptus* species, however, are also worthy of note. These include *E. loxophleba* (Plates XXIV, XXX) which as the characteristic tree of another rather sharply bounded formation, will be referred to in greater detail later. *Eucalyptus salmonophloia* (Plate XXVI) is another species which will be discussed later.

Where the Eremaean constituents of the Wandoo woodlands are numerous the physiognomy of the undergrowth also becomes considerably modified. This is particularly the case on more compact soil which resembles the red loamy earth of the Eremaea. The shrubs become extremely sparse as do also *Melaleuca uncinata* (Myrt.) *Eucalyptus uncinata, Acacia laricina* (Meissn.), with *Parmelia* and other Eremaean types. Sometimes

Wandoo-Wald: Eucalyptus redunca Schau. (Bestand hinten.)

Eucalyptus occidentalis Endl. (vorn einzeln).

Distr. Stirling, Cranbrook. — E. Pritzel phot. November 1901.

Fig. 53. »Immortelle« Compositen der Südwest-Provinz: *A Helipterum Manglesii* (Lindl.) F. v. M. *B Helipterum cotula* DC. *C Waitzia acuminata* Steetz (Original).

shrubs with glaucescent stiff leaves, such as species of *Hakea*, *Daviesia incrassata* (Legum.), *Bossiaea rufa* (Legum.) and *Acacia pulchella* predominate show a strong development of sclerenchymatous tissue.

In the dry hot season the ground is sparsely covered with the remains of everlastings. Even then the xeromorphic undergrowth contains many striking colour mosaics. Mature growths of *Eucalyptus* of a pale blue-green colour grow near rigid deep green *Hakea* bushes. Small *Acacia* shrubs bear bright yellow-green leaves while slender casuarinas bear aloft their more or less black-coloured branches. The whole scene presents more the mood of the Eremaea than does the woodland scenery which really conveys the character to the Southwest Province.

b. Mixed woodlands of the coastal plain (Plates XIV, XV, XVI)

The woodlands of the flat sandy surfaces of the coastal plain possess a thoroughly independent character. The soil consisting of fine detritus from the plateau margin is comparatively loose, very much more so than, for example, the soil of the shrubby heaths of the interior, where the real sandplains occur. Furthermore one finds many changes in the chemical character of the soil from place to place in so far as the amount of humus is concerned.

The high proportion of tree-like growths in the coastal plain vegetation gives it its special character. In places it is a true mixed woodland formation composed taxonomically of heterogeneous elements. In no other formation of the south-west do we find anything like as many tree-like forms represented as here.

One gets the best impression of these woodlands in the low-lying stretches between the Vasse River and the Moore River on the one hand, and the plateau margin and the coast on the other. In this region flooded swampy alluvial wetland areas alternate with slight elevations of the undulating surface. The community is light and open - much more open than in the *Eucalyptus* woodland of the plateau. From a distance it gives the appearance of a closed community, but the picture rapidly changes as one approaches, until each tree stands out and can be viewed individually.

Eucalyptus marginata still remains the dominant tree species although it is not always the most common tree. It is, however, a rather different type of tree than that which we observed on the surrounding plateau country. The growth there was tall and slender and clearly limited by the effect of the surrounding densely crowded other trees. Here with no restrictions imposed by crowding the trees reach an imposing size in girth and height. (Plates XIV, XVI). The timber value of these trees is less highly regarded than Jarrah from the plateau. Nevertheless the species is rarely as stately elsewhere as it is on the western coastal plain. Where mature Jarrah trees have been left standing from the old bush in the trim suburbs of Swan River settlement they give an impression of great harmony and power to the area.

One rarely sees *Eucalyptus marginata* growing to a height of over 30 m in the woodlands of the coastal plain. Even so it exceeds all the other surrounding trees. The next closest in size is *Casuarina Fraseriana* which on drier soils is also the most commonly occurring tree of the mixed woodland (Plate XV). In its physiognomic appearance it gives an impression of being broom-like and stiff. It lacks that flexibility which lends something peculiarly graceful to the Casuarinas of Eastern Australia.

Eucalyptus and *Casuarina* may well be the most common constituents of the coastal woodland, but it is members of the Proteaceae which are really characteristic. *Xylomelum pyriforme*, *Adenanthos cygnorum, Hakea prostrata* and several species of *Banksia* represent the group. Certain peculiar features which they have in common bind together these heterogeneous elements. The tallest is *Xylomelum pyriforme* which often reaches heights of 10 m which is mostly greater than that attained by *Banksia* species. The dark green crown is composed of hard thorny toothed leaves which remind one of *Ilex. Hakea prostrata* and the peculiar *Banksia ilicifolia* show a similar leaf form. The latter appears very isolated amongst the other species of the genus. It grows best in the extreme southern landscapes, but its unusual silhouette appears as far north as the

Swan River. The stem branches just above the base but the branches remain short, so that the tree has the form of a narrow cone and appears unusually stiff in profile. The harshness of the leaf increases the impression of stiffness and in fact the tree in so far as its appearance is concerned might appear to be made of metal.

The peculiar conical shape occurs also in *Adenanthos cygnorum*. The arrangement of the crowded leaves is, however, quite different. Each is split up into many narrow segments of an almost black-green tint. As a result the plant presents almost a gloomy appearance in the woodlands, like a funereal cypress growing here. Nevertheless it tones in well with the subdued colour scheme of the whole (Plate XV).

Adenanthos, from the point of view of its distribution in these woodlands, belongs more to the elements of secondary importance. It is overshadowed by several species of *Banksia*. These, growing as small trees or tall shrubs, give character to these coastal woodlands at many localities. The district is really too dry for *Banksia grandis*. This species, in a much more beautiful shape, is very much more common in the dense woodland of the south and on the plateau. *Banksia attenuata* (Plate XVI) and *B. Menziesii* (in the north) show their best development in the coastal region. Almost vertically directed branches, with vertically placed leaf whorls, characterize species of the Southwest Province. The leaf is less rigid than that of *B. ilicifolia* but it is hard and xeromorphic and dark or grey in colour. The development of the stem varies in different areas; thus in general they grow taller in the south, although on the Swan River one may still see stately trees rising above the low young growths.

Another important feature of the woodlands of the coastal plain is *Nuytsia floribunda*. Reference has already been made to its curious nature (Plate VI), and it was pointed out how it often occurred as a solitary sentinel on the barren sandy surfaces of the interior. Often it grows on moist alluvial soils. However, it probably shows its best and most impressive development in the mixed woodlands of the coastal plain. There are places on the lower Swan River where during the flowering season (Fig. 9) wide expanses appear lit up, as it were, by fire.

With *Nuytsia* we conclude the relatively large list of trees of the coastal mixed woodlands. The smaller members like *Adenanthos* and *Banksia* lead gradually to the taller growing species of the shrubby undergrowth - of these only a few may be mentioned. Strictly speaking only the genus *Jacksonia* is well represented. Two species, *J. spinosa* and *J. furcellata* occur very commonly. The picture of the mixed woodland would be incomplete without the inclusion of the numerous leguminous bushes with their inextricably woven branches. They share this “virgate” ground plan of their branching system with the members of the family Proteaceae. However, the heaped-up mass of short and yet divided phylloclades with their thorny terminations produces a curious effect. The silvery look of the whole vegetative part of the plant is also a highly characteristic feature. It enables one to make a clear estimate, even in the non-flowering season, as to the extent of their role in the communities. There are places where their vegetative development is a cause for wonder since they reach heights of 5 m. Even then, however, there seems little tendency for a main stem to develop. One can therefore never really speak of tree-like forms as one often can in the case of *J. Sternbergiana*.

The lower undergrowth of the sunny mixed woodlands consists of a more or less dense thicket about 0.75 – 1.5 m high. Because of edaphic and climatic factors xeromorphism is more pronounced here than in the similar growths of the pure eucalypt woodlands. On the other hand conditions are more favourable for growth than on the treeless shrub heaths of the inner plateau country. The shrub vegetation, therefore, of the mixed woodlands communities of the coastal plain occupies an intermediate position between the two formations referred to above. This may be illustrated by selecting some examples. *Bossiaea eriocarpa* and *Hovea trisperma* are among the commonest occurring members of the Leguminoseae here. The leaves of both show unmistakable xeromorphic reductions as compared with their relations among the undergrowth of the dense *Eucalyptus* woodlands. The same phenomenon is excellently shown by *Hibbertia hypericoides* (Dillen., Fig. 29). This species is the most common one in sandy soils of the mixed woodland and

Gemischter Wald des sandigen Vorlandes.
Casuarina Fraseriana Miq. (links und rechts); *Eucalyptus marginata* Sm. (Zentrum).
Distr. Darling, Serpentine. — E. Pritzel phot. Dezember 1900.

readily makes us familar with the ecological profile of the community. Here it evidently constitutes a middle-phase in the adaptational range of this polymorphic genus; for in the open sand-heath, *Hibbertia hypericoides* shows even more extreme forms. Other genera on the other hand, which play a role in the dense woodlands, reach almost the limit of their possible development in the mixed woodlands of the coastal plain. The commonly occurring *Haloragis pithyoides* (Halor.), for instance, forms the terminal member of a vegetative series which begins with the types of the moist south coast.

The character of these components of the undergrowth give us a better idea of the role each plays in the separate phases of vegetation.

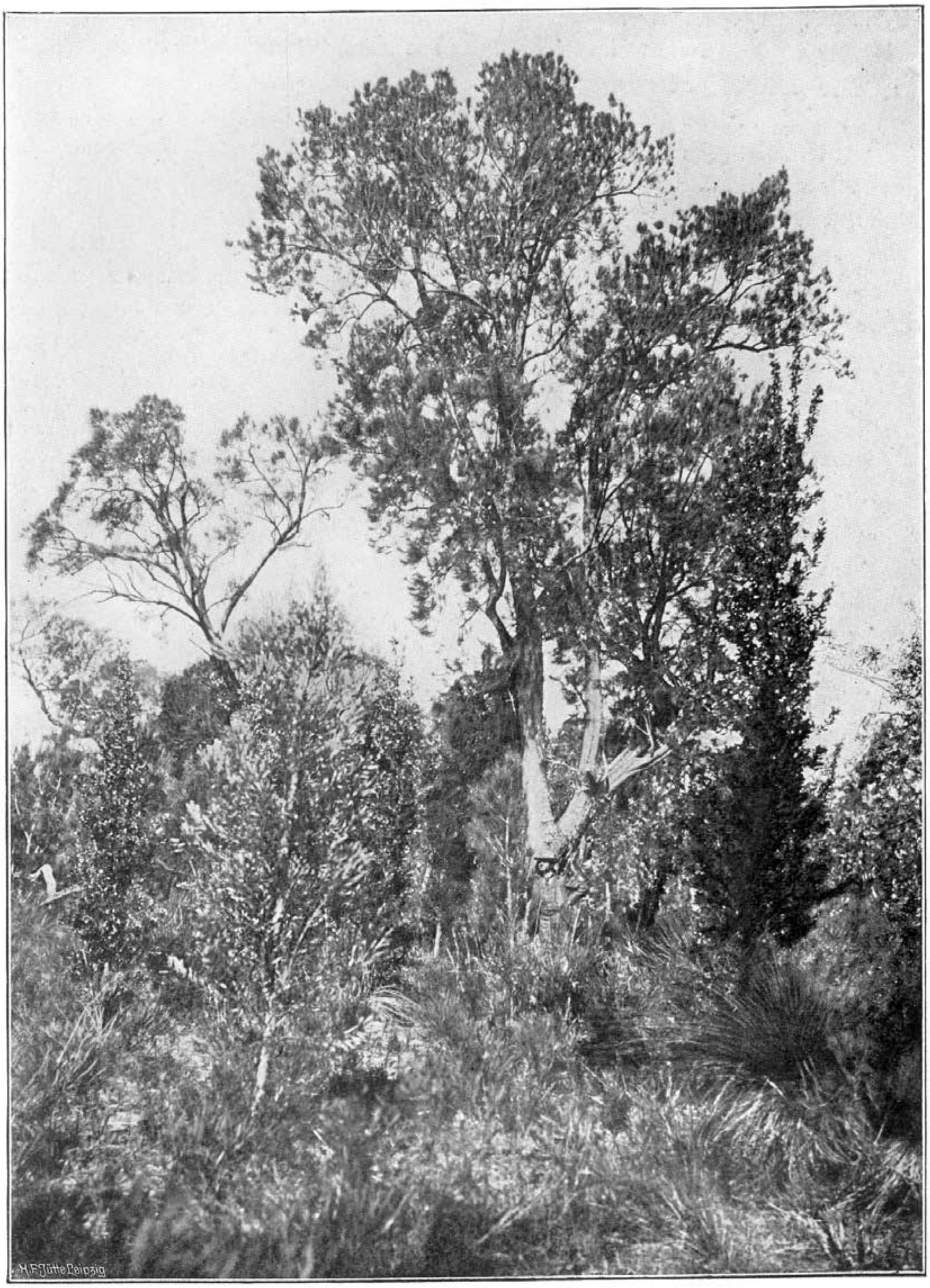
By the end of the dry season the mixed woodland appears as if almost dead. It is even poorer in flowers than the other formations. The opening rains, however, quickly penetrate into the loose sand and immediately the undergrowth which is comparatively shallowly rooted comes to life. No sooner does the first green appear and hardly show the outer pale leaf tips of bulbous plants (*Caladenia* and *Drosera*) just, above the soil surface, than the shrubs already exhibit their flowers. All this is in the course of development which began some time before. Often, even at the beginning of May, the *Hibbertia hypericoides* bushes (Fig. 29) show masses of freshly opened flowers. The smaller shrubs follow soon after. For a time epacrids dominate the scene, the climax of their floral development often being reached in May. *Conostephium* is particularly common, although its flowers (Fig. 47H) are inconspicuous and consequently less important scenically than its brighter and more stately flowering relations. Many are extraordinarily common and give the chief character to the wood. *Astroloma* with bright red flowers, *Leucopogon conostephioides* with its white corolla, and *Styphelia tenuiflora* with its narrow tubular flowers are certainly among the most common. It is surprising that even the first plants in spring produce such an abundance of flowers. This is particularly so in the case of *Styphelia tenuiflora* where the dark leaves often almost disappear behind the mass of bright corollas. In crown form one sees the *Erica* type of the Cape region repeated. The statement that these ericoid types are replaced here by the Epacridaceae holds good particularly in so far as resemblances in flower biology goes, while the vegetative parts in the two groups show various differences.

Associated with the members of the Epacridaceae we find the legumes, *Daviesia* and *Acacia* playing the most important role in May and June. *Daviesia*, represented by several species is rarely absent. Its bushes are completely covered with unusual yellow-red flowers. Many Acacias, e.g. *A. stenoptera, A. teretifolia* and *A. strigosa* which are typical in these woodlands are conspicuous with their bright yellow “heads”. They represent the start of a long succession of species which flower successively until way into the dry season.

Among the herbaceous perennials, *Xerotes* species flower about this time as does also the tender *Laxmannia ramosa*. Of the Glumiflorae (not as yet well advanced towards flowering), no genus is more conspicuous than *Mesomelaena* with its yellow anthers and dark bracts. The climbing species of *Drosera* penetrate and spread over the branches of the taller shrubs.

By the time the first wave of the flowering season has passed we have reached the middle of the rainy season. This is also the coldest period of the year. It is true that the temperature is never as low in the mixed woodlands of the coastal plain as on the sand heaths of the interior, yet an apparent dormancy period is unmistakably present. A leading Proteaceous plant of the undergrowth is *Stirlingia polymorpha* (Prot.). This has already been at the flower-bud stage for some months but there is as yet no indication of the flowers opening.

At the end of July the picture again shows more brilliance in colour. Where the bush provides richer shade a delicate carpet of annuals tends to spread. *Didiscus pilosus* (Umbell.) is fairly common here, but much more frequently in occurrence is *Briza maxima*. This is more abundant than any of the natural grasses of the country. None of these annuals is, however, peculiar to the mixed woodland formation and we shall meet them again in other communities.



Gemischter Wald des sandigen Vorlandes.

Casuarina Fraseriana Miq. (Hauptbaum); *Banksia ilicifolia* R. Br. (schmalpyramidenförmige Baumsträucher); *Adenanthos cygnorum* Diels (Proteac., grau, links vorn), *Xanthorrhoea Preissii* Endl. (rechts vorn).

Distr. Darling, Bayswater östlich von Perth. — E. Pritzel phot. Dezember 1900.

The diversity of the shrub flora of the undergrowth becomes manifest as the season gradually advances. New species with beautiful flowers range themselves alongside those already long in fruit. Species of *Bossiaea* (Legum.), *Burtonia* (Legum.), *Pimelea* (Thymel.) and others, follow on in succession. In between them and rising from ground rosettes are the slender stems of peculiar species of *Stylidium*, eg. *St. striatum*. *Conostylis* species (Amaryll., Fig. 28) indicate that this characteristic genus of Western Australia is also present in the mixed woodlands.

In this manner the rainy season draws near its close. The surface sand rapidly begins to dry out but the deeper layers still remain quite moist for sometime. The tallest undergrowth is still producing active vegetative growth. The fresh colour of young leaves is conspicuous and flowers are still common. *Petrophila linearis* brightens the open places; with its blue-green leaves and woolly bright pink inflorescences on its spreading branches. It is probably the most striking of the late flowering species of the mixed woodlands.

At the beginning of November the mixed woodlands appears once more in active growth. Its dualistic constitution consisting of low bush and high trees now becomes effectively apparent. Both constituents are correlated with different living conditions. The growth curve of the superficially rooting bushes coincides almost with the curve of the rainfall, but the deeply rooted trees reach their period of full growth activity some time after the rains. It is because of this that the community presents such a pretty picture at the end of the rainy season. A European would in fact consider the season to be Autumn provided that he did not raise his eyes above the shrubby undergrowth. The presence of young eucalypts bearing the fresh delicate and red-green leaves, the rust brown hairs of the new twigs of *Banksia Menziesii*, the contrast between the white flower wreaths and dark red branches of the full grown Jarrah suffices to give a rich and varied tone display to the woodland scenery. In addition, however, we have the imposing inflorescence of *Banksia attenuata*, and here may be seen, in various shades of yellow, all stages from the first sprouts to the fully mature condition. *Nuytsia floribunda* flower buds become brighter in colour day by day which indicates that its flowering time is rapidly approaching.

Growth still continues actively in the shrubby growths and brings other genera and species to maturity and importance. Members of the Myrtaceae are the main ones here. Species of *Melaleuca, Calythrix, Verticordia* and *Eremaea* are among the most important. For the first time one appreciates how different these bushes are, previously they looked very similar with their uniform ericoid leaf-form. *Scholtzia obovata* is a very striking neighbour to the above. Its branches radiate along the ground each ending in a dense group of reddish white flowers.

In the meantime the undergrowth as a whole gradually ceases flowering and its colours rapidly fade. Only a few individuals remain in full bloom. The flowers of the perennial stylidiums are commencing to dry out. The flowers of the annuals have almost all faded. Yet one can still find the white flowers of *Waitzia nivea* on the floor of the woodlands, and the pretty blue flowers of slender lobelias, e.g. *L. tenuior* and *L. rhytidosperma*, and here and there a fleeting *Stylidium*. Otherwise the majority of the herbaceous flora is in the fruiting stage with the leaves wilted and the shoots yellowed. The ground has again taken on that faded yellow colour which remains until the next rainy season changes it once more.

C. *Shrubland Formations*

a *Sclerophyll scrub* (Plates XVII, XVIII)

The sclerophyll scrub occurs best developed on the slopes and hills at the margin of the plateau where no woodland formations are present. Its climatic and edaphic conditions are linked with this distribution. It replaces the woodlands as soon as the rainfall falls below that essential for tree growth. It is capable of development until the rainfall falls to such small amounts as to be only sufficient for growth on sand heaths. The soil of the sclerophyll scrub corresponds in type to that of the woodland regions - it is gravel or stony, the coarser constituents being cemented together by loamy substances.

As a rule the sclerophyll scrub is formed of low shrubs which only rarely attain a

Sehr lichter Wald des sandigen Vorlandes.

Eucalyptus marginata Sm. (Zentrum). — *Banksia attenuata* R. Br. (niedere Bäume, besonders links).
Distr. Darling, Bayswater östl. von Perth. — E. Pritzel phot. November 1901.

height greater than 2 m. Usually they average about 1 m in height. Looked at from the outside one would say the formation was very uniform and monotonous in constitution. A peculiar drab grey-green signals its presence from afar and during most of the year a closer approach results in a vista that is anything but friendly. At the same time, however, one recognizes the extraordinary diversity of the constituents of this vegetation.

Its real constitution is disclosed only during the flowering season when thousands of flowers are present. Each shrub, whether large or small is covered with flowers and the air is filled with a spicy fragrance. As far as the eye can see one is surrounded by an unparalleled native plant garden and the diversity of flower type therein is so great that each spot presents something new to the eye. It is in the sclerophyll scrub formation that we see the extraordinary richness of form and of species which occurs in the flora of Western Australia. It provides the long lists of species in the genera noted for variety in form. It appears in fact to provide more diverse species than the sand heaths with which it has so much in common.

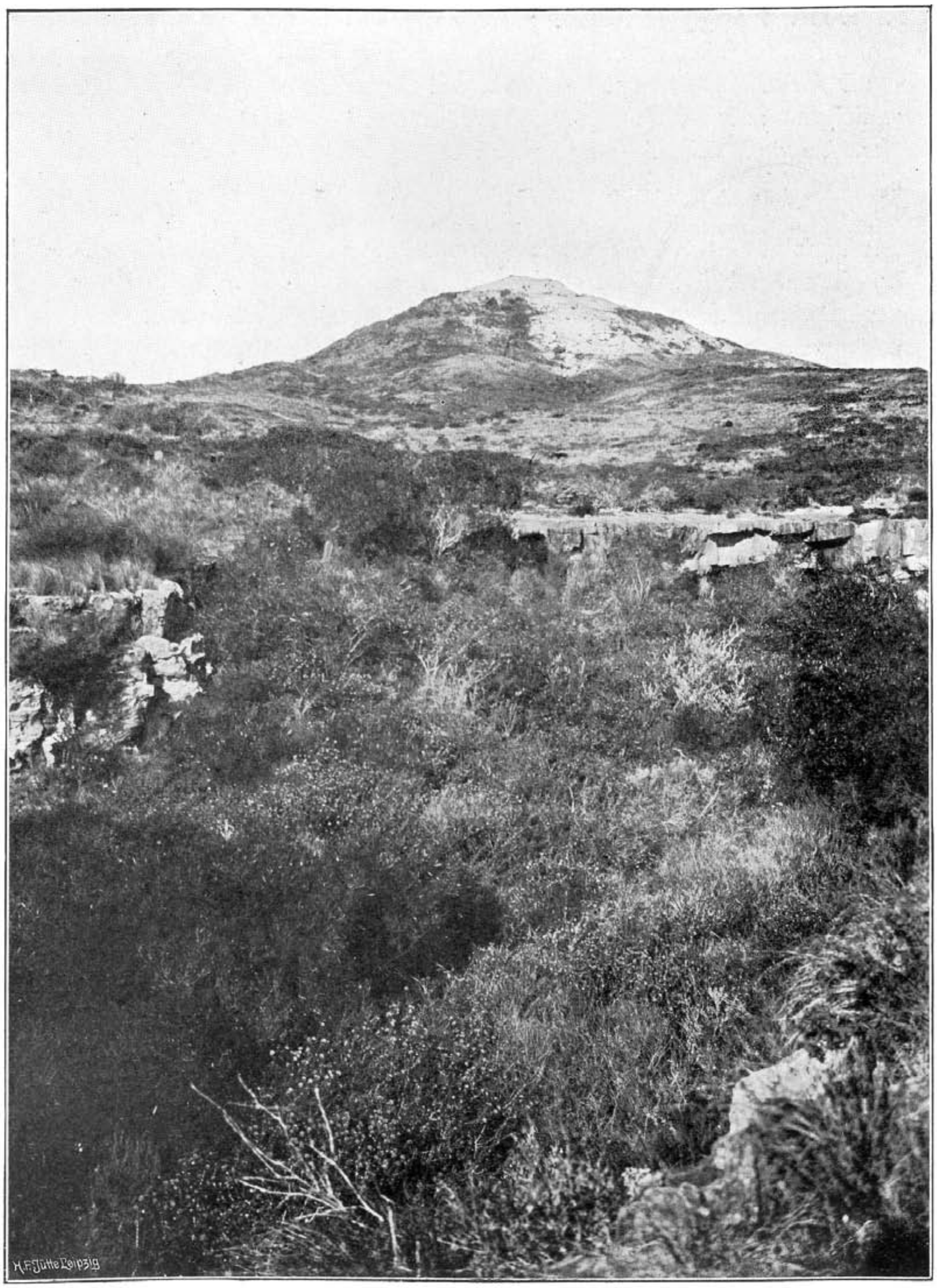
The number of species in the sclerophyll scrub varies according to the different constituents. Some lines of plant evolution are particularly successful in providing a range of forms. The Proteaceae for example easily takes first place. All of the Western Australian genera of this group are present and the most distinct autochthonous genera such as *Petrophila*, *Conospermum*, *Banksia* and above all *Dryandra* have most of their western endemic species represented in the sclerophyll vegetation. Many parallel appearances are presented by the –Podalyrieae (Legum.). The large genera such as *Gastrolobium*, *Oxylobium* and others provide large numbers of local species which occur in these sclerophyll communities. The Sterculiaceae should also be mentioned. Many of its beautiful species are found exclusively in this xeromorphic bush and often only on small limited areas. Finally we may note the Myrtaceae. While it is true that the family as a whole does not show any preference for this formation, nevertheless there are many species which find their most favourable conditions within it. In *Darwinia* for instance we have an excellent example of a typically occurring genus showing a progressive polymorphism.

Despite all the richness in composition the basic character of the community remains the same as in the woodlands. In it the closeness of the coast and the amount of rainfall cause only gradual fluctuations. However, for the extension of the community the closeness of the coast and the amount of rainfall are of fundamental importance for the very existence of this community. Though the decline in rainfall stops the growth of trees the undergrowth flora continues to flourish. The latter changes from a subordinate element to an independent dominant formation, that of the sclerophyll scrub.

It is, however, only a modified undergrowth since the only mesophytic forms are excluded or changed. *Tetratheca* (Tremandr.), *Hibbertia* (Dillen.), *Haloragis* (Halor.) and a host of other examples show this and illustrate how the shade adapted species are replaced by others which are more resistant and possess a correspondingly different ecology. This transformation process is perhaps seen most strikingly at the transition from woodland to scrub landscape. It does not cease there, however, but continues on throughout the formation, being correlated with climatic change. In places it goes still further and results in the change of the sclerophyll scrub to pure sand heaths.

The extent of the typical sclerophyll scrub is determined in the first place by rainfall.

In the northern part of the Southwest Province, therefore, its area is everywhere narrow. It is limited to a narrow strip along the coast and further to the east it is soon replaced by the sand heath formation. The slopes of the hills facing the sea breezes in this neighbourhood present the formation in its strongest development. The vegetation of White Peak, north of Champion Bay, represents one of the best examples. This little hill lies only 3 km from the shore line and receives the moist sea air directly. Permanent water holes lie hidden in the porous rock. The whole region has something surprisingly fresh about it. The scrub seldom rises to more than l m high, but grows so densely that in places it is only barely penetrated. The chief role is played by members of the Myrtaceae - and then follow *Acacia pulchella* (Legum.), a splendid *Hakea pycnophylla* (Prot.),



Strauch-Formation.

Sehr artenreich zusammengesetzt.
— Im Vordergrunde auffallend *Melaleuca megacephala* F. v. M. (Myrt.) blühend.
Distr. Irwin, White Peak nördl. von Champion Bay. — E. Pritzel phot. September 1901.

Philotheca ericoides (Rut.) (a very rare plant) and *Dampiera altissima* (Gooden.) which brings a bright bluish tone to the formation. *Drosera macrantha* (Fig. 30A) scrambles between he branches just as it does in the Swan River District.

Further south the speciation becomes even richer. Interesting examples are furnished by the ironstone hills, with few trees which lie to the north west of the Moore River between Mogumber and Moora - where the Wandoo woodland ceases to flourish. In August and September the vegetation in this area gives the impression of a fantastically decorated Persian carpet. Here and there a shrubby eucalypt or a rigid *Xantorrhoea* (Lil.) rises above the crowded mass of tangled shrubs. Species of the Proteaceae are the dominant plants. From the point of individuality the following species stand out : - *Isopogon roseus* and *I. teretifolia* which occur in all shades of rose red, and *Petrophila chrysantha*, *P. media*, *P. serruriae*, and *P. divaricata* with their yellow inflorescences. Scattered among these are species of *Grevillea*, the most common being *G. oxystigma*. This resembles a *Phylica* of Cape region, [South Africa], and *Grevillea Endlicheriana* whose long stiff and yet delicate twigs bear bright red inflorescences. From a distance this looks rather like a stunted almond tree. Here and there the stems of *Conospermum glumaceum* with their beautiful graceful inflorescences rise from the ground. Each bears a number of white bells with large bracts. One could never guess the relationship with *C. densiflorum* which occurs in large numbers not far away. In this species the flower heads are blue and in appearance and colour rather like *Jasione*. As a matter of fact blue colour tones are not common in the bush but the deep azure of *Comesperma paucifolium* (Turcz.) raises its value considerably. Here and there the violet flowers of the slender *Calythrix* (*C. brevifolia)* are striking members of the landscape. Small Sterculiaceae shrubs are widespread. *Guichenotia micrantha* (Fig. 24). is present covered with rose red flowers when it reaches the peak of its flowering season at the end of August. No colour, however, is as common as the warm yellow of the Acacias. Over wide stretches this is the dominant colour.

Again near the Swan River, at places on the plateau slopes where trees are sparse and where the formation is in close proximity to the Jarrah forest, one can see the unmistakable dominance of yellow colours about September. The most beautiful tints are present, intense yellow in *Acacia oncinophylla*, intensive orange in *Hibbertia aurea*, brilliant in *Verticordia acerosa* and somewhat faint in the delicate inflorescences of *Synaphea* and *Stirlingia*. Besides the yellow a touch of light purple can be observed due to the flowers of members of *Verticordia* and *Tetratheca*.

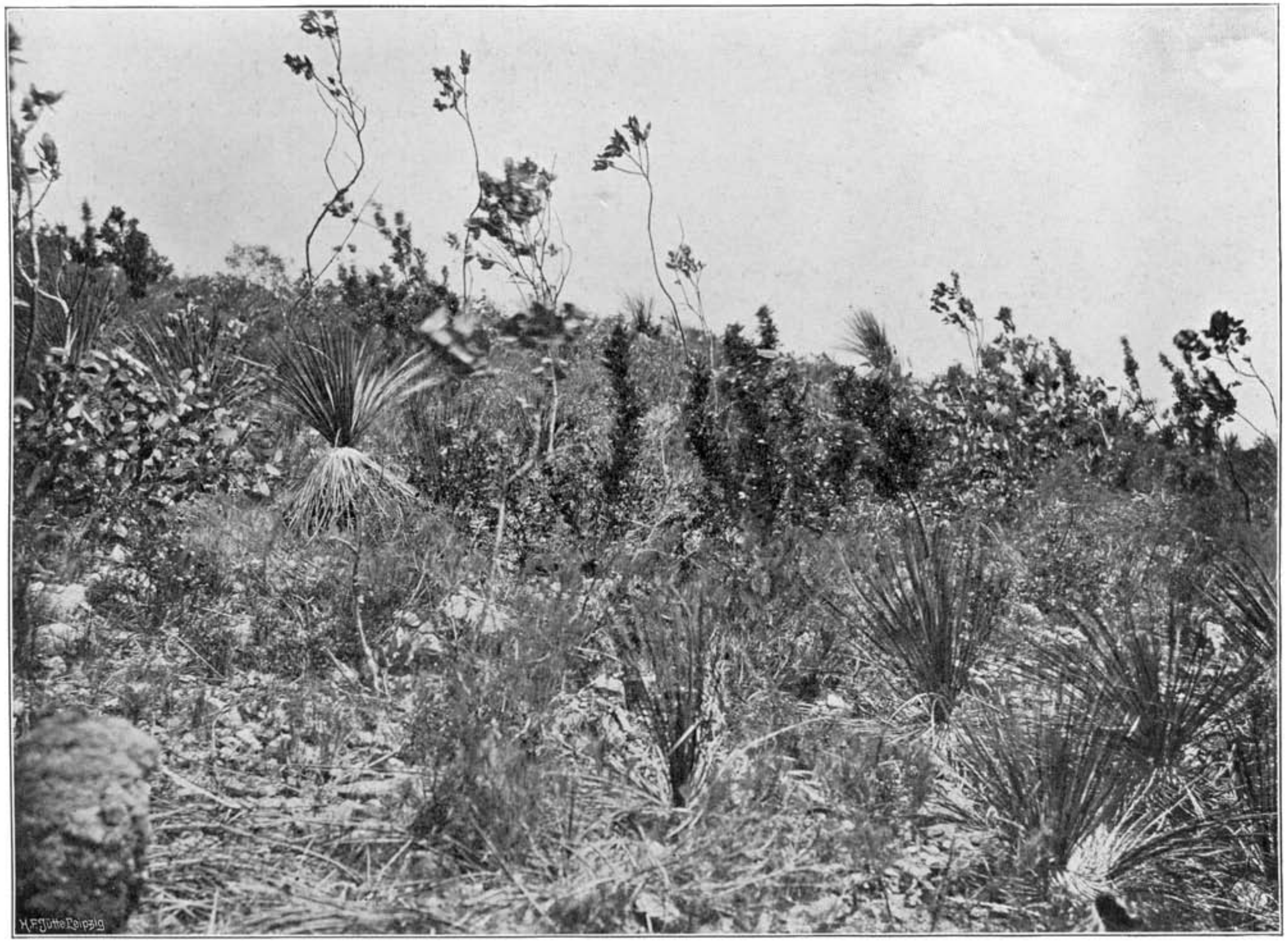
The whole formation is as at the Moore River, closely crowded and covers the ground at places with a veil of flowers. Orchids are frequently present, particularly in the vicinity of streams where the glorious light blue coloured *Thelymitra crinita* shows at its best.

The scrub of the south coast extends along the whole coast line. The flora, however, is only well known from the closely studied King George Sound area with its rich plant life surrounding the harbour.

The country is gently undulating. The eye takes in the basin of the harbour and the whole Sound, and beyond this the hills which separate the harbour from the sea. The slopes of the hills almost always catch a fresh sea breeze laden with moisture. The rainfall is only about 85 cm but it is not subject to the same extremes of temperature as further north. Transpiration takes place at a slower rate than is the case further north.

Generally speaking therefore, the scrub here is favoured climatically as compared with the conditions prevailing to the north. The undergrowth is also more closely related to that of the Jarrah forest, rather than to that of the Moore River vegetation. The boundary limiting the woodland formation does not appear to be determined by the climatic conditions, at least not in all parts. At present it is not possible to say what influences determine the lack of woodland trees on the country covered by this sclerophyll scrub formation.

The ecological picture of the southern scrub expresses the favoured constellations under which the formation exists. At many places it is permeated by small myrtaceous plants just like moister woodland areas of the country. The degree, however, to which the formation is favoured as compared with the more northern vegetation, is best expressed



Sklerophyll-Gebüsch im westlichen Stirling-Range.

Eucalyptus tetragona F. v. M. (dünne Stämmchen); *Eucalyptus Preissiana* Schau. (großblättrig, niedrig); *Xantorrhoea Preissii* Endl. (vorn); *Dryandra armata* (Proteac., sehr dunkellaubig).
Distr. Stirling, Suckys Peak. — E. Pritzel phot. November 1901.

in the form of its components. This comparison is clarified by the fact that the elements are essentially similar. The Proteaceae again thus occupies the first place and after it the Leguminosae. The part played by the Epacridaceae is greater than in the northern area.

A comparison among the Proteaceae soon shows the contrast between the north and south. Instead of the stiff species of the north as represented by the genera *Petrophila* and *Isopogon*, softer and taller species are present. *Lambertia* is represented in the north by an almost spiny species, in the south, however, by the leafy *L. uniflora*. The taller growing species of *Dryandra* in the south give an impression of softer almost tender plants, e.g. *D. mucronulata* and *D. serra*. The attractively built Banksias are particularly effective. Among these *B. Brownii* possesses the most handsome leaf. It is almost fernlike in form and is one of the most delicate species that this genus has produced. As a matter of fact *Banksia* reaches the summit of its development in this scrub formation of the south. At many places on King George Sound one may find six to eight species occurring together on a small area and all showing greater differences in their external appearance than in the structure of their flowers. The southern scrub often grows so densely and is so closely interwoven that it is a weary task to make one's way through it.

The part played by perennial herbs in this area is quite unimportant. Any space between the larger bushes is closely covered with ericoid shrubs of the most taxonomically diverse types, eg. *Leucopogon* (Epac.) *Phyllota* (Legum.) and *Comesperma* (Polygalac.). Often they are only small, feeble shrubs but even at the young stages of growth the axes very soon become woody and thus tend towards the shrub type. Bush-like members of the Restionaceae, eg *Anarthria scabra* and here and there clumps of Cyperaceous plants are the best representatives of the perennial herbs all others are of little account in the tangled bush.

An interesting repetition of the southern coastal scrub is met again in the highest parts of the Stirling Range, particularly on the southern slopes. It is doubtless conditioned by climatic conditions. In the lower regions of these mountains the vegetation is essentially xeromorphic; in the mid regions it becomes more and more thick but still retains its character. It is only in the higher zones that it becomes an extremely thick shrub formation (about 2m high) with many species, and shows all the physiognomic traits of the King George Sound flora. Of the four *Banksia* species *B. Brownii*, *B. coccinea*, *B. grandis*, and *B. Solandri*, collected on the summit of Mount Toolbrunup, the first three are well known at King George Sound. *Isopogon latifolius*, *Dryandra formosa* and *D. mucronulata* (Prot.) also occur again while *Beaufortia decussata* (Myrt.) replaces *B. sparsa*. A characteristic variety of *Kunzea recurva* (Myrt.) is present. The glorious flowering colour of this bush on the steep slopes, the fiery red of *Beaufortia* and of *Banksia coccinea* and the glistering yellow-red of *Dryandra formosa* reach their best from the end of September into early October - exactly a month later than at the Moore River.

The very summits of the Stirling Range once more are covered with a different type of scrub. On the rocky small plateau, on the tips of the highest points, the environmental conditions are not as favourable as in the rich shrubland just mentioned. The shrubs are lower, the leaves smaller and ericoid forms more dominant. Even so the bush is still uncommonly dense and not lacking in fine colours. One sees crowds of *Leucopogon unilateralis* (Epacrid.) and between them species of *Lasiopetalum* (Stercul.) and *Darwinia Meissneri* (Myrt.) with glorious bright red involucres. Members of the Leguminosae, in particular *Gastrolobium* and *Oxylobium* are almost always present, catching the eye from afar by their rich yellow or red corollas.

Returning once more to the form of the sclerophyll scrub formation occurring at King George Sound we need to look at the area over which this facies extends. At present little is known about it. There are signs, however, that with frequent breaks it extends a considerable distance along the south coast. Analogous formations which need closer study occur even as far east as near Esperance Bay.

At other places on the south coast, where the vegetation grows under conditions less suitable for rank growth, more marked xeromorphic modifications are developed in place of the above described normal type. The climate of the south coast often gives occasion for this. It is rather more diversely subdivided and local modifications are more numerous than on the west coast. Corresponding to this the vegetation falls into a number of form-types each characterized by its own peculiar combinations and by the presence of certain endemic varieties or even species. The whole corresponds in general with the more northern vegetation yet its floristic composition is strikingly different.

A paradox of this vegetation form can be studied not far from Cape Riche on Mount Melville. The hill was called Konkoberup at an earlier date, and as such is mentioned by Preiss and Drummond whose collections were considerably enriched by specimens from this area. Its steep slopes are directed seaward and are sprinkled with rocky outcrops. One can see that it is composed of an uncommonly hard material which weathers very slowly. The scrub is usually about 2 m in height, and is hard and spiny everywhere. Nevertheless within the limits of this xeromorphism there is nothing monotonously uniform in the leaf structure. Shrubby *Eucalyptus*, e.g *E. incrassata*, *E. Lehmanniana* and *E. tetragona*, with strong glaucous leaves, are common. Side by side with the foregoing grow *Casuarina trichodon* (Casuar.) and *Persoonia teretifolia* (Prot.) with an immense number of stiff projecting twigs. Then there is *Hakea crassifolia* and *H. laurina* (Prot.) whose leaves are remarkably broad and thick. Between these plants lower growth-forms are crowded; the extremely rigid *Calothamnus robustus* (Myrt.) bearing closely heaped up branches of stiff needle-like leaves at the ends of its branches; the thorny masses of *Dryandra falcata* (Prot.), and the sparsely leaved Daviesias, eg. *D. pectinata* and *D. trigonophylla* (Legumin.). A rare member of the family Rutaceae, *Phebalium rude*, on whose branches hundreds of thick leaves are crowded occurs here. Other forms include small bushy Leucopogons with their virgate branches, and also species of *Acacia*. The whole formation is just as thick as the scrub near King George Sound but it is much harder to move through. There are no flexible branches - all is firm, rigid, hard and spiny. Meanwhile thickets show taller growth than those of the north because the environment here on these southern shores is subjected to less abrupt change.

The scrub shows a peculiar development on the limestone surfaces of the littoral zone. The limestone often outcrops the surface being identified from afar by its white colour. Between these places the scrub is low, dark in colour, and strongly xeromorphic in structure.

At many places it is scarcely 1 m high and is of rather less density. Stiff thorny member of the Proteaceae play the most prominent part. *Petrophila serruriae* and *Dryandra sessilis*, in a small conical form, are the leading species. The whole consists of a diversely mixed growth of low bushes interspersed with perennial herbs. *Casuarina humilis* (Casuar.) and *Melaleuca acerosa* (Myrt.) are present and recognisable by their somewhat stiff branches. At open places small colonies of Everlastings (Compos.) are found which give life and colour to the vegetation later on in the year. *Athrixia australis*, *Podolepis nutans* and the beautiful golden yellow *Helipterum involucratum* are the most important species, of this unpretentious association in the Swan River area.

There are variants of this formation in which the scrub is much denser. Thus near Fremantle large numbers of *Casuarina humilis, Hakea ruscifolia, H. tripartita* and *H. glabella* (Prot.), together form almost impenetrable thickets because all the branches are so stiff and rigidly interlocking. The undergrowth is sparse and xeromorphic. The leaves of *Conostylis candicans* (Amaryll.) are covered with silver white hairs and *Hovea pungens* (Legum.) is extremely thorny. Here and there where there is deeper shade, *Leschenaultia linarioides* (Gooden.) is present. One scarcely recognizes its branches since the leaves are scanty and small. It is only in the flowering season when the large bright yellow and reddish coloured inflorescences appear that the singular effect of the *Leschenaultia* is appreciated.

Further towards the interior where the littoral limestone ceases or disappears under a thick covering of sand, the low bush rapidly changes to light woodland. The shrubs become taller while the silver grey forms of *Jacksonia sericea* become more and more numerous. The occurrence of a rigid form of *Acacia pulchella* with its small leaves covering each other like roof tiles becomes more frequent, and soon one sees in the background the stately forms of *Banksia* and high above them the broad crowns of the first Jarrah trees.

b. *Sand Heaths* (Plates XIX, XX, XXI)

The whole inner margin of the woodland zone of the Southwest Province is bounded by a broad girdle of sandy heathland. At first glance it appears the least stimulating and most monotonous section of the whole of the south west. The everlastingly grey-green plant cover rises and falls in unending flat waves. The eye can follow it for "miles" into the distance and the horizon always appears the same. The picture is also the same and the colours unaltered, dull and drab. Seldom is the cry of a bird heard. No shadows occur over wide areas, and no water can be seen. The eye looks longingly towards the dark line indicating the *Eucalyptus* stand, where perhaps a small basin in the granite or a hollow in the shade of the melaleucas has perhaps sheltered a little water. The whole area of the shrub heath appears worthless for exploitation by present day civilization. Its tremendous size impresses itself even on the visitor who only stays a short time in the country. Because of this the word "sand" came to be a catch-cry to the gold seekers and for adventurers from the Eastern States. It epitomized the essential character of Western Australia. Even the residents of Western Australia speak with sad resignation of the waterless wastes and overpowering heat of the sandplains.

It is surprising, however, for the investigator to discover how diverse the constitution of the sand heaths really is. The Macchia of the Mediterranean are monotonous in comparison; the shrub formations of the Cape do show a similarly wonderful diversity on the hill slopes, but on flat sandy country it is not nearly so rich. Schomburgh speaks of corresponding formations - Scrubland - in South Australia on similar soil and agreeing in all essential respects with the sand heaths of Western Australia[1]. However the list of constituents of the sand heaths in Western Australia is much greater and the company much more gaily mixed. It is not difficult to collect over a hundred species from the most differing families on a limited area of about half a square kilometer. The water supply of the sand heath takes peculiar forms. As the geographical distribution of the formation indicates it is best developed in the region of diminished rainfall less than 50 cm per annum.

The rain sinks into the soil relatively rapidly and consequently as far as the reawakening of the dormant vegetation is concerned, the extent of the rainy season is extremely rapid on the sandplains - just as it is on the sandy communities of the coastal plain. At the same time the porous soil dries out at the surface again very rapidly after each fall of rain. This is evidently too rapid to provide for the needs of large numbers of annuals. In any case there appears to be very few of them on the sand heaths.

Effects which appear to be peculiar to the open sand heaths are the strong insolation, the high radiation and the uncommonly heavy fall of dew. Even in the dry season the ground is commonly wet with dew. Thus one of the factors which ensures a certain stability in the impoverished household of the heath vegetation, is created.

The typical heath consists of shrubs about 0.5m to 0.75m in height. They usually grow well spaced out leaving light-coloured sand spaces showing in between. Only occasionally does the branchs interlace to form a dense scrub. The dominant dull green colour is duller than that of any other formation of the country. A real ericoid habit characterizes the whole growth. Completely aphyllous plants occur here and there, while broad leaves are rare. Where they do occur they are extremely hard and xeromorphic. The uniformity of the whole vegetative scene is so great that the unfolding of the flowers always brings many surprises. The flowers follow one another slowly and flowering extends over a long period. Few other formations present such a range of colour in the height of the dry season as is provided by the sand heaths - the apparently completely dead dwarf growths of the soil stand in the most striking contrast. It has not been possible so far to analyze fully the conditions determining this contrast, but it has also been

1 See darüber die Einleitung p. 20-21.

observed in the same form to the east of the Great [Australian] Bight.

If one examines sand heaths in the central regions where the formation is seen in its purest form, one sees how the bulk of the vegetation reaches an almost uniform height forming a kind of level surface. Above this height the strong wind blowing across these plains appears to inhibit growth.

Only a few taller plants occur, these being sloping scattered at random. It is only towards the sloping margins of the sandplain where the soil is more compact that more commonly one finds the taller forms occur.

In considering the overall vegetative growths occurring on the sand heaths one can classify plants according to height into tall shrubs, low shrubs and undergrowth**.** The tall shrubs are found as noted above towards the sloping margins of the heath. There is a tendency for the finer detritus particles to stick together there, the soil is more loamy, better consolidated and provides food and space for the growth of a more strongly developed plant association. The eucalypts of the neighbouring formations appear here and there in the heath. They seldom, however, give character to the formation - only *Eucalyptus eudesmioides* occurs frequently at such places (Plate XIX). On the other hand the family Proteaceae can be termed dominant, the genus *Banksia* being again the main representative. *Banksia prionotes* is perhaps the most reliably occurring species at such places. According to the locality it stands 1 - 5 m high. Its branches make close angles with the bluish trunk and all grow to about the same height. The growth form and the vertical position taken by the leaves increases the impression of the upright growth-form which is always a feature of the Banksias. The distribution of this beautiful species extends over wide stretches of the sandy area. It is sometimes found in association with *B. Menziesii* or *B. attenuata*. In other localities it is replaced by other elements which extend to a certain degree up into the higher parts and far over the loamy zone. A similar limitation, but in this case on compact soil, is disclosed by *Xylomelum angustifolium* (Prot.). Here also the bark is glaucous and the branching almost vertical, while the leaves are borne vertically. It forms an interesting semblance to the Banksias. At the height of summer it develops its white flowers.

Species of *Eucalyptus* and those of other genera in the Myrtaceae and Casuarinaceae play some small part in the tall growing shrub flora of the shrub heaths. *Casuarina campestris* is, however, the only form that I have seen which attains real importance physiognomically. It forms entire thickets in the landscapes of the Irwin and Greenough systems.

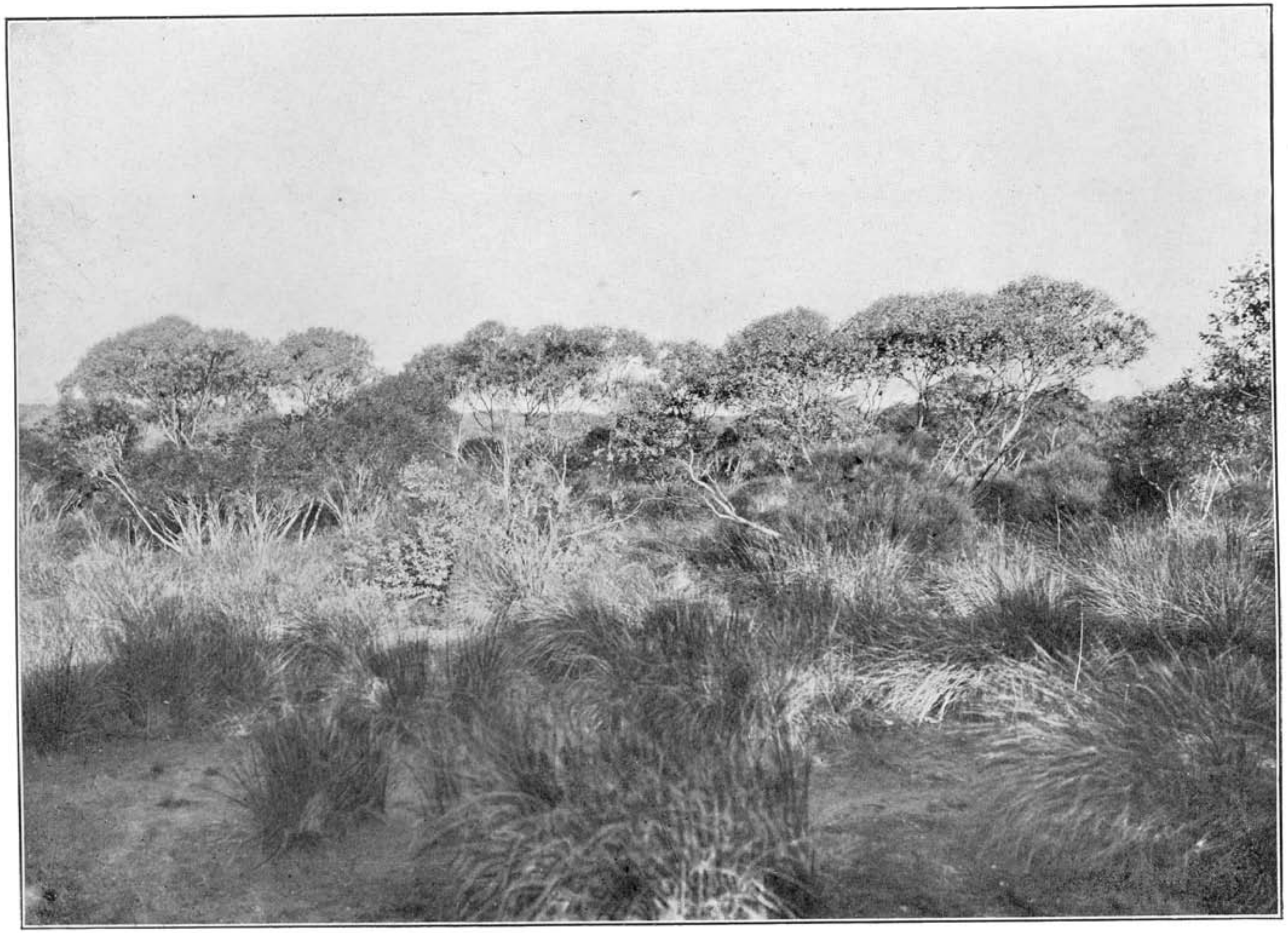
In the undergrowth of these border-zones of the shrub heath elements are seen, which generally occur either independently within the shrub heath, or have their headquarters there. Really characteristic species are, however, limited. One of them is *Comesperma scoparium* (Polygal.), a widely distributed xeromorphic derivative of this diverse genus. The bright blue colour of its flowers makes it stand out at the flowering season. It was observed by the first settlers in the colony who named it “Swan River Broom” Another broom-like form, a tall Restionaceous plant which grows beneath the *Casuarina* and *Banksia* trees of this zone, is *Ecdeiocolea monostachya* (Plate XIX). With its rigid stalks and scirpus-like ears at the tips it looks extremely like members of the Cyperaceae. The clump-like colonies of this plant are only met with in the northern districts. There, however, specimens are frequently found on the type of locality we are discussing. *Ecdeiocolea* is also interesting biologically as it represents one of the most advanced types of xeromorphic development in the family. In the Cyperaceae the genus *Lepidosperma* also deserves mention. Its stately inflorescences rise from the spaces in the bushes. Its vegetative parts, however, are mostly hidden in the shade of the higher plants and are seldom as obvious as *Ecdeiocolea*.

As we pass from this lower outer zone over the very slowly rising heathland and towards the highest point of its area, the taller growing shrubs no longer occur. The whole community shows rather stunted growth so that one has no difficulty in being able to look far away over the formation. Only a few projecting forms, which rise here and there out of the tangled low bush, can be seen. These are mostly species of *Banksia*. From a distance they appear as broadly rounded bushes with outwardly directed, spreading branchlets, carrying the tufts of leaves and the candle-like cones. This is the basic form around which the many other species vary. Their existence clearly depends on certain qualities of the coastal climate. For this reason coastal areas produce their own distinctive *Banksia* species, irrespective of the relatively low rainfall occurring there. Characteristically the shrub heath contains the most localized and most beautiful banksias at the wings of its distribution, namely, with *Banksia speciosa* near Cape Arid in the far east, and with *Banksia Victoriae* in the north at the Murchison River. On the inland shrub heath, however, conditions are becoming really too dry for the genus to survive, and only *Banksia Caleyi* or *B. Elderiana* are left. In these low rigid bushes we see for the last time the proud type of the genus.

Only few *Eucalyptus* species penetrate into higher lying areas of the sand heath. Here this predominant genus of the Australian flora is represented by forms of extraordinary adaptations. Although their growth form varies most of them present several well developed stems growing from a common stock. Because of this they occur in small clumps. *Eucalyptus pyriformis* and *E. Oldfieldii* are northern species - they are certainly the most dwarf-like species of the genus in Western Australia. *Eucalyptus pyriformis* makes up for its small size by the beauty of its very large red or yellow flowers - it is one of the finest flowered species in Western Australia. Still more peculiar is *E. macrocarpa*, which at times appears on the heaths in the centre of the dune regions (Plate XX). It, like *E. pyriformis*, bears large flowers. Its vegetative structure, with the mealy covered decussate leaves is paralleled in *E. tetragona*. This is the most important of all these dune eucalypts. With the bright blue-grey of its leaves it dominates in particular the psammophyllous shrub heaths of the entire southeast. Thus from the Stirling Range to Cape Arid no other *Eucalyptus* species is more symbolic than *E. tetragona*, whether it occurs in the sand plain or in the open areas. Quite a number of other *Eucalyptus* species grow in these regions and occasionally together with *E. tetragona*, however none of these are strictly speaking psammophilic and none occurs so frequently and has such an effective appearance.

Only a few other species apart from *Banksia* and *Eucalyptus* produce an effect on the physiognomy of the sand heath through their growth-form. The first in importance of these is *Nuytsia floribunda* which often occurs in the form of quite isolated solitary trees on the open sand heath. Another example is a species of *Xantorrhoea* with a short flower spike (Plate XX). These grass-trees are often to be seen in groups on the crests of the sand plain in more coarsely constituted soil. They are visible for miles appearing like sentinels on the lonely watch. Finally we may mention *Lambertia inermis* which it is true only occurs in the south east but is in the highest degree characteristic of the sand heath situated close to the coast there. It plays a part in the scenery of these parts somewhat similar to that of *Eucalyptus tetragona* further inland. It is a dominant figure in the chaos of similar looking forms.

The uniform heath consists of low shrubs, all of which are subject to similar growth conditions (Plates XX, XXI). Essentially it corresponds with the undergrowth of the western and southern woodlands or the littoral bush of the south, yet it is more xeromorphic than either. Many traits are expressed so strongly as to level everything to a common state. Thus, for example, we may note the reduction of the leaves, the tendency to form needle leaves and the production of ericoid forms which bring close together the families Leguminosae, Proteaceae, Myrtaceae and Epacridaceae. It creates the type of leaf which must be considered normal for sand heaths. Frequently this type dominates the whole picture of the vegetation. Here and there a few *Hakea* leaves and phyllodes of *Acacia* do retain the oval or elliptical shape, but all else shows the needle-like leaf and related structures. Even the genus *Acacia* comes under this influence and several species are affected. Amongst these are some gregarious species which are of high physiognomic importance. The ericoid Myrtaceae are never absent from any sand heath and V*erticordia* and *Calythrix* unfold the most beautiful of their flowers. The genera *Baeckea*, *Melaleuca*, *Beaufortia,* and *Eremaea* are also rich in species with true ericoid leaf form. Members of the Epacridaceae are also well represented. *Leucopogon* and *Andersonia* might be men-



Rand-Zone der Sand-Heide.

Eucalyptus eudesmioides F. v. M., vorn *Ecdeiocolea monostachya* F. v. M. (Restionac.)
Distr. Irwin, Greenough River Crossing. — E. Pritzel phot. Juni 1901.

tioned as being particularly important on the sand in the south east, while *Oligarrhena*, a typical ericoid element of this family, is one of the most important character plants of the region.

A parallel process, the breaking up of flat leafy surfaces into finely divided assimilatory organs poor in parenchyma, gives many of the Proteaceae their strange appearance. The total disappearance of foliage also takes place and aphylly is common. Among genera showing this the following may be mentioned : *Conospermum* (Prot.), *Psammomoya* (Celastrac., Fig. 43), *Logania* (Logan.), *Tetratheca* (Tremandr.), *Hibbertia* (Dillen.) and many members of the Leguminaceae.

The degree of thickening and hardening of tissues increases and affects all parts of the plant. Thorny bushes become frequent. The families Leguminaceae and Proteaceae which have already developed hard leaves with spiny teeth in the woodland formations develop extreme forms on the sand heaths. These are quite unapproachable. *Hakea platysperma* (Fig. 46) *Dryandra horrida* (Prot., Fig. 51) or *Daviesia pachyphylla* (Legum.) only find their like again in the Eremaea. In addition we find genera, which are only present as shade forms in the undergrowth of the woodland, appearing here with spinous members, e.g. *Hibbertia* (Dillen.) and *Tetratheca* (Tremandr.).

Among other manifestations of xeromorphism the development of hairiness is found on many species of the sand heath. In any case one finds that in Western Australia which in general is poor in strongly developed pubescent growths, the greatest number occur on the sandy regions of the interior. The families Sterculiaceae and Goodeniaceae contribute most. *Verreauxia* (Gooden.) and *Lachnostachys* (Verben.) are the most typical felt-like plants of the country. The latter is known to every Western Australian as the “flannel flower”. None of them is more common than *Lachnostachys Walcottii* where the woolly growth completely covers the inflorescence. These white flowers with their soft outlines form a very peculiar feature in the picture of the sand heath. This holds good, however, only for the northern facies of the formation since it is only in the northern part of the south west that they are common and gregarious enough to influence the scenery. This exclusivity appears to be due to climatic factors since it is only in the same regions that other genera also show a striking increase in hairy covering. The white felted *Halgania holosericea* (Borrag.) and *Pentaptilon Careyi* (Gooden.) are also confined to the most northerly sandplains of the south-west.

A more widely distributed group of plants develops a considerable hairiness about the inflorescence. This is first indicated by certain members of the Verbenaceae which come close to the real flannel flowers. It is most marked in *Physopsis* and *Mallophora* (Verban.) whose inflorescences form felty balls, but some species of *Conospermum* (Prot.) which I group as Trichanthae are particularly important. Their leaves are glabrous or pubescent; the inflorescences on the other hand are closely covered with felt. These forms are among those which are physiognomically important elements of many sand heaths (Plate XXI). There are extensive areas which are covered for weeks during the early summer with a warm white felty coat. Finally when the fruits have ripened the once beautiful panicles swing to and fro slowly in the wind.

Succulent plants appear to be quite unknown on the sand heaths. There is not even a trace of a fleshy structure to be found anywhere. This lack, it is true, is only the full expression of a tendency which holds good for the whole Australian flora. This is all the more remarkable when one remembers how the succulent shrub flora consisting of *Zygophyllum*, *Tetragonia*, *Euphorbia*, and others is so general in the sand hills of the boundaries of the Cape region [in South Africa].

Together with the ordinary adaptations which appear to stem from the arid conditions one observes also special forms of xeromorphism. The reduction of vegetative activity is combined with a peculiar growth-form in a section of the Goodeniaceae. The branches radiate out from the main axis without rising much above the surface of the soil. They are closely covered with leaves so that the whole forms a firm round cushion with a slightly domed surface on the sand. Such a form is rare in other communities. This type is found in *Leschenaultia formosa* (Fig. 24A), also in *Scaevola paludosa* and its

Strauch-Heide auf Sand:

Eucalyptus macrocarpa Hook. (weißgrau, im Hintergrund); *Xantorrhoea* [*Preissii* Endl.?]; *Petrophila scabriuscula* Meißn. (Proteac., blütenreiche Büsche im Vordergrund).
Distr. Avon, Meenaar. — E. Pritzel phot. Dezember 1901.

relatives, and *Goodenia geniculata*. Several Sterculiaceae (*Rulingia cunceata* for example) also follow this habit. The best example is *Emblingia calceoliflora* (Cappar.) which has already been mentioned as the type of this growth-form.

Built on a morphologically different plan is, however, the richly divided vegetative structure of the genus *Stylidium*. Its significance is, however, the same. *S. repens* may be taken as the example for this group (Fig. 55). Here and there it forms closely woven mats on the sand which during the flowering season becomes obvious due to its bright rose red flower colour.

A similar morphological plan is achieved by the growth of the main axis parallel and close to the ground surface (prostrate habit). It is met with in the genera *Banksia* and *Dryandra* where it has led to very peculiar forms. Most widespread in the whole region is *Dryandra repens* which we have already met in the woodland. It is, however, only in the large leaved species of *Dryandra* in the south east, e.g. *D. pteridifolia* and *D. calophylla* that the peculiarity of this growth becomes striking. The same applies to modified species of *Banksia*, occurring in the same area (*B. prostrata*, *B. repens* and others). Their stiff leaves of the usual *Banksia* type, stand in vertically directed whorls up to 25 - 30 cm in height. Often these clumps of leaves arising from the sand, are the only structures one can see over wide areas. They appear at first as independent plants, but closer examination reveals that they are connected. Other members of the Proteaceae telescope their vegetative structures in unfavourable habitats, as for example in the dwarf *Protea* species of the Cape and some peculiar *Isopogon*, *Petrophila*, and *Conospermum* species of Western Australia. Such a completely geophilous stem as that described above is found, however, only among the Banksias of the sand heath of Western Australia.

Together with the peculiarities of the vegetative structures described, there are certain devices in the arrangement of the flowers which are worthy of comment. The concentration of the leaves on the lower parts of the plant axes tends to the development of terminal inflorescences. The almost uniform height of the dominant shrubs render the display of these inflorescences difficult. The result is the projection of the inflorescence above the vegetative parts of the plant to facilitate survival. As a matter of fact one often sees a kind of upper storey of flowers supported by elongated stems above the lower storey of foliage. *Verticordia habrantha* (Myrt.) and *Baeckea pentandra* (Myrt.) are typical examples of this in the south eastern areas. The same method of exposing the flowers is met with in the case of the already mentioned felty-flowered genus, *Conospermum* (Prot.). The best examples, perhaps, are provided by the genus *Grevillea*. Thus the fine *Grevillea leucopteris* is inconspicuous in the surrounding shrubbery during the non-flowering stage. It becomes conspicuous in the landscape when the large whitish inflorescences unfold among the undergrowth, where the rigid stalks bearing cream flowers rise as leafless axes high above all the bush. *Grevillea polybotrya* and, in particular, *Grevillea eriostachya* (Plate XXI) are outstanding. The vegetative part of this latter plant is completely sheltered in the undergrowth, but the bright yellow flowers are raised on leafless axes high above the surrounding bush. The plants can thus be seen from considerable distances and the scenery from Moore River north as far as the Murchison district is quite dominated by their strange inflorescences. In fact the appearance of these plants is so striking that it was commented upon by the aboriginals. Drummond states that they call the plant "woadjar".

As the heath of the sandplains is perhaps the most characteristic formation of Western Australia, it is of particular interest to glance at related formations in other parts of the continent. A study of this kind brings out far-reaching parallels with the country in South Australia described by Schomburgk as Scrubland. There also we have "wide desolate dry plains, whose soil is too poor to lend itself to any industry. There is no water visible on its surface. The vegetation is stunted and the scrub practically lacking in grasses and herbs". "Their absence is compensated for, however, by the endless diversity of the genera and species among the shrubs. On the whole the scrub presents a dull impression although the great diversity of the species is a big stimulus to the botanist". "The predominant colour is a bluish green, sprinkled here and there with the whitish leaves

Fig. 54. *Pentaptilon Careyi* (F. v. M.) E. Pritzel: *A* Habitus. *B* Blüte. *C* Griffel. *D* Fruchtstand. *E* einzelne Frucht. (Nach DIELS und PRITZEL.)

of *Rhagodia* and the reddish-brown of other shrubs". "The uniform and dull appearance of a wide expanse of scrub land is particularly apparent when viewed from an elevation. The uniform height of the vegetation and the dull bluish leaf colour make it look like a sea extending for hundreds of miles". "Everyone avoids the scrub as much as possible. Many have lost their way in it and have died for lack of water". "One almost always, however, finds one or other species of shrub in flower. Most plants unfold their flowers in September or October." All these features have been found to hold good in the west of the continent. The remark of Behr[1] concerning the South Australian scrub: - "Plants of different families so resemble each other in habitat that only the flower or fruit is a safe guide to their identity" has already been found to apply exactly to the sand heath of Western Australia.

Fig. 55. *Stylidium repens* R. Br.: *A* Habitus. *B* Blütenstand. *C* Blüte. *D* Frucht. *E* Querschnitt durch den Fruchtknoten. (Nach MILDBRAED in »Pflanzenreich«).

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1 In Linnaea XX, 549.

Rand der Strauch-Heide auf Sand.

Actinostrobus pyramidalis Miq. (Pinac., ganz links); *Jacksonia eremodendron* E. Pritzel (Legum., hinter dem Actinostrobus); *Grevillea eriostachya* Lindl. (Proteac., scheinbar laubloser Strauch, in der Mitte hinten); *Conospermum stoechadis* Endl. (Proteac., weißfilzige Inflorescenzen).
Distr. Irwin, Watheroo. — E. Pritzel phot. Dezember 1901.

sion although the great diversity of the species is a big stimulus to the botanist". "The predominant colour is a bluish green, sprinkled here and there with the whitish leaves of *Rhagodia* and the reddish-brown of other shrubs". "The uniform and dull appearance of a wide expanse of scrub land is particularly apparent when viewed from an elevation. The uniform height of the vegetation and the dull bluish leaf colour make it look like a sea extending for hundreds of miles". "Everyone avoids the scrub as much as possible. Many have lost their way in it and have died for lack of water". "One almost always, however, finds one or other species of shrub in flower. Most plants unfold their flowers in September or October." All these features have been found to hold good in the west of the continent. The remark of Behr[1] concerning the South Australian scrub: - "Plants of different families so resemble each other in habitat that only the flower or fruit is a safe guide to their identity" has already been found to apply exactly to the sand heath of Western Australia.

On the other hand the detailed study of the South Australian formation shows that different kinds of combinations of the taxonomic elements have taken place there. The dwarf plants mentioned by Schomburgk do not occur in the genera *Santalum*, *Exocarpus*, *Dodanaea* and *Callitris* in Western Australia. Amongst the smaller shrubs Schomburgk also names a series of types which are more or less strangers in our formation in Western Australia, for example, *Cassia*, *Alyxia*, *Myoporum*, *Eremophila* and *Rhagodia*. These are all typical Eremaean elements in Western Australia. They grow in the undergrowth of the woodland, and even form independent associations where the soil is not so loamy. They stand, however, in the whole Eremaea in Western Australia in striking contrast to the typical sand heath community.

Schomburgk refers also to the undergrowth of the scrub, and describes a rich rain flora of bulbous plants and orchids, of many kinds of annuals and transient perennial herbs. Quite a large section of the loamy soil flora (given under IV 5 b b) appears in his list. This is far more than is found anywhere on the sand heath of Western Australia.

From all this it is clear that even the most closely related formations of the rest of the continent are less individual in composition than the typical sand heath of Western Australia. Superficially there often appears to be considerable agreement, but closer inspection shows that the inner structure is of quite a different nature. In South and East Australia the Eremaean flora characterizes the scrub, In Western Australia on the contrary, it is the flora of the south-west but modified to a xeromorphic form. The shrub heath of south east Australia, e.g. in Victoria and New South Wales, which physiognomically and taxonomically correspond to the sclerophyll scrub of the West occur in isolated patches and are restricted to regions near the coast. There is a marked lack of that host of fine example of hardy types which in Western Australia have penetrated far into the sandy regions of the interior.

D. Swamp Formations.

a. *Alluvial formation* (Plate XXII)

In the Southwest Province a great many large alluvial surfaces occur. Their soil usually consists of fine grained material - derived from the detritus from the plateau rocks. They are found in the first instance on the plateau itself, ie. in shallow hollows, and in gently sloping valleys where there is little or no water run-off. Here the finest particles soon sink and slowly accumulate. These deposits are more extensive on the littoral plains to the west of the plateau. They alternate with the sandy mixed woodland and occupy a very considerable fraction of the whole area.

The manner of water supply of this swampy land is rather unusual. Its heavy soil takes up water only slowly and, at the beginning of the rainy season, is almost impenetrable. As a result, the water collects here and there in considerable quantities flooding the ground and delaying the growth of vegetation. Gradually, however, the water begins to sink in, the soil becomes saturated and then holds this moisture firmly for a long time. It dries out very slowly but at the same time all the more completely. As it dries it contracts

1 In Linnaea XX, 549.

and becomes as hard as a tile. These conditions govern the development of vegetation in these alluvial communities. The vegetation is late in commencing to grow. It reaches its peak only when the growth of plants on the more open soils is well advanced. During the whole of the first half of the dry season plant activity is considerable. All the more rapid, however ,is the decline in activity in the later months of the dry season and all the more complete is the apparent cessation of all activity. It must be noted that these rules, which hold good for the greater part of the south west, require considerable modification for the vegetation along the south coast, due to a less extreme climatic periodicity.

The communities which are present on the swamp lands in many ways provide a strong contrast to those of the sandy and slightly loamy soil. Essentially this may be set out under four headings : - (a) the relative participation of different life forms, (b) the relative participation of related groups, (c) the relative number of individuals, and (d) the presence of widely distributed species.

If one considers the first of these one is struck by the unusually great importance of the annual plants. The stimulus or factor controlling this is evidently the high water-holding capacity of the soil. With this is associated the fact that there are none of those occasional disturbances in the water supply during the vegetative period, such as occur on more loosely bound soils.

It is difficult, or in fact quite impossible at the present time to comprehend the facts which result from a study of the relative participation of related groups. It is very noticeable how poorly represented the Proteaceae and the Leguminosae are here and yet these two families are the ones which play such an important role in many other associations. In the family Myrtaceae there is a peculiar contrast between the Chamaelaucieae and the Leptospermeae. The former occupies quite a subordinate position in the alluvial formation. The Leptospermeae on the other hand is the most important element. Its dominant position is due less to the diversity of form or richness of species than to its great productivity and gregariousness of its occurrence.

As a rule the crowded occurrence of individuals is characteristic of many kinds of swamp country. Social species are more numerous than in the drier formations. This may be correlated with the same conditions which are responsible for the abundance of annuals. (see above).

The swamp and alluvial formations taken together, although rich in peculiar species - are not so overwhelmingly rich in endemic forms as are the growths on drier country. How many non-endemic species are actually present cannot be stated exactly, but it always appears to be very large. This is supported by previous experience in plant geography. In fact there is reason to doubt whether many of the widespread participants are indigenous to Western Australia.

Extensive areas of swampy land in the Southwest Province are characterized by tall growing species of *Eucalyptus*. In places *Eucalyptus patens* dominates the formation. Much more commonly, however, we find *Eucalyptus rudis* playing the part of the leading tree. This is a stately species, which only differs from *E. rostata* (the important creek tree of extra-tropical Australia (see IV. Part 1. Ch. 1) in unsubstantial details. Its crown is broad, the leaves and also to some extent the twigs, are pendant, in other details they follow the usual eucalypt leaf type which is so constant under remarkably different conditions. On the whole these eucalypts scarcely impose on the overall character of the alluvial formation.

By contrast the trees of the genus *Melaleuca* lend a very individual feature to the scenery. Several species are quite important in Western Australia. The most widespread are *Melaleuca rhaphiophylla* and *M. Preissiana*. They are similar in habit, but easily distinguished by the shape of their leaves. The peculiar shape of these trees is clearly shown on Plate XXII. The stem does not attain any great height, but, owing to its gnarled growth and the irregular branching of the crown the *Melaleuca* may easily be recognized from a distance. The white bark which hangs down from the stem in shreds, contrasts sharply with the deep green of the leaves. In the rainy season the dusky image of the tree is mirrored in muddy pools of water. When the soil has dried out the tree commences to flower. Its scenic effect is then greater than usual owing to the bright contrast of the white flower spikes and the dark coloured foliage (Fig. 13, 56).

The strange yet attractive appearance of *Melaleuca* is not paralleled by any other tree growth of the swamp land. *Banksia grandis* is occasionally associated with *Melaleuca*, *B. littoralis* is, however, more common, particularly in the south where it reaches an imposing size. I have seen trees 25 m high with their smooth grey bark and branches which first bend downwards and then in a curious manner rise upwards to carry the rigid whorl of blue-green leaves surrounding the yellow flower cone.

In many places a thick shrubby undergrowth occurs, this being strongly developed under the trees. It consists chiefly of certain species of Myrtaceae - Leptospermeae, which in habit and life form are closely similar. All show very frequent branching with the branches always being flexible and slender, almost vertically directed and closely covered with small leaves. The colour of the leaves is also similar, a fresh clear green decidedly different from the grey and bluish tints which are so characteristic of the vegetation of Western Australia over extensive areas. When one observes it from a distance the closeness of the growth, the wealth of leafy branches, and the colour remind one of a meadowland or savanna rather than of a shrub formation. The most important species of this growth, which seldom attains a height greater than 2 m are *Astartea fascicularis* and *Leptospermum firmum*. The first is very generally present and is in fact the most dependable character plant of the formation. *Leptospermum firmum* shows a similar wide distribution yet it does not attain the importance of *Astartea fascicularis*. In the southern districts some other species are also important - the graceful *Melaleuca incana* for example whose young leaves are covered with beautiful silvery grey hair, and its associate, *Agonis parviceps*. Others include *Callistemon speciosus*, which is sharply distinguished from other plants by reason of its broad and more bluish coloured leaf and the brilliant red of the flowers. In the same districts *Agonis juniperina* also plays a conspicuous part. The species is similar to the other *Agonis* species in build, but under certain circumstances attains a much greater stature. Thus in the neighbourhood of King George Sound on wet swamp land not far from the coast it may be found up to 12 m high. It is a beautiful and delicate tree, covered with white flowers at the beginning of the rainy season. It would look rather like a *Prunus padus* in bloom if it were not for the leaves which are quite different.

If one looked at the other taller shrubs present in addition to the above members of the Myrtaceae one would first take notice of *Viminaria denudata*, *Jacksonia furcellata* or *Oxylobium lineare* (Legum.). The latter reminds one from a distance of a willow type of tree. *Viminaria* and *Jacksonia* are easily recognised by the dense branching of their leafless branch system. The branches of *Viminaria* often hang limply downwards - the plants are conspicuous and resemble in appearance many broom-like members of the Leguminosae. The branches of *Jacksonia* are densely clothed with short flattened branches (phylloclades) and the whole is visible from a distance because of its silver-grey covering of silk. The shrub is not an alluvial plant in the sense that the tone-giving members of the Myrtaceae are. The character of its occurrence as well as its vegetative structure indicate that it has only secondarily become adapted to the alluvium. It flourishes there and grows up to 5m in height. Amongst the Leguminosae of the formation *Viminaria* is the only other plant of equal or greater height.

Where the Myrtaceous vegetation is developed at its best little undergrowth is tolerated. Such isolated undergrowth plants that one does occasionally come across are mostly slender pliable, weakly branched forms which are only obvious at flowering time. Certain species of *Pimelea* (*P. hispida*) and many species of *Boronia* (Rut.) are not uncommon amongst these, and it is in this type of situation that the famous Black Boronia (*Boronia megastigma*) (noteworthy because of its glorious perfume) is found - often in places where the soil is underwater at the flowering period.

In other areas myrtaceous shrubs alternate with open places where either tiny shrubs grow or herbaceous plants cover the soil. This low shrub vegetation is less uniform than the Myrtaceous formation itself. *Thomasia* species (related to *Th. pauciflora*) (Stercul.)

Alluvial-Formation:

Melaleuca Preissiana Schau. (hinten); *Xantorrhoea Preissii* Endl. (vorn).
Distr. Darling, Bayswater, östl. von Perth. — E. Pritzel phot. Dezember 1901.

are common there and are easily recognized by their soft and comparatively large leaves. *Dampiera hederacea* (Gooden.) is ecologically related to them. *Aotus cordifolia* (Legum.) also has relatively large leaves. With these, however, grow *Sphenotoma gracile* (Epacrid.), *Platytheca galioides* (Tremandr.) and *Compesperma nudiusculum* (Polgal.), all of which in general form are not hygromorphic yet are adapted to their situation by the delicate and limp nature of their whole structure. Vegetatively they are most productive and their thin stems and leaves develop so abundantly that thickets are formed in which delicate twining fibers of *Thysanotus* (Lilac.) and *Cheiranthera* (Pittsporac.) are interwoven. Above these rise the taller stems of *Anigozanthos flavida* just as in the thick undergrowth which covers the damp ground in the woodland of the south-west.

Instead of such undergrowth a zone of perennial and annual herbs directly replace the myrtaceous shrubs. Where the soil is waterlogged for weeks every year, the low bush does not develop. The vegetation consists of rhizomic plants or annuals which only become active after the water disappears. Several types can be distinguished. They will be more sharply defined later. It is to be expected that special edaphic adaptations will take first place in the formation of these types. At the present time, however, we have no reliable information on this point. We will therefore content ourselves with the descriptions of the facts already discovered.

Among remarkable species growing on alluvial land we find certain members of the Restionaceae. The most important of these are *Lepyrodia glauca* (Fig. 25) and *Leptocarpus scarious*. In any case they are the largest and most striking of the West Australian restionaceous taxa. There is nothing to be gained by dealing with their differences here. In habit and in the part they play they resemble each other closely. They are most comparable with certain tall growing members of Cyperaceae, yet they possess a strange, stiff character which is quite peculiar to them. The leafless stems branched together in great numbers form a more or less large clump which looks like a stiff broom which one has stuck in the mud. The two species named grow upwards to 1 m or more in height while related species of similar growth form are less tall. These restionaceous clumps grow in a scattered fashion often with quite large spaces between them. For the greater part of the year they present an unattractive appearance. It is only in the flowering season when their freely swinging inflorescences and brightly coloured bracts are developed, that they bring something pleasing to the scene.

Very often the spaces between the restiad clumps remain bare even at the best season of the year. Sometimes, however, they become covered with vegetation as soon as the water has drained away. They then appear like those parts of the swampland where the tall growing members of the Restionaceae are absent. Smaller species of this family are present, many of them gregarious and common, e.g. *Leptocarpus coangustatus*. Occurring together with these are geophilous plants and transitory herbs whose flowers indicate that the biological year is reaching its end. *Triglochin procera* has been frequently noticed as being important here. It endures through the dry months in a bulbous swollen root which has reserve stores of food. This is responsible for its rapid development once conditions become favourable. There are places where entire depressions of gullies are filled with masses of vegetation of this kind so that they appear from afar to be fresh green meadows. Other bulbous or tuberous plants are less gregarious but still important. Of the Droseras there are several common species, e.g. *D. heterophylla*. It adorns the alluvium from June to August with great white flowers like those of the European wood anemone. *D. Huegelii* is also fairly common in similar places as are some of the smaller species. A whole series of Liliaceous plants with bulbs or thick rhizomes flourish on the swamp land. The genus *Tribonanthes* is extremely characteristic. Of the species of *Anigozanthos*, *A. viridis* grows well in this situation and some of the other species occur here and there. *Haemodorum* is represented by *H. simplex*. The small *Pritzelia pygmaea* (Phildr.) with its yellow flowers is common and scattered orchids are to be met with almost everywhere among the alluvial growths. Among the most common are the inconspicuous species of *Microtis*. Species of *Diuris* with their yellow and red flowers (Fig. 23) are also quite characteristic there.

Mixed with these thinly scattered bulbous plants covering the clay loam of the swamp country are herbaceous annuals. No idea of their importance can be gained from February to the end of May or longer, for they have dried up out of all recognition or have completely disappeared. Later on a touch of green gives the first hint of their existence. By August, however, they have produced a thick carpet which soon commences to bear bright coloured flowers thereby advertising the diversity of its constitution. The species are thoroughly inter-mixed and none can be said to hold a dominant position. It is only over small stretches that here and there one species is a little more abundant than others.

Fig. 56. *A—E Melaleuca Preissiana* Schau: *A* Spitze eines blühenden Zweiges. *B* Blüte. *C* Blumenblatt. *D* Staubblattbündel. *E* Früchte. — *F—M Astartea fascicularis* DC.: *F* Blühender Zweig. *G* Blühendes Seitenästchen. *H* Blatt. *J* Blüte. *K* Staubblattbündel. *L* Gynaeceum im Längsschnitt. *M* Ovarium im Querschnitt (Original).

A closer glimpse of this herbaceous vegetation discloses a rare or unusual world in miniature (Fig. 58). Usually one is struck by the reduced structures visible. Few species are more than 10 cm tall, while many scarcely reach to 5 cm. The leaves are few in number and exceedingly feebly developed. They have often withered by the time the flowers unfold. The annual members of the Stylidiaceae on these clay alluvials eg. *St. calcaratum* (Fig. 58H), *St. canaliculatum* and *St. breviscapum*, the species of *Levenhookia* (Stylid.), *Myriophyllum* (Halor.), *Utricularia*, *Polypompholyx* (Lentibul., Fig. 58G) and *Haloragis* (Halor., Fig. 58E) are vegetatively very simple. So far as the plant families, Utriculariaceae and Haloragaceae are concerned the species of *Utricularia*, *Polypompholyx* and *Myriophyllum* occurring in these formations of Western Australia are the most primitive. It is worth noting that the groups possessing these remarkable and theoretically important dwarf forms in Australia are so widely distributed and biologically so uncommonly diverse. In conclusion *Phylloglossum drummondii* (Lycopod.) must be mentioned for this tiny plant is also one of the characteristic elements of the alluvial flora. In it, too, we see the extreme simplification of a cosmopolitan botanical element.

Fig. 57. *Levenhookia* : *A—C L. stipitata* F. v. M.: *A* Habitus. *B* Blüte ausgebreitet. *C* Säule mit Scheide. — *D—G L. Preissii* F. v. M.: *D* Habitus. *E* Blüte. *F* Schlund der Kronröhre mit Säule. *G* Schlund der Kronröhre ohne Säule. (Nach Diels und Pritzel).

As already stated this vegetative reduction affects the whole association of annual plants on the clay surfaces of the Western Australian swamplands. Besides the genera already given the following important examples may be mentioned : - *Triglochin* (*T. mucronata*, *T. centrocarpa*), *Hydrocotyle* (*H. hispidula*, *H. alata* (Fig. 58F), and *H. diantha*), *Glossostigma elatinoides* (Scroph.), and several members of the Compositae. Members of the Glumiflorae remain very small in height, eg. *Schoenus apogon* (Fig. 58C), one of the most common and most social species of the Cyperaceae, and *Cyperus tenellus*. Members of the Centrolepidaceae consist exclusively of very tiny plants, although they form a character-family of the formation. Thus the author found particularly widespread the most delicate *Brizula Drummondii* and *Centrolepis aristata* which, in places, grow abundantly and in thick masses.

From the point of view of flower biology this herbaceous flora is not uniform. The monocotyledons and also *Myriophyllum* and *Hydrocotyle* possess the structure of wind pollinated plants. Since these groups make up a big percentage of the whole, the botanical element we are considering is markedly influenced by this floral type. Thus a large number of small inconspicuous pale and greenish coloured flowers are present. In contrast to these some entomophilous elements are also important. We may mention the large flowered purple *Drosera* species and the violet coloured *Utricularia* species. *Polypompholyx multifida* has smaller corollas but as the species occurs together in large numbers the general massed effect is considerable. *Levenhookia* (Fig. 57) with rose coloured corollas and species of *Stylidium* with their red spotted flowers are very effective and are often crowded together in such abundance that the ground appears as if embroidered with them.

Fig. 58. Annuelle der Krautflur auf Alluvien, alle in natürlicher Größe: *A Selaginella Preissiana* Spring. *B Triglochin calcitrapa* Hook. *C Schoens apogon* R. et S. *D Brizula Muelleri* Hieron. *E Haloragis nodulosa* (Nees) Walp. *F Hydrocotyle alata* R. Br. *G Polypompholyx multifida* F. v. M. *H Stylidium calcaratum* R. Br. *J Rutidosis argyrolepis* Schlecht. (Original).

The dwarf flora described above occurs again elsewhere in Australia, but no where is it so well developed and so rich in species as in the south west. F. v. Müller had already pointed this out in 1866 and had suggested that there were more of these miniature phanerogams endemic in Australia than anywhere else on earth. In this there is an expression of the edaphically limited vegetative activity, the result of a climate marked by great periodicity. A similar case is met with in connection with the dwarf plants of Lindman's[1] "locis limosis" in southern Brazil and "mutatis mutandis" on the shallow parts

1 see Lindman "Vegetation I Rio Grande do Sul" 1900. p 19, 20. Also see Grisebach, Vegetation der Erde, II. 391.

of the exposed ponds of the Holarctic region. They are, however, not so well developed in those areas.

In south west Australia the herbaceous flora as described is characteristic of a subsoil strong in clay, with little humus, and which dries out considerably in the second half of the dry season. It undergoes many alterations on the more strongly humus soil. Again at places which in the dry season remain very moist for a long time, or in the neighbourhood of perennial water courses the same effect occurs. In such places grow *Stylidium junceum* (Stylid.)and *Amphipogon cygnorium* (one of the few grasses of the south west) in light shade between myrtaceous bushes. There one also finds ombrophile annuals, again of very small and delicate build, namely *Selaginella Preissiana* (Fig 58A) and *Mitrasacme paradoxa* (Logan.). Both are the only species of their genus in Western Australia. *Epilobium junceum* (Oenother.), *Gnaphalium japonicum* (Compos.), *Gratiola peruviana* (Scroph.), *Centipeda Cunninghamii* (Compos.) are also frequent, a sub-cosmopolitan contingent, in numbers unusual in Western Australia. Together with these are Australian types such as *Samolus junceus* (Prim.) and different forms of *Goodenia tenella* (Gooden.). *Villarsia* (Gentian.) species grow in even more moist places. *Hydrocotyle plebeia* (Umbell.) roots in the mud. The rest of the formation is made up of species which we have already met those small, often dwarf herbs like *Centrolepis aristata* (Centrolep.), *Juncus caespitius* (Junc.), *Cyperus tenellus*, the almost stemless *Angianthus humifusus* (Compos.) and *Cotula coronopifolia* (Compos.). Of these the two Composites are very widespread. *Centrolepis* is also one of the most important characteristic plants of this type of formation.

In the south of the Southwest Province the herbs play a less conspicuous part in the constitution of the alluvial formation. The more equable climate is not as favourable for annuals. In any case the dry season is not intensive enough to favour the annuals as against the perennial growth-forms. On the southern alluvials, therefore, long lived plants predominate and are often in full bloom in summer. They make up diverse shrub associations. In some cases they are quite low in stature but they are always characterised by a growth form marked by the lignification of the supporting axes.

The Myrtaceae again play the dominant role, and the growths of *Beaufortia sparsa* (Myrt.) which grow almost inseparably from *Evandra aristata* (Cyper.) are important. The brilliant scarlet red of the *Beaufortia* renders it obvious from a distance whilst the delicate inflorescences of *Evandra* with pendant heads supplies the closer view with a quite distinctive feature. Where these species become less numerous members of the Epacridaceae occur in ever increasing abundance. They are all small heath-like bushes but due to the mass of individuals they exert a pronounced effect. *Andersonia caerulea* (Epacrid.) with its reddish calyx and bright blue corolla occurs frequently as does also *Lysinema conspicuum* (Epacrid.). The name of the latter is most appropriate for it is the most striking of all. At the flowering season it covers many places as with a fresh layer of snow. Among other families present the Thymelaeaceae is well represented by *Pimelea* species; *Pimelea longiflora* (Thymel.) being particularly common in this formation.

Where the low bush thickets of these small and simple heath shrubs are less thick a gaily mixed community of plants takes possession of the soil. Tufts of Restionaceae grow there with species of *Stylidium* and several members of the Goodeniaceae, of which *Diaspasis filifolia* with its pure white flowers is most noticeable. *Boronia* species (eg. *B. juncea*; Rutac.), *Epilobium* species and others also occur. Webs of *Cassytha* (e.g. *C. racemosa* and *C. pomiformis*; Laur.) are richly interwoven in the undergrowth.

It would take us too long to discuss the occasional or rare elements of this sub-formation, but it is desirable that we mention the curious *Leptospermum crassipes* since its peculiarities are to a certain extent symptomatic of the ecology of the sub-formation. The shape of this strange plant is brought about by the hypertrophy of the base of the stem. It is closely related to *Leptospermum ellipticum* which as a rule is a much taller shrub of the alluvial lowlands. A peculiar sparse, open arrangement of the branches, a thick leaf (shaped somewhat like a spatula), and the arrangement of the flowers, (single flowers in the upper axils) all these together with the systematically characteristic features of the gynoeceum are common to both species. Practically the only difference lies in the swelling

Vegetation des Granitfelses (im Vordergrund).

Die Granitplatten teilweise überlagert von schwarzgrünen Polstern des *Campylopus bicolor* (Musci). In den Zwischenräumen *Anthocercis viscosa* R. Br. (Scrophular., Baumstrauch), *Agonis marginata* DC. (Myrtac., Strauch ganz links), *Anarthria scabra* R. Br. (Restionac., Büschelrasen vorn), *Eucalyptus cornuta* Lab. (rechts hinten).

King George Sound, Kuppe des M. Elphinstone. — E. Pritzel phot. Oktober 1901.

of the stem in *L. crassipes*. This is produced by a huge development of thin walled wood tissue. This strange feature appears to be correlated with the conditions of the locality but it is difficult to explain how. It seems eminently suitable, for *Leptospermum crassipes* is gregarious in these places and often appears in great numbers.

Transition zone plants. At the margin of the alluvium on sandy soil a mixed zone is formed. This consists of low bushes and shrubs. *Leschenaultia expansa* spreads out its branches, *Drosera gigantea* lifts its branched stem upright and the pale yellow grape-like bunches of *Comesperma flavum* are visible here and there. This is also the home of *Byblis gigantea* and in areas where it is common it looks splendid with its deep rose red flowers. Amongst the shrubs the Myrtaceae take the first place, *Leptospermum ellipticum* often forming little thickets of its own. Where the soil is more sandy *Verticordia* or *Calythrix* are found occurring alone or in groups. *Calythrix aurea* is yellow, *Verticordia nitens* is a glancing orange, *V. Drummondii* and *V. Fontanesii* are rose red. The more they increase the more the formation loses its peculiar nature and contains foreign elements. It also brings one nearer to the scrub zones which lead to the light woodlands.

b. *Formation of the Granite Rocks* (Plate XXIII)

In many places in Western Australia the granite country rock is freely exposed in the form of great rounded masses. These granite rocks are never completely covered with vegetation. There are great stretches of bare rock on which only the smallest cryptogams are found. Often, in fact, the granite tops are absolutely free of all plant forms and appear smooth and grey, glistening like ice, silvery in the sunshine where water has trickled over.

Other parts of the rock surface are covered with a dark carpet of moss, composed of *Campylopus bicolor*. This species forms close mats of a deep black-green colour, like heavy velvet.

The moss is the pioneer for all the following vegetation. The first plants to associate themselves with it are some lichens, (*Cladonia verticillata* for example) and then *Borya nitida* (Lil., Fig. 21) which one can consider as a character plant for these granite surfaces. In company with it one meets quite a collection of small annuals or delicate bulbous plants in the soft substratum of the mosses. At King George Sound one meets the pretty *Utricularia Menziesii* and also *Polypompholyx multifida* (Lentibul., Fig. 58G). Both are often numerous and under such circumstances are very decorative in their small way as their large bright purple flowers rise to form a pattern in contrast to the deep dark green of the mossy ground. *Drosera microphylla* is another similar ornament at flowering time. It develops from little knob-like structures which remain dormant in the moss during the dry season. The stem is strikingly weak and rambles over the surface of the moss as if seeking support until finally it raises its flowers and the beautiful red petals unfold. Small species of *Hydrocotyle* (e.g. *H. diantha* and *H. callicarpa*) grow almost inconspicuously on the mossy ground. This plant association consequently reminds one of the miniature flora of the alluvium. There are also some parallels in the conditions under which it exists - complete saturation with water is limited to a relatively short season just as the needs of the annuals are only met for a few months on the clay substratum of the alluvium.

In the open clefts and hollows between the rocks one finds an even more luxuriant layer of vegetation according to the depth of the soil. Close to the margin of the rock where the earth covering is not so deep only shallow rooting plants find a hold, such as bulbous orchids belonging to *Prasophyllum* and *Pterostylis* (Fig. XXIII). In better positions, however, one finds bushes and even tall shrubs. *Hakea* species with almost succulent leaves, *H. suaveolens* is probably the most peculiar of these. Even unusual little trees develop in these positions. Thus on the south coast there are, together with low forms of *Eucalyptus cornuta*, specimens of *Anthocercis viscosa* which attract attention. (Plate XXIII). Its branches are bare for some distance and the relatively large leaves are crowded towards the tips. The leaves are bright green, richly provided with glands and covered with a sticky secretion. In the middle of the clusters of leaves the large bell-like flowers appear. These with their delicate white colour and strong scent, belong to another biological class poorly represented in Western Australia.

PART IV

The vegetation of the Eremaean Province

CHAPTER I GENERAL CHARACTER

The relationships between the Southwest and the Eremaea were referred to earlier (Part 2, Ch. 3), which result in a well-defined boundary between these Provinces. In this volume we consider only an arbitrarily separated part of a much larger area of the Eremaea.

Regarding topography, climate and vegetation the Southwest Province is a region of graduated change, while the essential character of the Eremaea is that of almost imperturbable homogeneity and monotony.

Because of insignificant and capricious rainfall (some years rainfall is plentiful, others almost nothing), precipitation has but little influence. Also there are no large valleys but extensive shallow depressions, flooded after rain. These dry out quickly, leaving a thin crust of glistening salt, which imprint on the overall appearance of the whole landscape.

In the Eremaea leached sands of the upper soil are less prominent than those of the south west. The prevailing conditions favour the development of a lateritic soil. Among other formations *Eucalyptus* woodlands occur analogous to those of the transition zone. They are mainly found where the winter rains still exert a fairly regular influence. Where this is no longer the case, ie. somwhat north of 30^{o} S. the Eucalypts phase out and Acacias become the dominant feature of the vegetation.

The West Australian Eremaea is thus divisible into two quite different portions. The more southern part owes its existence to the last traces of the winter rains. *Eucalyptus* woodlands alternate with arid shrub heaths depending on whether the subsoil is composed mainly of clay or sand. *Eucalyptus* species ranging from very low trees to ones of imposing stature occur in the form of light woodland. The lower growth in these woodland consists of an assortment of shrubs including *Melaleuca* (Myrt.), *Acacia*, *Eremophila* (Myopor.), *Dodonaea* (Sapind.), *Casuarina* (Casuar.) and others. In one area these are crowded together to form close thickets, while in other areas they are scattered as broom-like bushes. Delicate plants are absolutely dependent upon the vagaries of the weather. In many years they are absent altogether. If, however, the rains are more abundant than usual the ground becomes quite richly covered with annuals. In particular the everlastings (Compos.), (*Helipterum* and *Helichrysum* species) are important. Grasses may even appear in moderate abundance. At such times the relationship of the formation to the *Eucalyptus-Acacia* woodlands of the south west transitional zone is most clearly seen. It also becomes evident that the sand shrub heath of the southern Eremaea is nothing but a reduced form of the vegetative formations so richly developed to the west of the Eremaea.

This mutual intermingling of features of the southern Eremaea with those of the transition zone of the Southwest Province has already been dealt with above. It is important for the proper understanding of the Eremaea since in its northern half it is no longer evident. The role played by *Eucalyptus* there has been reduced to a very minor part indeed. Tree growths are almost non-existent apart from those in certain shallow valleys where conditions are more favourable in so far as subterranean moisture is concerned. *Acacia* is the dominant character element of the flora, usually occurring in the form of tall shrubs with phyllodes which are like *Eucalyptus* leaves in form but easily recognised by the permanent grey-green colour. These plant growths, rich in *Acacia* and *Eremophila* correspond roughly to the monotonous Mulga scrub typical of Eastern Australia. These regions are subject to severe climatic extremes, being exceedingly hot in summer. Scarcity of water is almost everywhere a real problem.

The two great vegetative provinces of south west Australia are however, more sharply separated by floristic differences than by any features of general appearance. In the

Eremaea *Xantorrhoea* (Lil.) is lacking over wide stretches. One may only see an isolated grass-tree at a few widely separated spots where conditions are more favourable. *Macrozamia* (Cycad.) is completely absent. Very few members of the Proteaceae are present apart from a few species of *Grevillea*. Just as this remarkable family avoids the Eremaea so also does the Epacridaceae. Orchids and restionaceous species are extremely rare. The Eremaea plays the same role for these families as the Karroo region in South Africa.

The positive characters of the Eremaea also remind one somewhat of the Karroo. The high number of composites, the excellent development of succulent members of the Chenopodiaceae are two features that one must put first in discussing the floristic nature of the Eremaea. True characteristic plants of the West Australian Eremaea are members of the families Myoporaceae, with the genus *Eremophila*, and the Lachnostachydinae and Chloanthinae.

Most of the endemic plants of the south west Australian Eremaea are recruited from the above mentioned types. As far as I know they make up about 43% of the total number of species - a relatively high figure which will probably be reduced in the future. Due to the great uniformity of the environment, undoubtedly many species will be found beyond Western Australia towards the centre of the Continent. In addition, included in the above figures are all those species which are endemic to the sand heaths of the border zones. These should really be considered as outposts of the Southwest Province and strictly speaking removed the list of the Eremaean flora because they appear to be uncharacteristic elements.

Crop cultivation is not possible in the Eremaean without irrigation. Such schemes would be linked to such an enormous cost that it is very unlikely to ever be a practical consideration.

CHAPTER 2 PHYSIOGNOMICALLY IMPORTANT PLANTS

I. The Eucalypts

The most important feature of the *Eucalyptus* flora of the Eremaea is its distribution over such a wide area of this Province in Western Australia. There is, however, an unexpected contrast between the north and south. The conditions regarding this will be discussed later. In the north *Eucalyptus* species are of little importance, only one species being worthy of mention - namely *Eucalyptus rostrata*, a type characteristic of water courses. In the south, however, the genus occupies a dominant position, quite a number of species being present all of which may be considered as characteristic plants of the formation. Several of these are additionally important in that they also occur in the border zone of the Southwest Province, thus contributing here to a certain partial balance between the two provinces.

1. *Eucalyptus rostrata* Schlecht. – Flooded Gum (Plate XXXII).

According to most authors *Eucalyptus rostrata* is widely distributed throughout Australia. It is found in the marshy or at times flooded low-lying portions of shallow depressions and valleys of the interior. It also occurs along the banks of creeks there. Because of the availability of underground water the tree does not show Eremaean characteristics. In Western Australia it is by no means confined to the Eremaea and through many transitional forms, is continued as *Eucalyptus rudis* which is present on the moist soils of depressions in the Southwest Province.

Eucalyptus rostrata is one of the white-stemmed eucalypts**.** Its outer bark is shed continually in thin strips exposing the white colour of the inner bark. Branching is extensive and the crown of wide extent. The biggest lateral branches project out making a wide angle with the main trunk. The extremities of the branches and the long sickle shaped leaves hang downwards. Plate XXXII gives a typical view of this beautiful tree. It is always present along the creeks of the Eremaea and in the northern landscapes of the Southwest Province.

Eucalyptus loxophleba Benth., **York Gum.**
Im Hintergrund Bestand von *Acacia acuminata* Benth. Vorn abgeerntetes Weizenfeld.
Distr. Avon, Newcastle. — E. Pritzel phot. Februar 1901.

2. The true Eremaean eucalypts. (Plates XXIV, XXV, XXVI, XXVIII).

The species of *Eucalyptus* lending colour to the southern Eremaea possess many features in common giving them all a similar physiognomic value. This is most striking to an observer when he travels eastwards from the *Eucalyptus* woodland of the Southwest Province.

The first new species of *Eucalyptus* (*E. loxophleba*) is met with in the Avon River District. In this species the trunk begins to divide into branches at about half way up the height of the tree. The shape of the crown is then conditioned by acute angled branching while the main branches rise steeply upwards. Towards their apices these branches divide up into slender twigs which carry a thin canopy of leaves. The crown is widest at the top, the upper surface being weakly convex. The whole form somewhat resembles an inverted cone or funnel. It is also not uncommon to find the main trunk dividing right at its base, the result being several equally large stems. Each of these follows the scheme described above. This eucalypt is the most widely distributed Eremaean type in the west. From its general occurrence round York it has been named the York Gum (Plates XXIV, XXVIII). To complete the description a word is necessary with regard to the bark. Its outer tissue only remains hanging to the main trunk. The main branches produce none or very little, the inner bark appearing free and glistening as if oily and olive green or muddy yellow in colour. The vertically hanging leaves of the York Gum are rather thick, dark green with somewhat strongly shiny surfaces and their oil content is high.

All these peculiarities of *Eucalyptus loxophleba* are found again in many other inland *Eucalyptus* species. *E. celastroides*, *E. oleosa* (Fig. 59A) and *E. salubris*, for example play an important part in the constitution of the light woodlands.

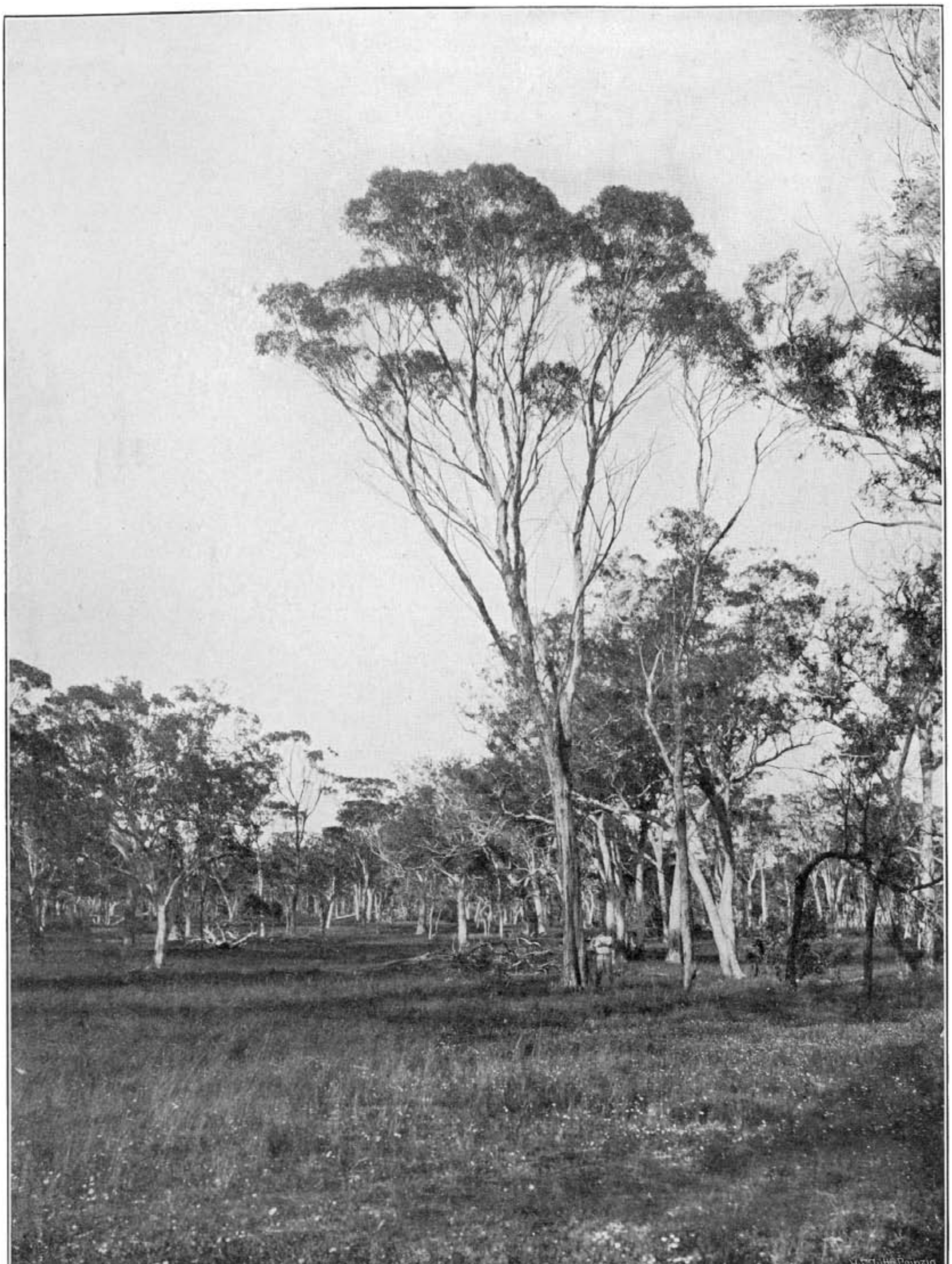
The most essential physiognomic characters also recur in a species which deserves particular mention because of its important position in the flora of the south eastern part of the Southwest Province, This is the "Flat-topped Yate" *Eucalyptus occidentalis*, (Plates XIII, XXV; Fig. 9B). It belongs to an exclusively west Australian group of the genus, sharply distinguished by its floral morphology. It is thus only slightly related to the York Gum and *E. celastroides*. It is therefore somewhat surprising to find that the external shape and ecological adaptations of all are so similar. *Eucalyptus occidentalis* presents the same main trunk covered with black bark, the obconical form of the crown, and the slight convexity of the canopy.

It was mentioned that *Eucalyptus occidentalis* did not belong exclusively to the Eremaea. It is in fact doubtful whether the main part of its area of distribution falls in this region. It is possible that it occupies a greater area in the Southwest Province. I have, it is true, seen it near Coolgardie, but large numbers of trees - of the size of associations - are only known to me from the Wandoo District round about the Stirling Range and from thence eastwards. It may extend still further as far as the Russell Range where its presence was noted by Roe. In any case, however, the tree is altogether Eremaean in its external shape. It belongs to those units of vegetation which, so far as scenery is concerned, break the contrast between the Eremaea and the Southwest Province.

Another eucalypt which is quite typical of the Eremaea is *E. salmonophloia* F. v. M. (Salmon Gum, Plate XXVI). This is distinguished from *E. occidentalis* by the shedding of its bark - the bright reddish yellow of its inner living bark led to its scientific and common names. Like the York Gum it penetrates westwards into the marginal zone of the Southwest Province. It attains more stately dimensions there because of the more favourable climate than it does in the Eremaea. Its brightly glancing trunk which can be 20 - 25 m high is as a consequence a most effective feature of the landscape.

The distribution of *Eucalyptus salmonophloia* is still uncertain. We know the western boundary only here and there. Its edaphic conditions, however, are everywhere the same - it being adapted to the hard loam soils.

This soil is without doubt the essential medium for the Eremaean eucalypts. From a distance over the treeless surfaces of the sand heaths one may recognize the region of the red loam by the black contours of these trees.



Eucalyptus occidentalis Endl. »Flat-topped Yate« (Vordergrund).
Bestand von *Eucalyptus redunca* Schau. »Wandoo« (hinten).
Vorn viel Annuellen, besonders Compositen in Blüte.
Distr. Stirling, Cranbrook. — E. Pritzel phot. November 1901.

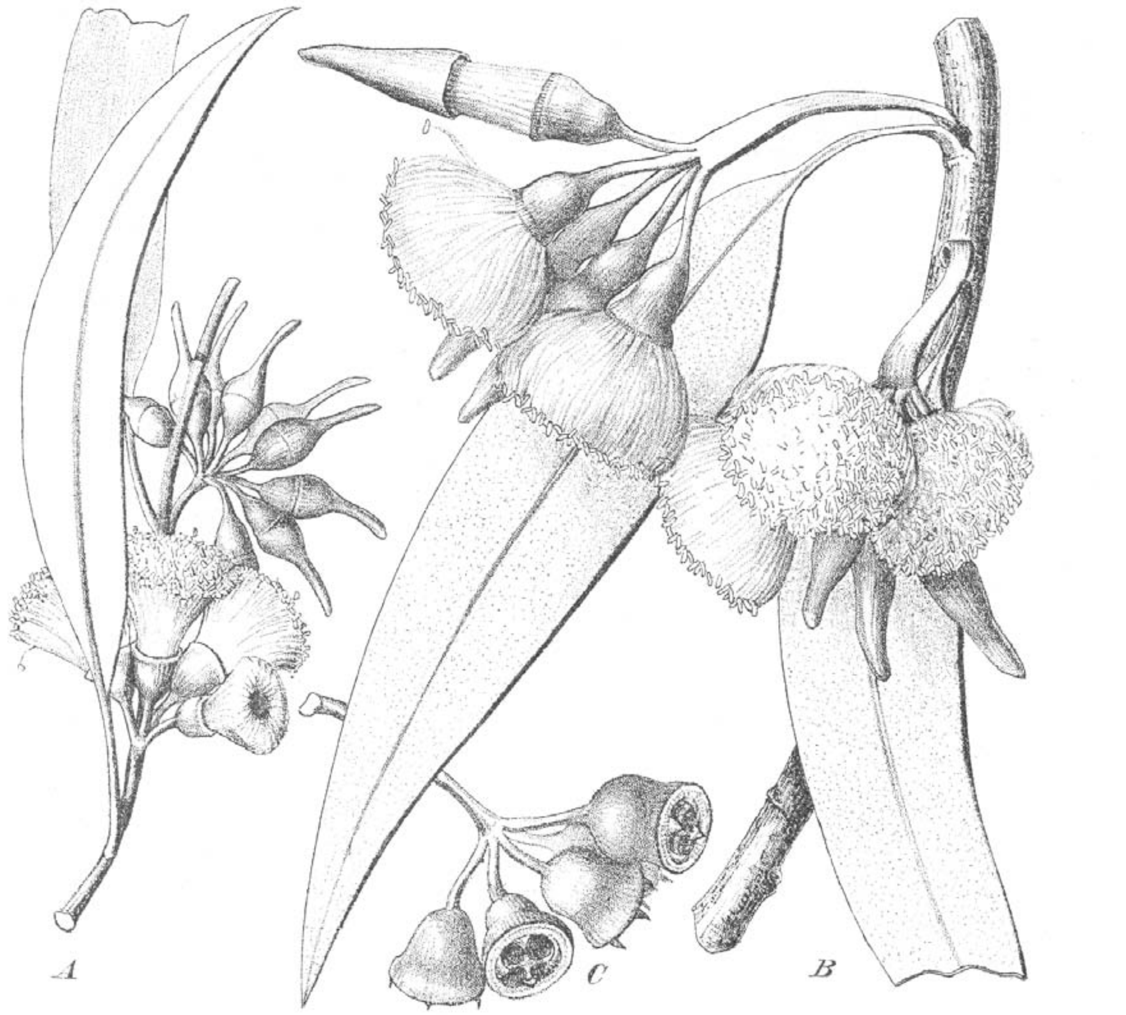


Fig. 59. Eucalypten der Eremaea: *A Eucalyptus oleosa* F. v. M. *B, C Eucalyptus occidentalis* Endl.: *B* Blütenzweig. *C* Fruchtstand (Original).

II. The species of *Acacia*

(Plates XXVII, XXX, XXXI, XXXIII)

In the Eremaea, *Acacia* has an even more important role in the vegetation than it has in the Southwest Province. And since growth form and leaf structure is on the whole more uniform in the Eremaea the genus is physiognomically more important. Furthermore, in contrast to the western districts where the usual habit is that of small-leaved, low bushes, in the Eremaea we find tall shrubs and tree-like species predominating. The phyllodes of these plants with their narrow oblong shape and entire margins approximate somewhat to the leaves of *Eucalyptus*.

E. Pritzel characterizes this type which he names the "willow leaf form" as follows[1] : - "The tree-like acacias tend, like the eucalypts, to have curved, vertically-hanging phyllodes (Juliflorae § Falcatae, Uninerves § Racemosae). This willow-leaved *Acacia* type, like *Eucalyptus* extends over the whole of Australia and is met with under all climatic conditions. The further adaptation of these phyllodes like that of the *Eucalyptus* leaf is extraordinarily limited. Species with similar phyllode shapes are found whether it be in moist and cool Tasmania, in the dry hot tropical Eremaea, or in the tropic moist stretches on the north east coast of Queensland. Differences which can be correlated with climatic diversity are restricted to such characters as consistency, gloss, waxy covering, feeble hairiness and such-like. Furthermore acacias and eucalypts regulate their transpiration

1 Diels and Pritzel Fragm. Austr. occ. 280, 281.

Eucalyptus salmonophloia F. v. M. »Salmon Gum«.
Das Unterholz ist *Melaleuca uncinata* R. Br.
Distr. Avon, Meenaar. — E. Pritzel phot. November 1901.

in such a way that the species of dry interior areas considerably reduce the leaf mass. The drier and more clear of vegetation the locality is, the smaller is the leaf mass, and the more open and less shade-offering is the tree. This willow-leaf type of *Acacia* has evolved in numerous ways but phylogenetically separated from each other. We find it in the Juliflorae, § Falcatae, the Uninerves, § Racemosae, and in the Plurinerves. It is synchronous with the occurrence of the tree-like form. The similarity in the vegetative parts of the most different species is often so downright that it is quite impossible to identify from sterile material. Notwithstanding the above, this type of leaf-like structure is capable of undergoing many modifications. Extremes range from the relatively broad and short phyllodes, as for example those of the Dimidiatae, to the elongate grass-like narrow leaves of say, *Acacia signata*."

The resemblance to the Eremaean eucalypts becomes even more apparent when we take a definite example. For this purpose the "Jam Tree", *Acacia acuminata* provides an excellent case. Plates XXIV and XXXI, illustrate the appearance of the plant. The parallelism to the York Gum for instance, in whose company this *Acacia* is so often found, is distinctly apparent. We see the same steep branching the same crowding of the vertically directed phyllodes towards the end of the (clearly broader) obconical margin of the crown. The phyllodes of *Acacia acuminata* are dark green in colour and glossy surfaced. In this respect they resemble the leaves of so many of the eucalypts of the interior.

In stature *Acacia acuminata* is somewhat limited. The tallest examples seen by the author measured about 10 m. In fact all these acacias are not far from the shrub form and they may be found in all stages of resemblance towards the common type of broom-like much branched bush, which is also presented by melaleucas, eremophilas and dodonaeas in the Eremaea.

Acacia acuminata seems to fall into the same geographical class as *Eucalyptus loxophleba*. It appears to have arisen from the species *A. doratoxylon*, so widespread in the interior. It now extends over the boundaries of the real Eremaea into the Southwest Province wherever the vegetation presents an Eremaean facies. These are the loamy areas, shallow valleys, and water channels where *Acacia acuminata* with other acacias such as *A. microbotrya*, *A. Harveyi*, and *A. aestivalis* (Fig. 60), and eucalypts form light mixed woodland. All these species are related to the really distinctive *Acacia* flora developed in the northern Eremaea. At about 30^{o}S the eucaypts disappear and the dominance of the acacias is undisputed. The whole landscape then takes on completely the type of the central Australian Eremaea - this formation is known as "Mulga Scrub". As Pritzel points out : "It is made up of the species *A. aneura*, *A. craspedocarpa*, *A. palustris*, *A. leptopetala*, and *A. salicina*. *A. aneura* can be taken as the characteristic plant for this formation in central Australia[1]".

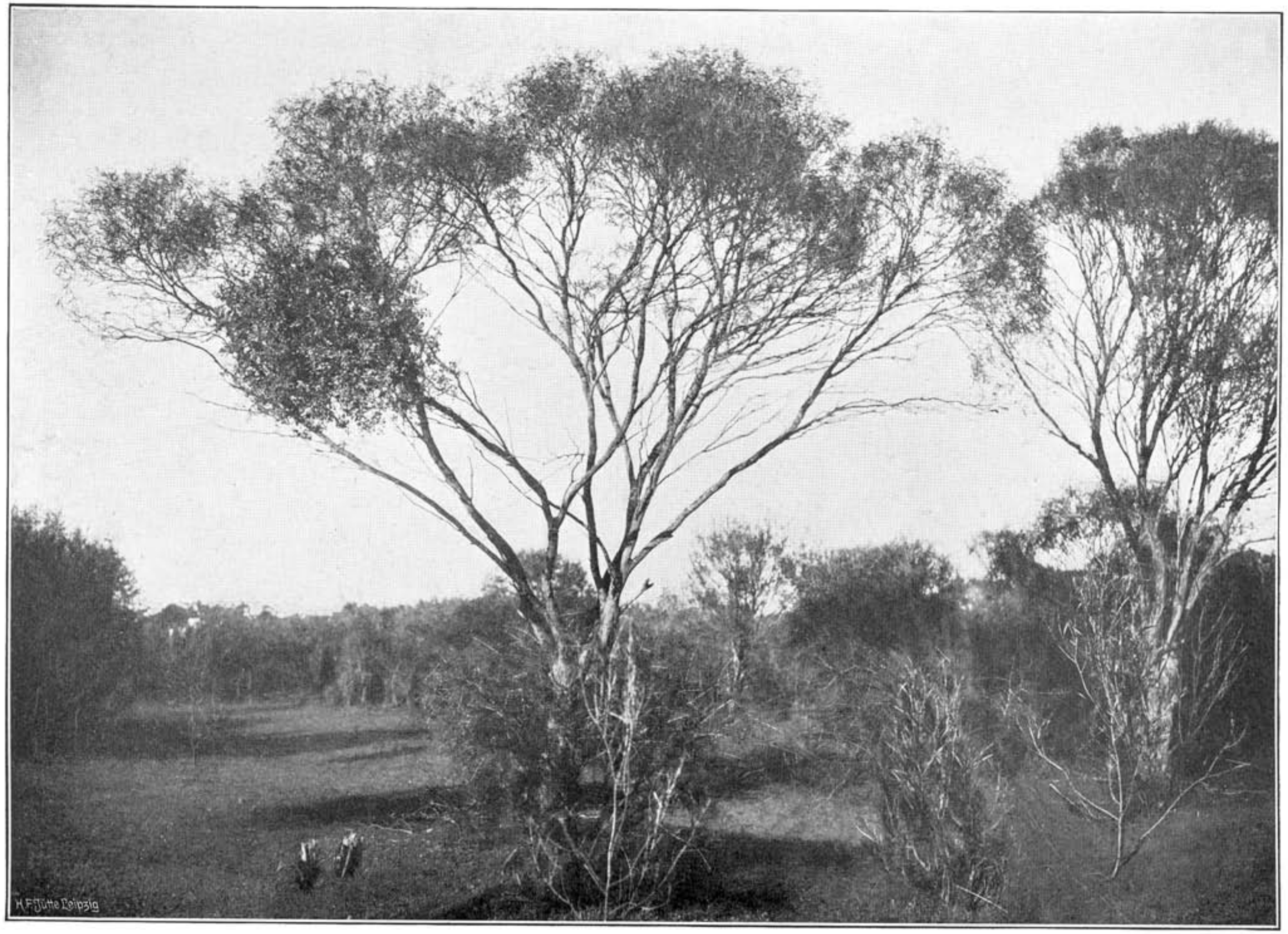
For the same of completeness we may indicate how far-reaching is the influence of the Eremaean *Acacia* type. It is expressed in the littoral districts of the Southwest Province where one can often see how taxonomic features typical of plants of the interior have reached the coast. The "Mulga" - acacia, *A. salicina*, of the whole of southern central Australia extends through the Western Eremaea south of the Murchison River to the west coast, and continues its distribution from there southwards in the form of *Acacia rostellifera* which is taxonomically scarcely different - it is confined to the sand dunes. This species however, finds its southern distribution just beyond the Swan River. *Acacia saligna* and *A. cyclopis* show similar taxonomic and geographical connections. In these examples the phyllodes are much larger than in any other Eremaean forms. This is a purely adaptational modification created by the littoral climate. Both species occur only in the proximity of the coast and along rivers up to the Darling Scarp. The willow-leaf form of acacias is otherwise absent from the true Southwest Province.

III. *Callitris robusta* R. Br. ("Pine").

Plate IV, Fig. 61.

Over wide stretches of the Western Australian Eremaea, as well as in eastern parts

1 Diels and Pritzel Fragm. Austr. occ. 288.



Acacia acuminata Benth.,
links oben mit einem Exemplar von *Loranthus quandang* Lindl. besetzt.
Distr. Irwin, Mingenew. — E. Pritzel phot. Juni 1901.

Fig. 60. *Acacia aestivalis* E. Pritzel: *A* Habitus des blühenden Astes. *C* Blüte. *D* Bractee. *E* Kelchblatt. *F* Blumenblatt. *G* Hülse. *H* Samen. (Nach DIELS und PRITZEL.)

of the Continent, grows only one conifer, this is *Callitris robusta* (Fig. 61). It is not exactly an imposing representative of the pines, and is not very individual in its appearance. In the Eremaea its stem only reaches a height of about 4 m and the crown is small. The branching is light and open. Seen from a distance the tree looks like a dwarfed pine. There is a very considerable resemblance to the related *Widdringtonia* species of southern Africa. The foliage varies somewhat in colour - the dark green tending sometimes towards yellow and sometimes towards blue.

The occurrence of *Callitris robusta* in the Eremaea of Western Australia is not continuous - its development seems to depend upon the presence of a certain percentage of sand in the soil. Ednie Brown states that *Callitris* under favourable conditions forms considerable zones, while only once I discovered such a zone - near Menzies. Brown also states that the plant is absent from the moist south west except along the littoral zone. There impressive individuals reach up to 10 m in height, eg. on the limestone cliffs above Freshwater Bay on the Swan River. the whole phenomenon is thus an exact parallel to the features presented by *Acacia.*

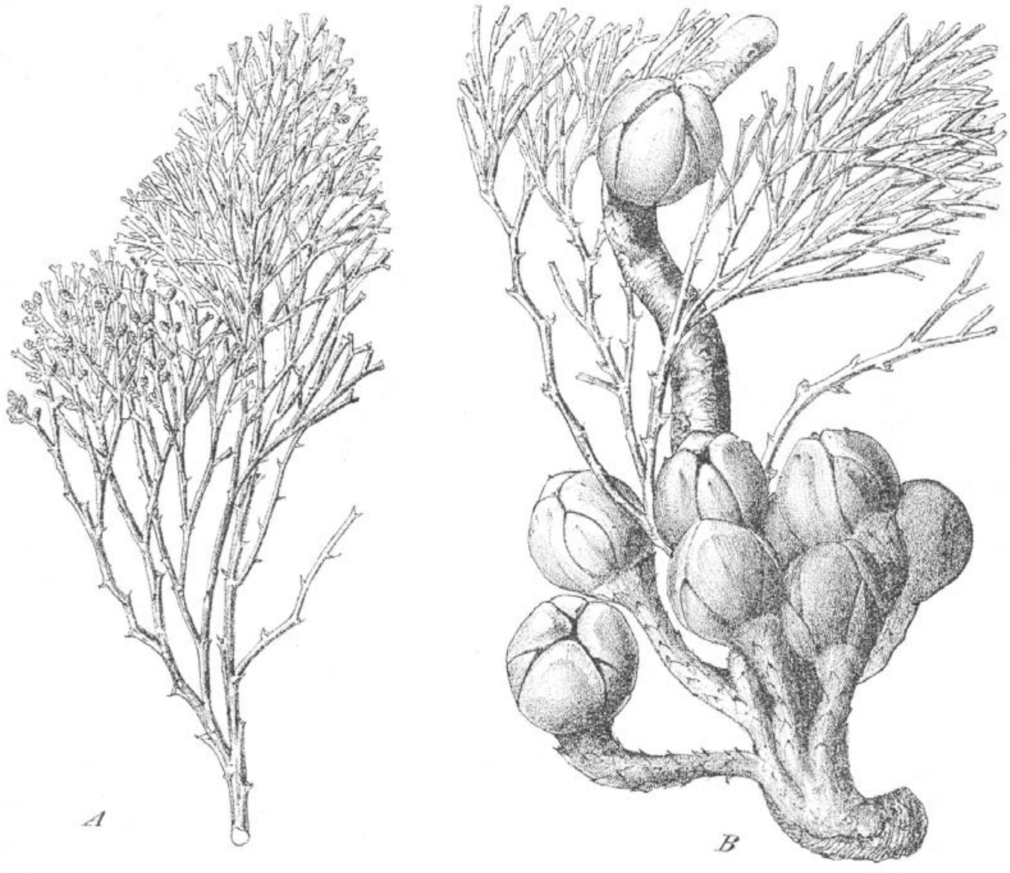


Fig. 61. *Callitris robusta* R. Br. *A* Zweiglein mit ♂ Blüten. *B* Zweig mit Fruchtzapfen (Original).

IV. **Codonocarpus cotinifolius (Desf.) F. v. M. ("Poplar")**

Codonocarpus cotinifolius belongs to the small (although rich in unusual forms) group of the Australian Phytolaccaceae. The species is found far to the east in the Darling and Murray River Basins - the apparent centre of the genus. In Western Australia I found this species widely distributed south west of the middle Murchison and there is evidence also that it occurs even on the south coast close to the sea by Phillips River. It is thus an Eremaean type in the fullest sense.

The plant may be identified from afar by reason of its peculiar habit. The main stem rises perfectly vertically to a height of 3 - 5 m. The branches grow out horizontally, becoming gradually shorter towards the apex of the plant, thus forming a narrow cone. The clearly obovate shape of the leaves (a rare form in the Eremaea), their light blue-green colour, and the position of the inflorescences (which are wholly terminal), complete the unusual appearance of the plant. It looks like something intermediate between a tree and a greatly magnified shrub.

Codonocarpus cotinifolius generally occurs in the sandy-clay zones. It either grows as isolated specimens or in small groups. No real thickets or communities are, so far as I know, developed.

CHAPTER 3 THE CHARACTERISTIC FAMILIES AND THEIR LIFEFORMS

1. Compositae	3. Myoporaceae	5. Verbenaceae	7. *Dodonaea*
2. Chenopodiaceae	4. Gramineae	6. Amaranthaceae	8. Santalaceae

1. Compositae. About 110 species - Plate XXXIV

A rough count of the species indicates that in the Eremaea not quite as many composites occur as in the Southwest Province. A closer analysis of the composite flora of Western Australia shows, however, beyond doubt, that the Eremaea is the richer and the more independent of the two provinces. It is not merely a transition zone for eastern elements - by contrast it contains a very large number of its own. Of this many grow in the west and south of the Southwest Province. This results in a great diversity of composites in the transition zone of both Provinces and therefore in a larger number of composite species in the south-west.

To obtain a complete picture of the vegetation in so far as composite types are concerned we need to bear in mind that two plant forms are essentially important - the shrub and the annual herb.

Among these are *Olearia* and *Helichrysum*, and more rarely, species of *Ixiolaena* which develop as shrubs or semi-shrubs. They remain dwarf in stature but show most extensive branching. Very often they parallel the pattern of the ericoid shrub, which is so widely followed in the undergrowth of the eucalypt formations by *Melaleuca* and other genera. In general, therefore, these composites are lost in the number of ecologically similar forms and do not form an effective independent group. This is reinforced by the fact that their inflorescences are quite inconspicuous.

The annual herbs, which appear after satisfactory rains, ie. generally at the beginning of the cool season of the year in the south, or at any time soon after good rains have fallen in the north, are much more important. Naturally these plants favour the loamy subsoil, or clay, where moisture is retained longest. Almost all these annual composites are very gregarious plants which often cover the ground in thick profusion. Three types are present.

The first is represented by the Anthemideae which is the least important group. It comprises feeble herbs with delicate foliage with bright and numerous flowers.

The second group is the Angiantheae[1] (Fig. 62.) . Externally this group is still less conspicuous than the first. The plants of this group are minute, and superficially appear to be of similar habit, although presenting some differences in finer details of structure. Usually they are quite inconspicuous - even at the flowering period. In spite of this they can become effective because of their abundance, particularly in the transition zones to the Southwest Province.

Far more important than the above is the third group - the Helichryseae, which comprises the well-known Australian everlastings. Their vegetative development is largely dependent on the vagaries of the weather, as is the case with all other annuals. Everywhere they show the same characters in regard to unprotected foliage and bright coloured scaly or scarious involucres. These are the structures which often lend pleasing colours to the Eremaean landscape. White, deep yellow, and a constant tint of rose red, are the

1 Fragm. Austr. occ. 601

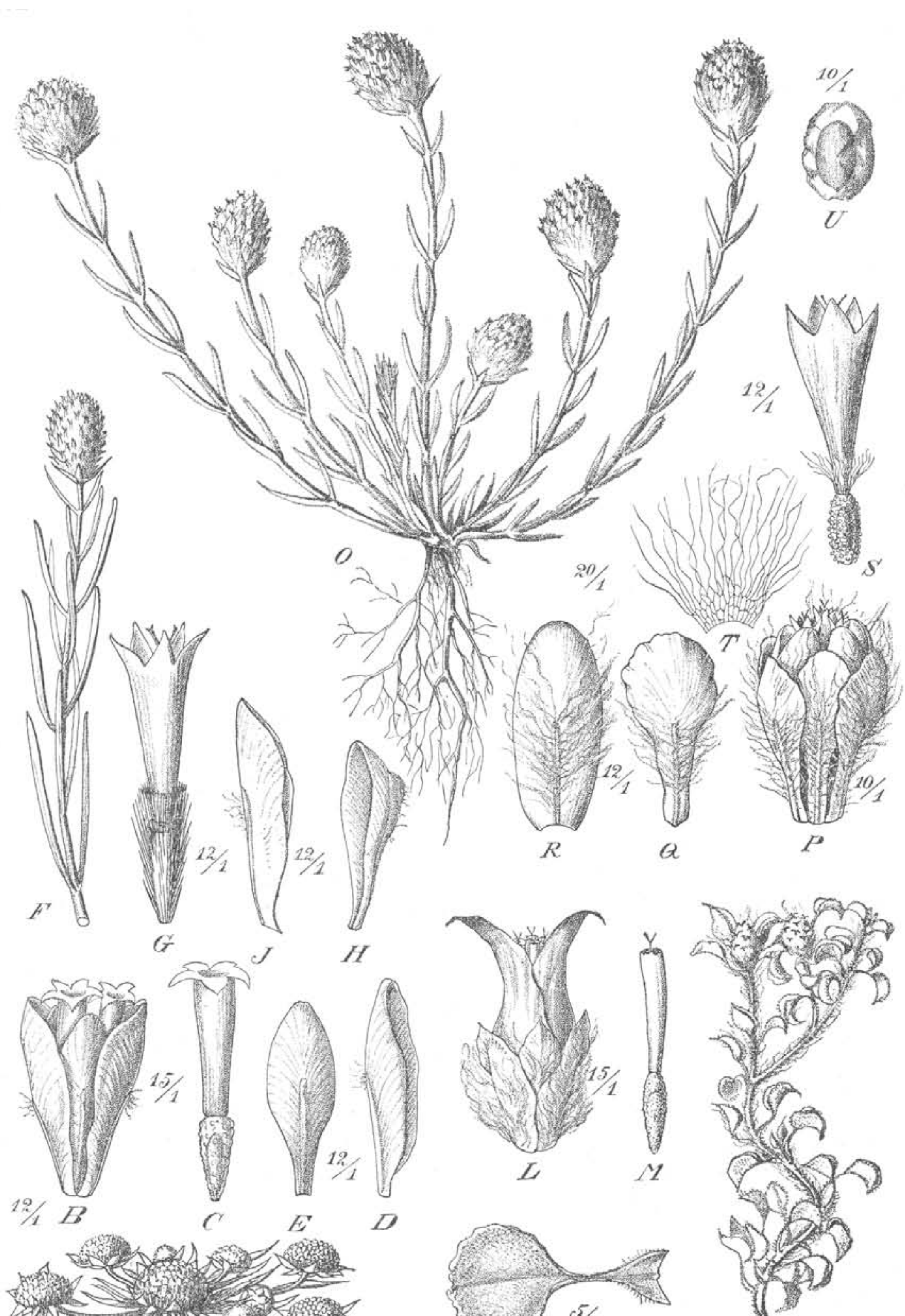


Fig. 62. *A—E Angianthus pygmaeus* (A. Gray) Benth.: *A* Habitus. *B* Köpfchen. *C* Blüte. *D* äußere Bractee. *E* innere Bractee. — *F—J Gnephosis gynotricha* Diels: *F* Blühender Ast. *G* Blüte. *H* äußere Bractee. *J* innere Bractee. — *K—N Gnephosis rotundifolia* Diels: *K* Habitus. *L* Köpfchen. *M* Blüte. *N* Blatt. — *O—U Calocephalus phlegmatocarpus* Diels: *O* Habitus. *P* Köpfchen. *Q* äußere Bractee. *R* innere Bractee. *S* Blüte. *T* Pappus-Schuppe. *U* Achaenium. (Nach DIELS und PRITZEL.)

three predominant colour tones which are often strengthened by contrasting shades. The most important genus is undoubtedly *Helipterum*. Plate XXXIV indicates how richly these ephemeral plants can be developed in favourable circumstances. What is attained by *Helipterum splendidum* with its satin-like white gloss and large flowers is matched in *H. tenellum* and *H. hyalospermum* by the larger number of the bright yellow though smaller heads. Where these plants show their strongest development one is reminded most strongly of South Africa, where in a strikingly similar manner the annual composites produce beautiful pictorial effects on what would otherwise be a sad wilderness.

2. Chenopodiaceae. About 50 species

Members of the Chenopodiaceae of Western Australia are from an ecological point of view mostly succulent. This gives them a peculiar degree of importance for the flora because, with the exception of a few members of the Portulacaceae and Aizoaceae, this type of vegetative form is lacking. This represents a remarkable feature, as analogies would suggest that it is exactly in Australia that one would expect succulent vegetation.

The family Chenopodiaceae is of undoubted importance in the flora of the Eremaea and is above all the only family amongst the leading elements which is almost confined to this area. The following statement is taken from Diels and Pritzel. Fragm. Austr. occ. p. 179 : - "The distribution of the family Chenopodiaceae extends over the whole Eremaea. It also projects into the transition zones to the Southwest Province wherever the Eremaean vegetation dominates the flora. In addition it extends along the coast in the dune areas. While, however, this halophyllous littoral flora is separated in the Southwest Province from the flora of the interior by the woodland or sandy regions, both meet in the north and probably also at the eastern extremity of the south west area. Thus, just as in the Amaranthaceae or Myoporaceae, there can be an exchange, and this can be demonstrated to have taken place in many cases (eg. *Atriplex halimoidei*). It would be a valuable piece of work to find out how the salt requirements of the species affects their distribution in the different localities.

This would settle the question whether the presence of the family always indicates an abundance of chloride in the soil. The group is present everywhere in the littoral formations - the species *Rhagodia Billardieri*, being of common occurrence there. *Atriplex paludosum* and others inhabit salty mud whilst *Atriplex isatidium,* which is almost arborescent, is a stately dune plant. All these species are naturally halophytic. On the other hand it is uncertain whether all the Chenopodiaceae of the interior are halophytic. Some are without doubt halophytic plants as for example those like the Frankeniaceae which are to be seen round the edges of saline lakes where there is an incrustation of salt. Others, however, are only found on the stony loam soils whose chlorine content is unknown. In these situations one finds the low species of *Kochia* with their delicate fruits, and the numerous forms of species of *Bassia* which are often quite gregarious. More striking still on account of their size are the semi-shrubby *Atriplex* and *Chenopodium* species - the salt bushes of the colonists. These are 0.5 to 1 m in height, and show some development of wood in the main axes. The leaf is either thick and succulent or of delicate fleshy texture, here glabrous and bright green in colour, there glaucous and broad oval to narrow linear in shape. One of the most widely distributed salt bushes in the interior of Western Australia is *Chenopodium Pressii*. Still more important is *Atriplex Drummondii* for the whole of the western Eremaea. Very often this bush forms the chief undergrowth of the light *Eucalyptus* communities and it is so gregarious and abundant at times that the vegetation is physiognomically characterised by the contrast of its matt silver leaves with the reddish brown soil and the dark green tops of the trees."

3. Myoporaceae About 45 species. – (Fig. 63, 70).

This family is also evident as a typical Eremaean element in the vegetation of Western Australia because of its geographical distribution in the State. The real Southwest Province contains only a few examples (*Myoporum* species and *Eremophila Brownii*) and these almost confined to the littoral formations (similar to the conditions under which the Chenopodiaceae is found in the State). In addition a few species penetrate into the sand country in the border regions of the north, into otherwise almost unmixed south western formations. This is all, however, unimportant compared with the part played by the family in the entire Eremaea.

"The Myoporaceae deserved attention from the biological point of view as an example of a family in which xeromorphs appear to have developed from littoral plants. Certain forms - for instance the very polymorphic genus *Myoporum* - are still typical littoral plants in Australia; in Western Australia I can at least name *Myoporum acuminatum* as a salt marsh plant, and *Myoporum oppositifolium* as a dune plant.

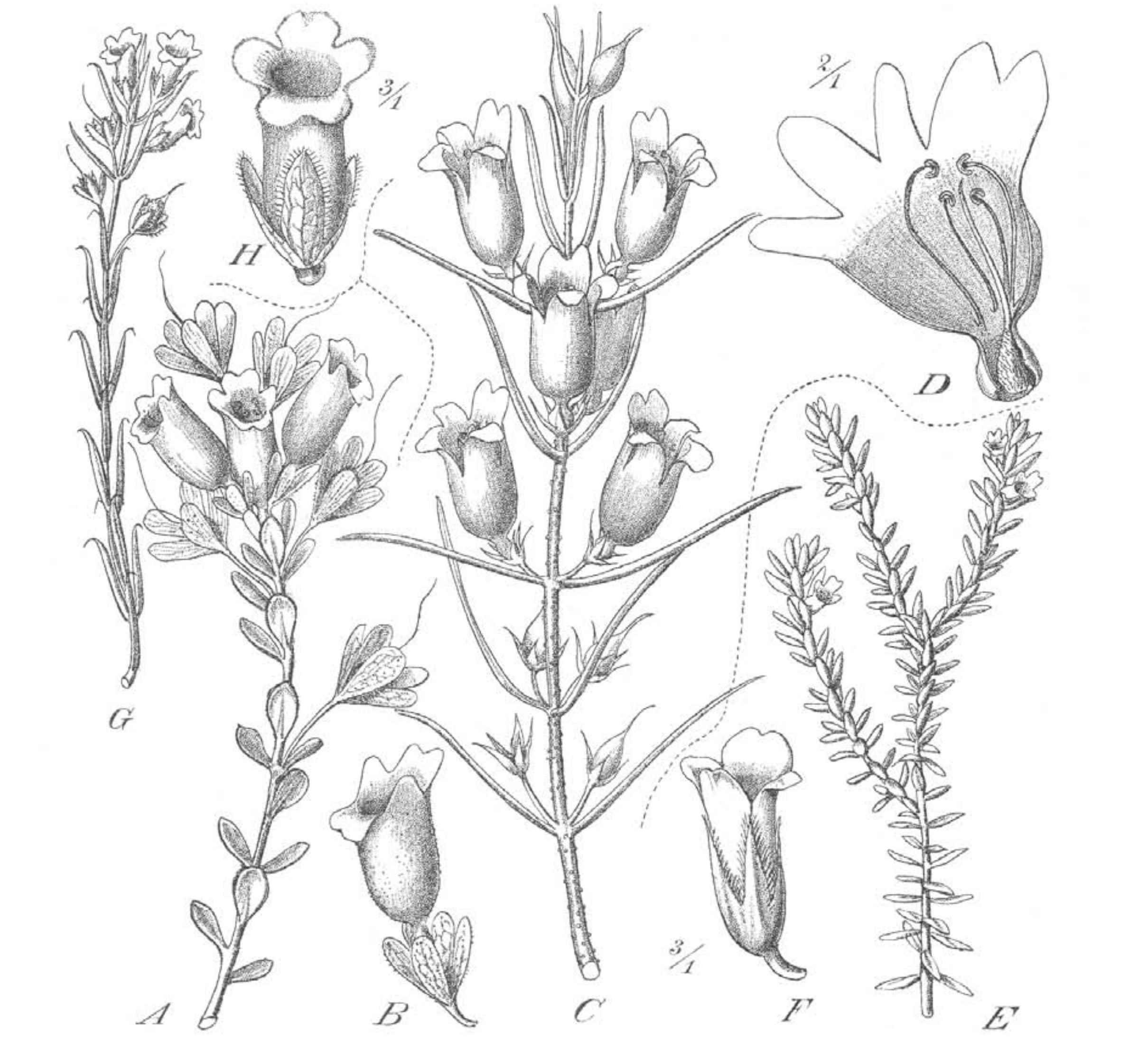


Fig. 63. *Eremophila: A, B E. platythamnos* Diels: *A* Habitus. *B* Blüte. — *C, D E. ionantha* Diels: *C* Habitus. *D* Blüte nach Entfernung des Kelches. — *E, F E. elachantha* Diels: *E* Habitus. *F* Blüte. — *G, H E. dichroantha* Diels: *G* Habitus. *H* Blüte. (Nach Diels und Pritzel.)

To these we must add those forms which are always found in the somewhat saline valley soils of small hollows, and the numerous species which inhabit the loamy, often similarly saline soil of light *Eucalyptu*s woodlands of the south-west, and in those places grow well both glaucous *Atriplex* species, and other fleshy Chenopodiaceae. At such places in Western Australia develop in particular the species of *Pholidia* group and the section Eremocosmos.

Their habit is chiefly marked by an extensive branching of the stem which carries numerous virgate vertical branches with very sticky and narrow leaves. Some species are tree-like (*Eremophila interstans*) but do not begin to branch until the very crown is reached and a splitting up into a close network of thin branches results. From the point of view of floral biology the *Pholidia* zone is characterised by the rich individual production of flowers. The flowers are white or lilac, and usually less than average size. The concentration, however, of the bright blossoms makes the shrubs very striking and at the flowering season they enliven the otherwise dull scenery of this zone with friendly colours.

Growing together with them are closely related solitary and often low ericoid bushes and some other widely distributed species of other sections. *Eremophila maculata*, of low and knotty habit occurs frequently.

On the still more sparsely vegetated and hotter surfaces of the northern areas somewhere on the far side of 30° S latitude, other types of the Myoporaceae occur. In these the branching is less intensive but more horizontal. The development towards the trichome-like structure is much more marked. The biological plan of the flowers shows a different tendency from that noted above. The flowers are less numerous but much larger and the colours much more intensive. Even the calyx, which only occasionally in the whole family becomes corolla like, takes part in this tendency and in forms related to *E. Fraseri* appears the principal part of the accessory floral structures.

In these regions many species flourish on stony loamy soil in doubtless non-saline substratum[1] and play a prominent part with their ornamental flowers in these arid districts. They provide a cheerful feature of these uniform *Acacia* wastes and were well named "the Pride of the Desert".

4. Gramineae About 40 species known, but probably many more occur.

When eucalypts are cut down in the arid loam regions of south west Australia (where there is an annual rainfall of 30 to 20 cm) the increased light apparently allows a surprisingly rich growth of grass. Also in the natural state the soil here and there may be colonised by grasses, particularly in areas where bush is absent.

These observations indicate that the Eremaea, in contrast to the Southwest Province favours development of grasses. How far this extends is unfortunately not known at present. We are still without any sufficient taxonomic and ecological knowledge, neither on the Cyperaceae in the Southwest Province, nor on the Gramineae in the Eremaea. We only know that most grass species are hard-leaved steppe or desert types. On the stony ground numerous species of *Stipa* flourish and the delicate *St. elegantissima* and some less well known forms are characteristic features of the grass flora of the Eremaea.

Only a few species occur on sandy ground. Amongst them is *Triraphis rigidissitma* (Fig. 64), an extremely xeromorphic species which with its rigid spiny clumps forms elongated cushions and so becomes of considerable physiognomic importance in many regions.

The annuals favour the southerly regions which are still more or less regularly touched by the winter rains. One finds large areas of the loamy soil occupied by them. The development of the grasses fluctuates with the irregular occurrence of the rain. Sometimes it is thick, sometimes sparse. In the *Acacia acuminata* or the *Eucalyptus occidentalis* communities outside the Eremaean boundaries and within the Southwest Province, one also finds flourishing grass growth at spring time. *Triraphis danthonioides*, *Koeleria phleoides*, *Festuca bromoides*, and some exotic grasses are the most successful species.

The important role of grasses in the Eremaea becomes particularly obvious when considering their insignificance in the Southwest Province. This contrasting point is most remarkable. It proves that the requirements for the growth of grasses are not so uniformly fixed as Schimper[2] assumed. His proposed scheme of having fixed climates for the growth of grasses on one side and for the growth of woodland on the other, is certainly not valid for Australia. Thus the regions of grass growth of eastern Australia are not conditioned by "frequent, although light rainfall to keep moisture in the upper soil layers during the

1 Diels and Pritzel Fragm. Austr. occ. p. 536.

2 A.F.W. Schimper, Pflanzengeograph p. 189.

growth period, and moderate temperatures", but there, during summer, high rainfall and high temperatures prevail. On the other hand Schimper's statement on the climate for grass growth fits well for the sandy soils of the Southwest Province, yet these areas are almost devoid of grasses. These facts indicate that one must be cautious not to generalize certain individual cases.

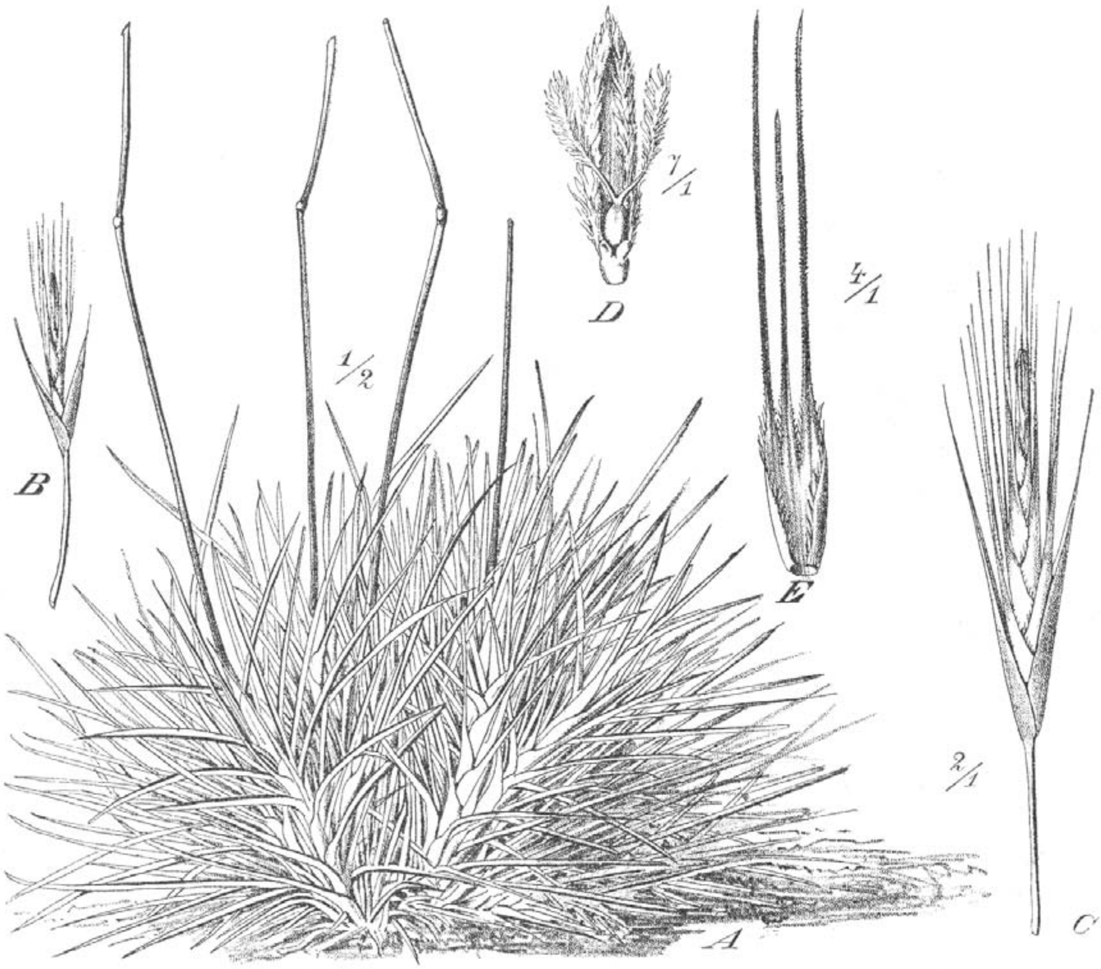


Fig. 64. *Triraphis rigidissima* Pilger. *A* Habitus. *B* Ährchen 1/1. *C* Ährchen 2/1. *D* Blüte mit Spelze. *E* Deckspelze. (Nach DIELS und PRITZEL.)

5. Verbenaceae. About 25 species. – (Fig. 65, 69).

The Verbenaceae present in many ways contrasts to the preceding leading elements of the Eremaea. They are much less important and less generally distributed, yet present a well graded range of species[1] which makes the family important for the proper understanding of the region. Furthermore they do not appear to be inhabitants of the loamy soil like the Chenopodiaceae, most of the Compositae and the Amaranthaceae, but are markedly psammophyllous and consequently count amongst the characteristic plants of the sandy Eremaea.

Many species of *Mallophora*, *Dicrastyles* and *Lachnostachys* tend to a strong development of hair-like organs and an unusually strong development of woolly hairs. This characterizes their habit and causes them to be extreme "felty" plants - a type doubly striking because usually so uncommon in Western Australia. The felty covering often extends over the inflorescence. *Lachnostachys* (which also extends into the boundary districts of the Southwest Province and plays a prominent role on the sand heaths) it is the woolly hair-covering of the inflorescence which is responsible for the important part

1 See detailed description in Diels and Pritzel, Fragm. Austr. occ. 493-524.

played by the plant in the vegetative scene. In the Eremaea still more striking examples of the same tendency occur. Thus south from the Murchison River, *Lachnostachys Cliftoni* - the real "Flannel Plant" of Western Australia, is found. With its thick felt it is one of the most unique species of the Eremaea.

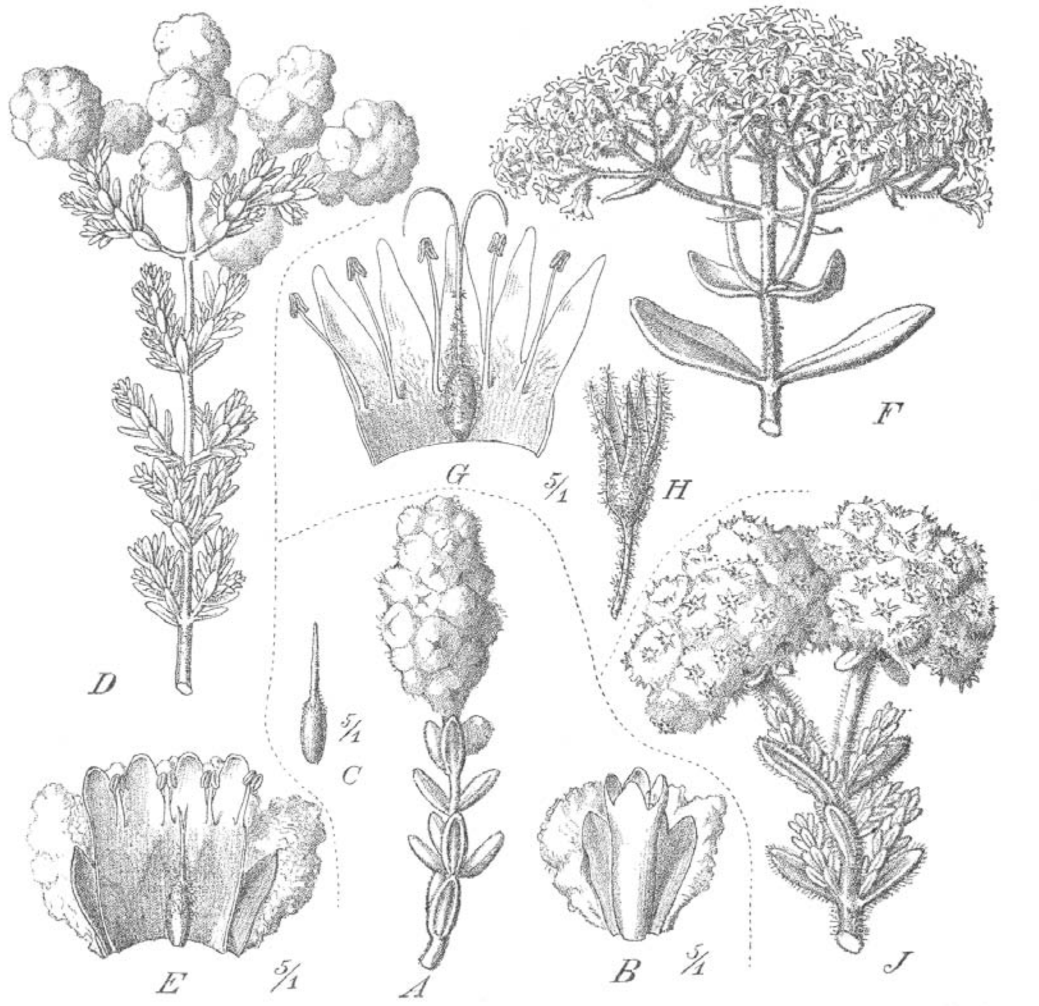


Fig. 65. Verbenaceae der Eremaea: *A—C Physopsis spicata* Turcz.: *A* Habitus. *B* Blüte. *C* Gynaeceum. — *D—E Mallophora globiflora* Endl.: *D* Habitus. *E* Blüte. — *F—H Dicrastyles fulva* Drumm.: *F* Habitus. *G* Blüte ausgebreitet nach Entfernung des Kelches. *H* Kelch. — *J Dicrastyles stoechas* Drumm.: Habitus. (Nach DIELS und PRITZEL.)

6. Amaranthaceae. About 16 species.

A sytematic-geographic investigation of the Amaranthaceae indigenous to Australia shows that the family is a real Eremaean type. Many species which are amongst the most common in the West show the typical distribution through the entire dry area of the continent (*Trichinium obovatum*, *Trichinium exaltatum*, and others). At the same time a distinct preference for the northerly zones is apparent. In the tropics the family, in contrast to the Myoporaceae for example, is still polymorphic. But this diversity of species as well as the physiognomic effect of the group diminishes gradually as one passes south. Thus it is only from the north that the Southwest Province is influenced by the family.

The stony red loam soil of the Eremaea furnishes by far the greatest number of Amaranthaceae. Everywhere one meets the rounded shrubs of *Trichinium obovatum.* This is one of the most common bushes in the extra-tropical Eremaea, and is easily recognised by the white or yellowish felt-work which covers the entire plant from leaf to flower.

The tall perennial species *Trichinium exaltatum* is also common (Fig. 71). Its imposing flowers are of a splendid purple colour and stand out most effectively from the grasses and herbaceous growth which have already faded when it is at its best. Many smaller species which are less impressive in appearance and of rarer occurrence add many other features to the total significance of the Amaranthaceae. The Australian Eremaea is one of the regions of the earth which still presents favourable opportunities for the further development of the family today.

7 ***Dodonaea*** (Sapindaceae - Fig. 66.) About 10 species.

The two very diverse series of the genus *Dodonaea*, the Cyclopterae and the Pinnatae are found throughout the greater part of the Australian Eremaea. It is possible that this can be explained by the occurrence of the winged fruit which facilitates wide dispersal.

Fig. 66. *Dodonaea: A D. attenuata* A. Cunn. var. *linearis* Benth. Habitus. — *B D. filifolia* Hook. Habitus. — *C—E D. amblyophylla* Diels: *C* Habitus. *D* Frucht. *E* Samen. (Nach Diels und Pritzel.)

Thus the most typical species occur along the whole extension of the Eremaea, from the eastern part of the Australian tableland through the interior to the west side. When considering the distribution of *Dodonaea* within the Southwest Province, it becomes obvious that the genus is less restricted than the members of the Myoporaceae. *Dodonaea* has not only penertrated the south west but has even developed an independent branch there, the series Cornutae (Diels and Pritzel Fragm. Austr. occ. p. 344).

Because of its frequency of occurrence and wide distribution, *Dodonaea* must be placed amongst the leading elements of the Eremaean vegetation. The genus occupies a prominent position, there being no areas of any size in the southern parts of the Eremaea where *Dodonaea* species are not represented. In appearance they follow the general type form of the various formations. Thus the extremely rich branching, the very narrow or even tiny leaf and the frequent close covering by secretions produce an external resem-

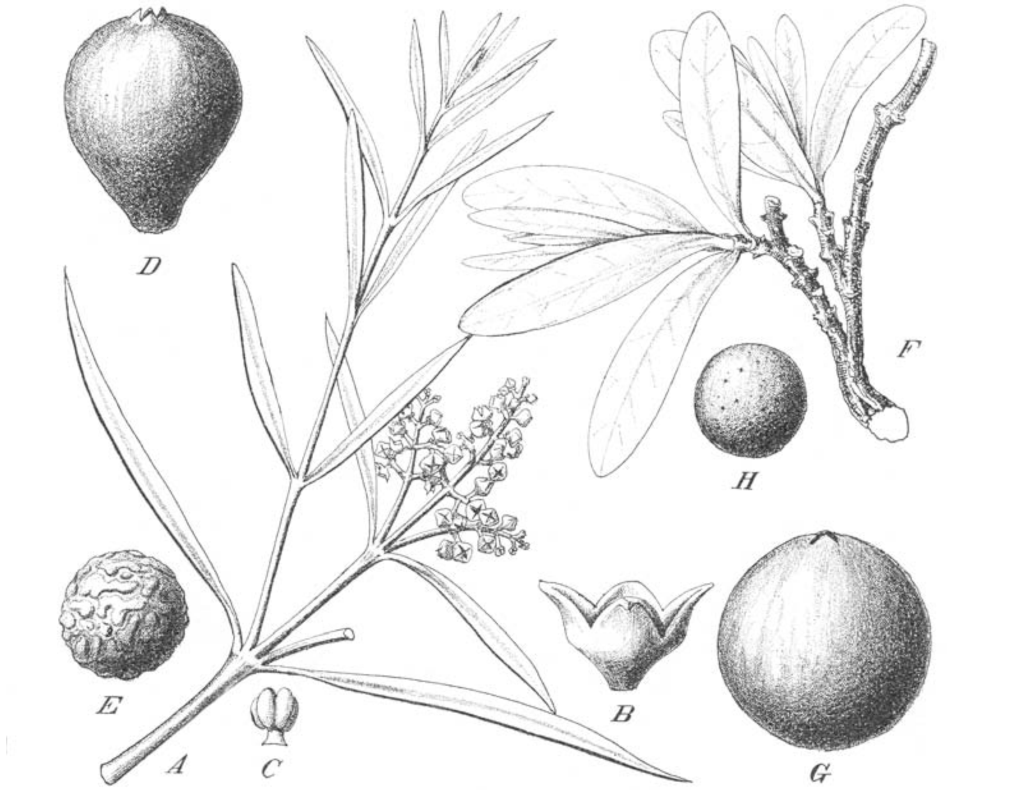


Fig. 67. Charakter-Santalaceen der Eremaea: *A—E Fusanus acuminatus* R. Br.: *A* Habitus. *B* Blüte. *C* Staubblatt. *D* Frucht. *E* Endocarp. — *F—H Fusanus spicatus* R. Br.: *F* Blatt-Zweig. *G* Frucht. *H* Endocarp. (Original.)

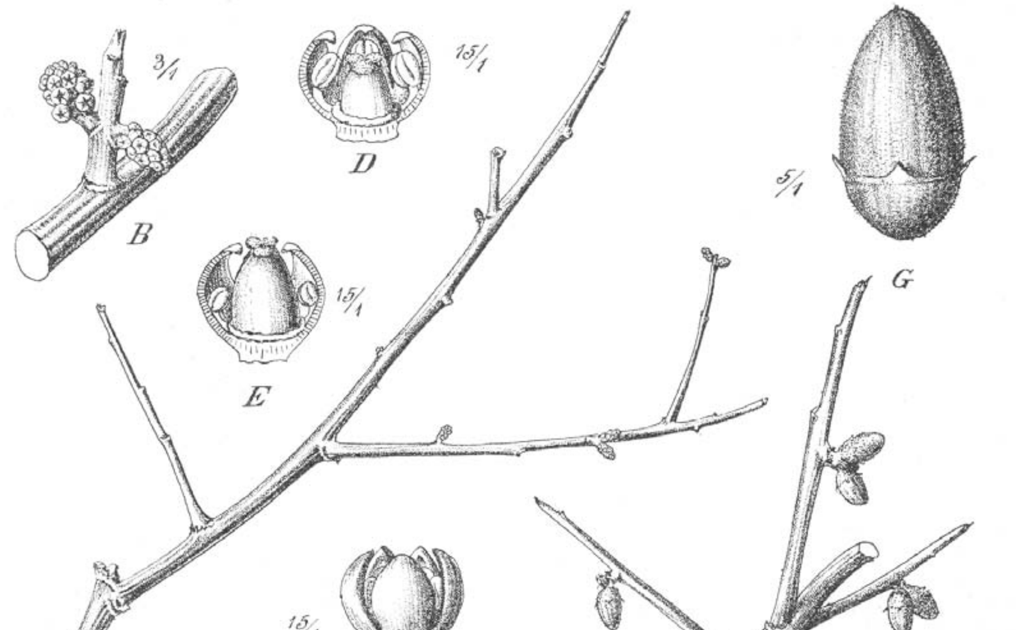


Fig. 68. *Exocarpus aphylla* R. Br.: *A* Habitus. *B* Zweigstück mit Blütenständen. *C* Blüte von außen. *D* Blüte von oben, ein Blütenhüllblatt entfernt. *E* Blüte durchgeschnitten. *F* Zweigstück mit Früchten. *G* Frucht. (Original.)

blance (Fig. 66) to many melaleucas, acacias and species of *Eremophila* which are in the first rank of constituents making up the flora of the southern Eremaea.

8. Santalaceae About 10 species.

The Santalaceae also are not confined completely to the Eremaea in Western Australia. They surround the Southwest Province in a narrow margin along the coast as does *Callitris robusta* or members of the Myoporaceae, for example. In addition they have enriched the Southwest Province with some endemic species. Yet the center of the group is undoubtedly in the interior. Many species extend throughout the whole tableland without any big gaps, eg. *Fusanus spicatum*, *Exocarpus aphyllus* and many others, are amongst the most common plants of the western Eremaea. The pale leaved bushes of *Fusanus acuminatus* (Fig. 67 A-E) are to be seen here and there and the related *Fusanus spicatus* (Fig. 67 F-H) was at least in earlier days, pretty generally met with. Now however, the little tree which, as sandalwood, is one of the valuable exports of Western Australia is present in greatly diminished numbers in easily to be reached parts of this country. Both species have relatively large leaves, 3 - 6 cm long and 1.5 - 2.5 cm broad, and are thus very different in this connection from another common Santalaceae of the Eremaea - *Exocarpus aphyllus* (Fig. 68). This is an extremely xeromorphic shrub, 1 - 2 m high which uses its branches for assimilatory purposes, the leaves being rudimentary. The suppleness of many other *Exocarpus* species has been transformed in this case into unapproachable spinyness. The branches are thick, hard and thorn like. This species embodies a growth form which is not exactly common in the western Eremaea, although well represented by *Exocarpos aphyllus* for the shrub is uncommonly widespread and is almost certain to be seen on stony loam soil so far as the bounds of the Eremaea stretch.

CHAPTER 4 ECOLOGICAL CHARACTER

The ecological character of the Eremaean vegetation differs very little in its more important features from the nature of the xeromorphic forms of the Southwest Province. In accordance with the uniformity of the environment it does not show any of the rich grading of the south west. However, to compensate for this deficiency the constitutional characters of the elements attain a greater freedom. To what extent finer details and peculiarities of the Eremean vegetation result from this is uncertain at present. For, despite the work of Spencer Moore and my own discoveries, most of the Eremean investigation still lies in the future. This is especially so since the dissimilarity between successive years requires a long period of observation before adequate satisfactory information is obtained.

a. Lifeforms

As an area of highly developed xeromorphism the Western Australian Eremaea represents to a high degree the well-known contrast between a groundwater flora and a rain flora.

The groundwater [perennial] flora as already mentioned exhibits a clear preference for the region south of 30° S. We meet tree-like growths, particularly *Eucalyptus* and *Casuarina* there, whilst further north they are only found in specially favourable spots. Details will be given in the description of the formations.

In general, woody growths are represented by shrubs. In comparison with the Southwest Province there is a marked diminution in the small shrubs which only remain on the sand in very extreme xeromorphic form. They depend on the uncertain help of the winter rain for the complete wakening of their functions. Very often they exhibit the signs of hard seasons - withered branches and flower buds and fruit dried up before ever becoming ripe.

In contrast to the above, the number of the taller species of shrubs is relatively high. In the wide areas of the Mulga zone north of 30° S the main body of the vegetation consists entirely of them.

The rain flora consists almost entirely of annuals of which the composites are the most important. As in other similar areas the quantitative development depends on the caprice of the weather. Since the Eremaea is more uncertain in this respect than any other region of a similar nature, the variability of the rain flora is perhaps more marked here than anywhere else in Australia. The same applies to the physiognomy of the entire landscape which owes very much to the rain flora in good seasons.

b. Forms of Branching

While the shrub and low bush forms present a similar structure to that seen in the Southwest Province the funnel or umbrella-like crown formation is the feature of the tree-like *Eucalyptus* and many acacias. This point has been sufficiently discussed in the section on the character plants. It is clearly illustrated in Plates XV, XVI, and XVIII.

The factors determining these branch systems which are so common in the warmer dry regions are still unknown. Because of their frequency in the Western Australian Eremaea, they are given particular mention, so that we may at least have some definite information regarding the geographical distribution of the phenomenon.

c. Stems

In connection with the ecology of the Eremaean stems, we may refer back to a remark made in an earlier chapter (Part 3, Ch. 4, Sect. C). Reference was made there in discussing *Eucalyptus diversicolor* (Karri) to the effect that it was impossible to correlate the development of bark directly with the peculiarities of the climate. A further proof of this is brought by the eucalypts of the Eremaean interior. Bearing in mind the variations in temperature it will be seen that they are exposed to much greater contrasts and extremes than the species of the landscapes nearer the coast. In spite of this they often

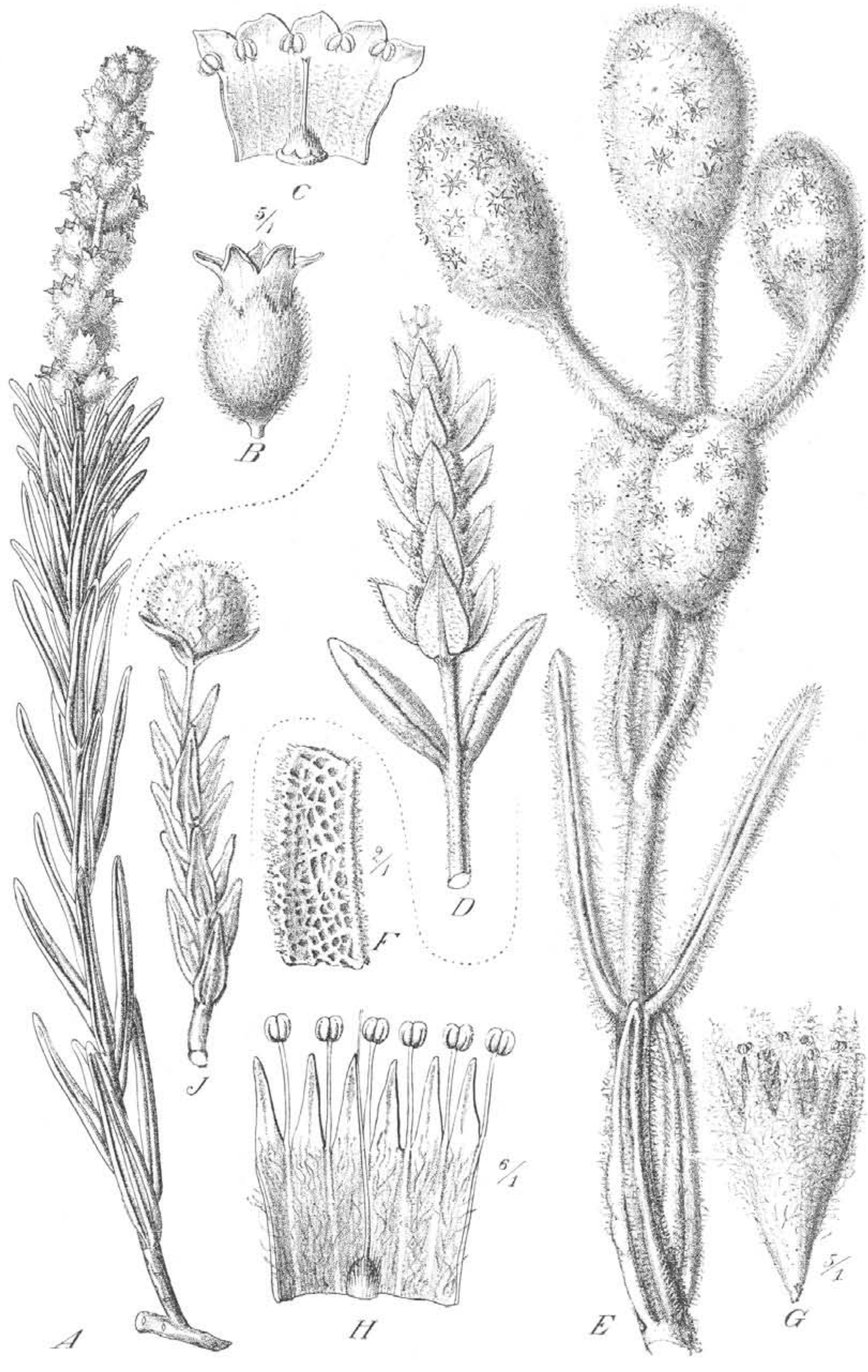


Fig. 69. Filzige Verbenaceae der Eremaea aus der Gattung *Newcastlia*: *A—C N. viscida* E. Pritzel: *A* Habitus. *B* Blüte. *C* Krone ausgebreitet. — *D N. bracteosa* F. v. M. Habitus. — *E—G N. insignis* E. Pritzel. *E* Habitus. *F* Unterseite des Blattes. *G* Blüte. — *H*, *J N. cephalantha* F. v. M. *H* Krone ausgebreitet. *J* Tracht eines Zweiges. (Nach Diels und Pritzel.)

possess only a thin smooth bark. Formation of new bark goes along hand in hand with a shedding of the old, so that the thickness remains almost constant.

The formation of basal cork described earlier also takes place in the Eremaea on the heaths of the sandy soil, the vegetation of which in any case shows strong south western character.

d. Leaves

In contrast to the condition in the south-west, all the peculiarities in leaf ecology which owe their existence to periodicity of climate, are lost in the Eremaea. The formation of new leaves is no longer a period of sudden development, but is a gradual and constant occurrence although advantage is taken of the more favourable phases of the weather. Thus young leaf structures may be found throughout the year on typical Eremean plants, and with them leaves of all ages. Specialized bud scales are completely lacking under these conditions. In general, however, the sensitive nature of the young parts expresses itself in a similar manner to that of the plants of the south west.

The mature leaf is characterized by strongly xeromorphic features. However, since these are the same as those of the extreme species of the south west (discussed previously) we need not discuss them here. This is further reinforced by the fact that they have also been treated in Spencer Moore's account. Diminution of the evaporation surface, vertical position of the assimilatory organs, leathery leaves, secretion of oil, water tissues in roots or stem, depressed stomata etc. are discussed with examples.

The Southwest Province is however, quite well endowed with many such expressions of xeromorphy. On the other hand the Eremaea possesses more in felted and succulent species. So far as felted plants are concerned (Fig. 69) this is due not only to the more common occurrence of families which tend to hairiness (Malvaceae, Verbenaceae, Fig. 69), but also the production of hairy investitures by species whose relatives in the south west lack such an indument, or where it is only feebly developed, eg. *Rulingia coacta* (Stercul.), *Phyllota lycopodioides*, *Psorales eriantha* (Legum.), species of *Solanum, Loranthus* and many composites.

Fleshy succulent foliage on the contrary is high-lighted in the Eremaea due to the systemmatic constitution of the flora. The strong development of the Chenopodiaceae and the presence of *Tetragonia*, *Gunniopsis* (Aizoac.), *Calandrinia* and *Zygophyllum* are important here. Nevertheless the development never attains to the height seen in Africa or America, and there is never any independent tendency to it in families which are usually normal-leaved.

A particular feature of the Eremean flora is the great importance of secretions within assimilatory organs, and consequently the frequency of "lacquered leaves". I doubt whether there is any other area on the globe where this type of leaf is so widespread as in the Western Australian Eremaea. The slender needles of *Acacia Rossii* (Legum.) or *Dodonaea* species (Sapind.), the rolled leaves of *Bertya dimerostigma* (Euphorb.) or *Halgania lavandulacea* (Borrag.), the broad leaves of *Olearia Müller*i (Compos.) and *Cyanostegia microphylla* (Verben.), the 3 - 5 partite leaves of *Burtonia viscida* (Legum.) all resemble each other in the secretion of substances which harden when exposed to the air on the free surface of the leaf. A coating of varying thickness results. The development of sunken stomata or at least the formation of markedly projecting horns over the actual opening, are concurrent developments here. The diverse nature of the families in which the above occurs indicates that we are dealing with a climatically induced peculiarity. However, I have been unable so far to obtain any clue as to the way in which the stimulus to this common production operates in such different groups. What was previously known regarding the climatic conditions influencing the "lacquer-leaf[1]" (Volkers, 1890) cannot be applied to the Western Australian representatives.

That the feature is due to a powerful influence is evident not only from the distribution of the condition through groups of plants which taxonomically are very different, but also from its strong development in *Eremophila*, one of the most characteristic plants of

1 Volkens: Über Pflanzen mit lackierten Blättern. Ber. Deutsch. Botan. Gesellsch. 1890, 120.

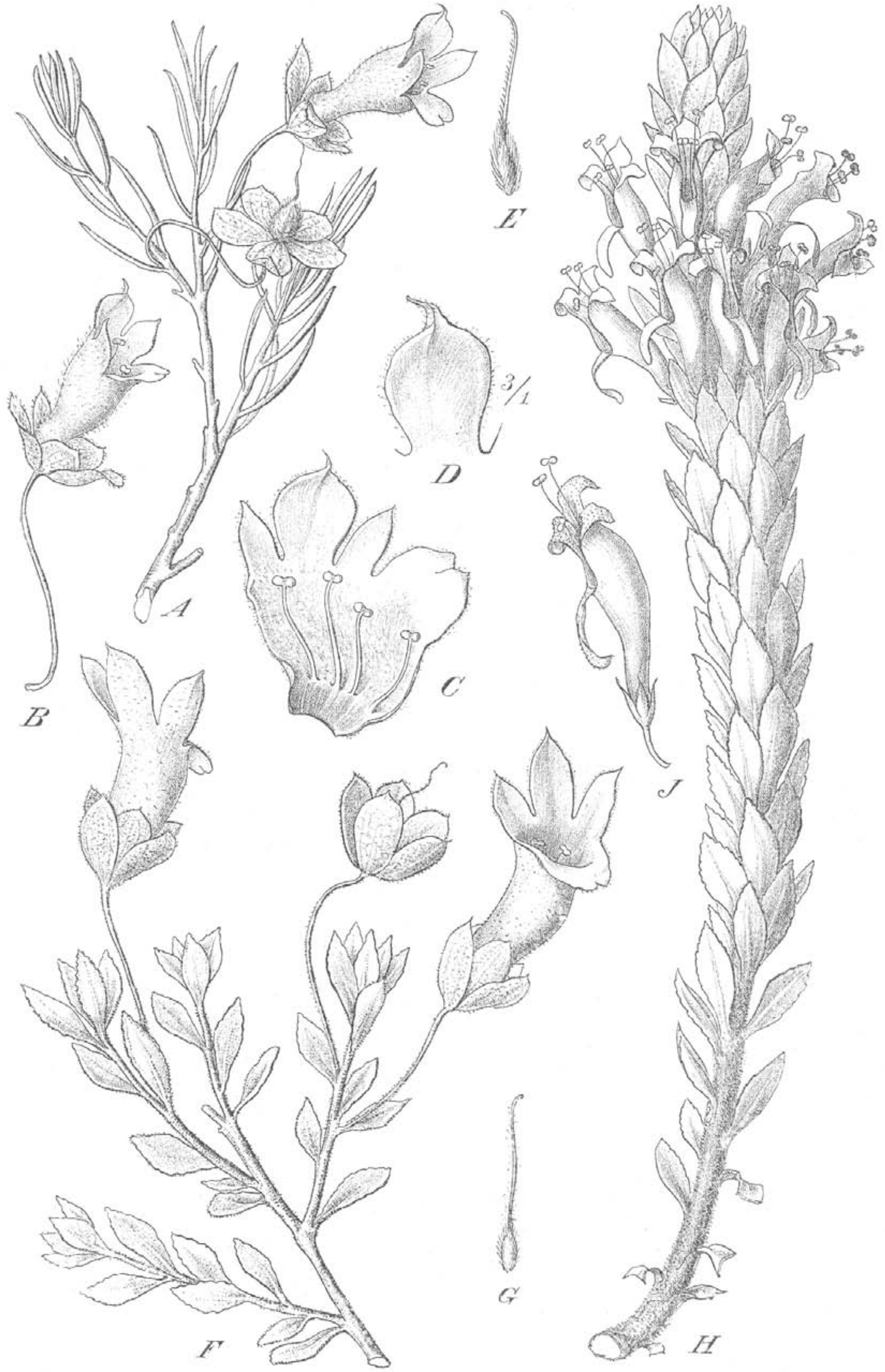


Fig. 70. *Eremophila: A—E E. granitica* Sp. Moore: *A* Habitus. *B* Blüte. *C* Krone. *D* Mittlerer Abschnitt der Vorder-Lippe. *E* Gynaeceum. — *F, G E. Georgei* Diels: *F* Habitus. *G* Gynaeceum. — *H, J E. calorhabdos* Diels: *H* Habitus. *J* Blüte. (Nach DIELS und PRITZEL).

the Eremaea. In all the sections of this polymorphic genus which have been founded on the flower morphology, one finds a glandular layer on the leaves and an intensive secretion of lacquer. Sometimes this is the only effect but sometimes secretion does not occur but is replaced by development of a felty covering. The cylindrical leaves of *Eremophila Drummondii* are sticky with secretion as are also the flat leaves of the wide-spread *Eremophila maculata* and other species. But in no species is the production of the lacquer so profuse as in *E. Fraseri.* The leaves of this beautiful shrub have a remarkably extensive surface when one considers the rainless nature of the district wherein they live. The epidermis of these leaves is covered with an uncommonly thick lacquer layer - the stomatal openings are highly elevated in order to reach the level of this coat. It is very interesting to find such a perfect development of the lacquer type in such a truly Eremaean species.

e. Flowers

In relation to the question of the development of flowers and their seasonal peculiarities we have no detailed information. A prevailing periodicity, seen in the south west, is not obvious. This is verified by the data which I have collected (Fig. 70).

Pertaining to bud scales of plants in the Eremaea no peculiarities exist. However purely floral features show a definite deviation from the south western types.

The tendency to crowd flowers together is largely lacking. Corolla structures are not greatly developed, or at least this is the condition which mostly applies. The real Eremaean Chenopodiaceae and *Dodonaea* species (Sapind., Fig. 66) are extremely inconspicuous in their manner of flowering. *Pimelea microcephala* the simplest of all the Western Australian species with its green flowers is a character species of the Eremaea and the only species of its genus which is common there. The same may almost be said about *Scaevola spinescens*. The inflorescence is whitish and inconspicuously veined. It is a remarkably unassuming species in a group otherwise so rich in colour. Both *Pimelea* and *Scaevola* deserve further study on account of the combination of wide distribution through the Eremaea, together with reduction in the floral development.

This combination, however, has only a limited importance, for groups with well developed flowers are not altogether absent from the Eremaea. Good examples of these are the *Cassia* species (Legum.) with their bright yellow flowers, and the beautifully coloured *Swainsona* (Legum.) which are so widespread and so rich in species. More important than either is the genus *Eremophila* (Figs. 63, 70) because it belongs to the entire Eremaea and is one of the most important of the creations of this region. From the point of view of the flowers, the species are by no means of equal value. There is no mistaking the fact that the greatest development in flower structure is found in the real Eremaean regions of the north. In the south, light colours or a dirty violet colour dominate the genus whilst in the north the deep red inflorescences are dominant. With great diversity in details of flower structure the shades of scarlet and purple remain peculiar to the whole *Eremophila* flora north of 30° S. We have already stated that these shrubs are known as the "Pride of the Desert". They furnish the Eremaea with the most beautiful flowers and play a very active part in brightening the otherwise drab vegetative picture of these vast areas.

On the whole the flowers of the Eremaea do not possess much scent. Aromatic plants are, however, not altogether absent. The Myoporaceae, many Labiates and Myrtaceae possess a penetrating odour, but this arises chiefly from the vegetative structures which are rich in oil and resins. In general therefore the strong scents of the south western flowers are lacking here.

f. Yearly Vegetation Cycle

Practically no information is available concerning the sequence of change during the year in the Eremaean region. My own observations are not extensive enough to enable me to give a satisfactory account of the matter. However, the little which I have been able to make out may be stated here.

In contrast to the Southwest Province one finds that the vegetation of the real Eremaea is less strongly affected by climatic factors. The individual tendencies of any species have greater freedom here and external influences are less directive than stimulating. The plants develop to flowering stage according to their nature so long as the climate permits. They continue to exist in the seed stage or in an exclusively dormant vegetative condition when the external factors are too unfavourable for germination or flowering. The unreliability of all climatic phases makes the vegetative cycle variable and inconstant, but does not have any marked influence on its nature.

This holds good only for the districts with the typical Eremaean climate. The southern portions which belong to the best known parts of the whole region (Yilgarn and around Kalgoorlie), are somewhat different, for in most years they form part of the zone of winter rains. They are therefore influenced by the seasonal arrangement for this regime. The vegetation is here most active between July and October as in the south-west. The sand heath flora develops, however, somewhat later. In unfavourable years when the winter rains are very light the whole activity is reduced considerably and many of the annuals do not germinate at all, or if they do they wither at an early stage rarely or never reaching the flowering stage. The flower buds on the shrubs also dry up. On the other hand when a favourable season comes along (as for example the year 1900) when the whole Eremaea of Western Australia received an unusually good rainfall, a richness of vegetation is unfolded which is undreamt of. It exists well on into the hot season and I found in 1900 a considerable number of species flowering at the end of November. This was, however, a highly exceptional year.

I visited the same neighbourhood again seven months later, but there was scarcely a flower to be seen. In all the Eremaean vegetation saw nothing in flower with the exception of a single species of *Eucalyptus*. This period of the year, however, (about the end of May) is the most unfavourable season of the year and the very low night temperature of these continental districts has a deleterious effect on the vegetation.

At the commencement of the dry season the vegetation of the southern Eremaea once more becomes dormant. The thunderstorms common to this period are of little value in so far as soil moisture is concerned, because evaporation in this climate is so high.

In the north, the more one nears the region of the tropical summer rains, the more distinctly do the conditions of the vegetation change. I learned much in regard to this from a visit to Lake Austin in the middle of the winter. The atmosphere was particularly dry and the temperatures slow, especially at night. The rainfall of the preceding months had been poor - February and March received 3.5 cm, in the following three months this continued with only a further 2 cm being received. In spite of this many of the elements of the strongly xeromorphic vegetation were in flower. A number of annuals were well developed but the most striking feature was the number of *Eremophila* bushes in blossom. There were also species of *Sida*, *Solanum*, *Cassia*, and others in flower. Taken altogether one received the impression of a considerable degree of independence so far as climatic factors were concerned. I had no opportunity of visiting the same place at another season. It still remains for someone else to show how far the independence of the Eremaean vegetation, discussed above, really extends. It is possible that it is limited to some extent by the summer rains, but data are lacking at present.

CHAPTER 5 FORMATIONS

a Littoral Formations.

a. *Mangrove and mudflat formations.*

In the Sharks Bay district the rise and fall of the tides begins to become obvious. Wide stretches of the flat coast land are flooded at high tide. Mangrove thickets consisting exclusively of *Avicennia officinalis* (Verb.) occur in the estuary of the Gascoyne River. Both banks of the river are quite low and formed of fine mud which passes gradually on the landward side into sandy loam. It is covered by high sand dunes only on the seaward side.

The vegetation of this mud soil begins on the outside with low *Avicennia officinalis* forming often a pure association with perhaps only dark green shrubby bushes of *Salicornia leiostachya* present here and there. Gradually however, the *Salicornia* becomes predominant and *Frankenia pauciflora* (Franken.) intermingles with it to form a tangled bush which covers many places so thickly as to exclude all other vegetation.

Still further inland the number of constituents increases. Convex *Atriplex* shrubs project above the lower *Salicornia* which is often only 0.25 m high. *Mesembrianthemum acquilaterus* sends far-reaching runners along the brown soil - they are misshapen, plump shoots - succulent and very brittle. They bear large flowers with shiny white petals (petal-like staminodes), and this is the only foreign colour in the chaos of greenish tones. All shades of green are present, varying indeed from dark sap green to pale greenish yellow or to grey white and blue grey. Each shade is characteristic of some particular species but what adaptational constitution lies at the basis of it is quite unknown. The delicate structure of the fruit (with membranous crustaceous or succulent pericarp) orientates the taxonomist in this confusion of forms and enables him to note at the outset that the great majority of the species belongs to the family Chenopodiaceae. Several species of *Atriplex* are noticeable, above all the pale green *A. halimoides*. Amongst other species of this diverse assemblage of Chenopodiaceous representatives are *Babbiga dipterocarpum,* several *Kochia, Chenolea curotioides, Sclerolaena litoralis,* and *Didymanthus Roei*. Their habit is dissimilar to the form of cushion-like growth characteristic of their typical growth. The limp *Chenopodium Gaudichaudianum* (Chenop.) raises itself under the protection of the taller *Atriple*x shrubs until it projects its branches with their rich inflorescences out from the supporting shrubs. Closely akin to the Chenopodiaceae by reason of its anemophillous habit is the Polygonaceous species *Emex australis*. It is uncommonly widespread and its sticky fruit lies scattered everywhere on the ground. Not quite so common is a species of *Samolus* (Primul.) and *Statice* (Plumbag.) but both deserve mention as interesting members of the community. *Statice salicornioides* is an ecological analogue of the genus *Salicornia* as its name indicates. *Samolus* is the ultimate member of a chain of development of *S. repens*, which leads to the complete suppression of foliage and the transference of the entire assimilating process to the stems of the plant.

Further away from the coast the number of the weaker halophytic elements increases rapidly. *Myoporum acuminatum* (Mypor.) a well known feature of the coast of the whole of Australia, begins to overtop the Chenopodiaceae. In the background still taller forms (*Acacia leucosperma*) are present. *Cassia* species (Legum.) also occur. In the undergrowth succulents lose their dominance, but grasses and soft herbaceous plants gradually but steadily displace them. At first rarely, then more and more commonly one finds patches of everlastings (Compos.). Finally the interior bush scenery becomes obvious although this scenery often exhibits the typical littoral character. Both are spatially directly continuous in the Eremaea and pass into one another without any distinct boundaries.

There exists therefore in the Eremaea of the western half of Australia one of those interesting places on the earth where the halophytic littoral formations are in direct connection with xeromorphic desert vegetation and where from early times a steady exchange of elements has taken place. One must bear this in mind when one approaches the salt-pans of the far interior and sees again the features of the coastal strand, or when far in the south-west in the territory of the richly varied heath and woodlands one comes upon the sea and discovers a coastal vegetation which quite suddenly presents again something of the dull colouration and monotony of the Eremaea.

b. Formations of the sandy beaches and dune scrubs.

I have only been able to study the dune scrubs of the Eremaea at the mouth of the Gascoyne River. Climatically the coastal margin is still not very unlike the Southwest Province, and its dune vegetation appears to be a continuation of that seen on the south side of the Murchison River. At the same time this resemblance rests chiefly on the colonisation successes of the Eremaean elements in the south west. The reverse immigrations have been much more rare, yet not so unimportant that we can pass them by. *Scholtzia leptantha* (Myrt.) is an example. At Shark Bay where it so frequently and characteristically covers the sand dunes it undoubtedly belongs to the southern elements. *Acanthocarpus Preissii* (Lil.) is another in the same category. Although these south western migrants are unimportant in number they are actually more abundant in the dune formations than in any other class of vegetation of the Eremaea.

The general picture of the dunes near the mouth of the Gascoyne is rich in contrasts of all kinds. From a distance shiny silger grey spots indicate the presence of *Atriplex isatidea* (Chenop.). It is one of the most beautiful and tallest species of the genus. Examples reach a height of 4 m. *A. semibaccata* is quite a modest sixed plant in comparison. Both are deeply rooted in the loose sand which at other places is firmly held by grasses and built up into little hillocks. *Spinifex longifolius* (Gram.) forms imposing groups and, on closer examination it is remarkable to find how frequently *Pollinia fulva* (Gram.) occurs on the dunes. In the wide patches between high-growing shrubs grows *Corynotheca laterifolia* (Lil.) deeply buried in the sand and growing spaciously in twisted ramifications.

The most common shrub is *Acacia leucosperma* and its bright green stands in striking contrast to the dull grey which otherwise dominates the formation. Another common *Acacia* (*A. stereophylla*) has a dull grey coloured leaf. Most of the bushes are rounded in form - the wind only allows them to grow slowly on the surface. A height of 1.5 m is reached however by *Pityrodia cuneata* (Verben.) which was already collected on these shores by Gaudichaud. The stems of this plant give off numerous branches which are further branched until the originally simple rounded form becomes a complicated structure of branches and twigs. The similarly rounded bushes of *Solanum orbiculatum* (Solan.) are present with a grey white covering and *Sida* species (Malv.) are not uncommon. They also bear a grey or white coloured hairy integument. Types which approach the succulent form are represented by *Gyrostemon* (Phytolacc.) and *Anthobolus foveolatus* (Santal.), two plants which are also present on the south western dunes. Thus hairiness and succulence dominate the ecology and physiognomy of the woody plants which here and there inhabit the dunes.

These sparsely distributed groups of shrubs form a nucleus, as in all dry areas, around which a microcosmos of plant life collects. Climbing plants it is true, penetrate their branches less richly than in the south west, but are at the same time quite characteristic. *Zygophyllum fruticulosum* is the most important species. Its leaves are fleshy and of a sap green colour. Tall perennials grow on the lightly shaded ground as for example *Lepidium linifolium* (Crucif.) and *Brachycome latisquamea* (Compos.). They are delicate and short-lived plants only capable of existence after the rains. More strongly built and independent is *Trichodesma zeylanicum* (Borrag.). It enlivens the dune flora here with its large blue flowers. This feature is missing south of the Murchison River.

Towards the interior narrow tongues of dune vegetation still project along sandy hill ridges. Its constitution remains much the same, consisting of fairly close groups of plants which are always separated by bare patches where the sand is freely exposed. The herbaceous element suffers some change, the taller perennials decreasing in number whilst the number of species among the low annuals becomes greater. *Trichinium* (Amar.), *Senecio Gregorii* (Compos.), several everlastings of the interior, (*Schoenia*, *Waitzia* and *Podotheca*) and dwarf Angiantheae (Compos.) are scattered on the soil amidst the bush so long as the rainy season keeps the soil moist. In well shaded spots they grow gregari-

Eucalyptus-Wald der Eremaea.

Eucalyptus celastroides Turcz. — Zwei kleine Bäume links vorn *Fusanus spicatus* R. Br. (Santal.); das übrige Gebüsch *Acacia* und *Melaleuca*. Distr. Coolgardie, Southern Cross. — E. Pritzel phot. Mai 1901.

ously together as in little garden beds hiding the surface of the ground completely.

b Woodland Formations.

a. Eucalypt woodlands of the Eremaea (Plates XXIV, XXVIII, XXIX)

The appearance of the Eremaean *Eucalyptus* wood remains the same throughout the wide extent of its distribution. The eucalypts project from an entangled bush made up of diverse forms. Most of them possess smooth, often shiny, trunks, the contour of their crowns is always umbrella-like and their narrow leaves are nearly brown green in colour. Their poverty-stricken crowns stand high up in the hot air and their shade never reaches the ground. They have a strange effect on the observer no matter what time of the day.

Externally most of the species which play a role in these regions are very similar. The most important are *E. salmonophloia*, *E. salubris*, *E. celastroides* and a tall growing form of the *E. oleosa* group which has been named *E. longicornis* by F. v. Müller. *Eucalyptus salmonophloia* is unmistakable by reason of the peculiar reddish tinge of its trunk and the shiny leaves, its crown has the form of an inverted cone of slender shape. When *E. salmonophloia* and *E. longicornis* grow in the same neighbourhood one can distinguish between the two in that the crown of the latter grows more in the direction of greater breadth and that the leaves retain a blue green colour even when mature.

This tree, which reaches a height of 15 - 20 m is the tallest of the community. It is unusually widely spaced. Under it the soil is a red loam, often mixed with stones and at times bare and without vegetation over large stretches. More frequently, however, the intervening spaces are occupied by undergrowth which is here loose, there closer and thicker, sometimes resulting in impenetrable thickets. The height of this undergrowth varies. This is because of the extended growth of young eucalypts. It is difficult to gain a clear survey of this mass of low-growing eucalypts. As soon as they have passed what may be a more or less distinctive primary stage they resemble each other surprisingly. In addition there are present a number of species of permanent low stature which are similarly easily mistaken for one another. *Eucalyptus gracilis*, *E. uncinata*, and *E. erythronema* can be regarded as the most widespread species of this category. All have thin trunks, well branched crowns of flexible branches and shiny thick leaves.

The smaller eucalypt trees are somewhat like the *Casuarina* species in size. They also possess the peculiar obconical shape which is the characteristic sign of the formation.

As for the rest, it scarcely rises above the height of 2 - 3 m, thus preserving the characteristic of shrub growths. The most important elements of this bush belong to the genera *Acacia, Fusanus* (Santal.), *Dodonaea* (Sapin.), *Melaleuca* (Myrt.) and *Eremophila* (Mypor.), *Alyxia buxifolia* (Apocyn.) and *Exocarpus aphylla* (Santal.) are also very widespread.

Considerable diversity occurs amongst these shrubs. The general appearance of the tree growths is repeated by the broom-like shrubs of *Melaleuca*, (e.g. *M. pauperiflora*) by *Acacia*, *Casuarina*, many species of *Eremophila* and to a smaller extent by *Olearia axillaris* (Compos.), *Westringia rigida* (Labiat.) and others. In all of them the shape of the crown is that of an inverted cone, the branching is uncommonly rich, and the twigs and twiglets directed upwards to their very tips. The leaves which are usually small or narrow-linear in form are generally placed vertically. There is therefore a rather general and complete continuance of the principle displayed by the vertically oriented *Eucalyptus* foliage so well known to all since the time of Rob. Brown. It leads to the most surprising convergences.

The branches are also directed upwards in *Alyxia buxifolia* (Apocyn.), but the thick leathery leaves are much greater in area than those of the brush-like shrubs. *Fusanus spicatus* and *F. acuminatus* (Santal., Fig. 67) both of which are important elements of the formation, have also large leaf surfaces. The more commonly occurring species is *F. acuminatus*, - its thick pale and dull-coloured foliage is met with at each step in these woodlands. *F. spicatus* has suffered greatly from uncontrolled cutting out and in many districts is now becoming rare. Ecologically it is very like *F. acuminatus*, but it forms a vertical main stem much more frequently.

Finally it may be mentioned that xeromorphism is apparent in many shrubs. This is indicated by an extensive increase in sclerencyma in all parts. There are plants which on account of their sharp and hard branches are almost unapproachable. Probably *Exocarpos aphylla* (Santal., Fig.68) is the most characteristic and widespread type of this form.

Fig. 71. *A—C* eine Charakterpflanze der Eremaea, *Trichinium exaltatum* (Nees) Benth.: *A* Habitus. *B* Bractee. *C* Blüte ausgebreitet. — *D*, *E* *Trichinium siphonandrum* Diels: *D* Blüte ausgebreitet. *E* Bractee. (Nach DIELS und PRITZEL).

This leafless bush with its reduced yellow green axes, and irregular branching is seldom missing from the undergrowth. Related to it ecologically is the stiff *Templetonia egena* (Legum.). Certain acacias (e.g. *Acacia genistoides*, Legum.) follow a similar plan except that they are covered with spiny phyllodes. Less common are the spiny bushes of certain members of the Proteaceae which have rich sclerid development. *Hakea Preissii* and *Grevillea Huegelii* have the widest range of any.

In all areas where the bush is somewhat less strongly developed - and this seems to occur frequently - the red loamy soil often is visible. After heavy rains water collects there and frequently remains standing for several days. As a result the soil becomes thoroughly moistened and the seeds of annuals commence to germinate. A rain flora awakens to fill the spaces in the formation during the climatically favourable period of the year. Sometimes it is the grasses (*Stipa* species, in particular *Stipa pycnostachya* and *elegantissima*) which attain importance although the grass is very transient and only springs up with the winter rain. Under the influence of rising temperatures it soon ripens and by November it is again yellow and dried up. However, on the easy slopes exposed to the south wind one can see evidence of the well distributed grass seeds.

At other places grasses are almost completely lacking their place being taken by composites. These composites of the Eremaean woodland are similar to the everlastings described on earlier. Their vegetative development is, however still more impoverished. *Waitzia acuminata* occurs in depauperate form, while *Helipterum Fitzgibbonii* grows in round tufts with its branches pressed to the soil. Many species consist almost entirely of the much branched stem and a large straw covered flowering head. A sample of this humble form is *Helipterum tenellum* Turcz. which covers wide stretches of the ground at Yilgarn with a shining yellow carpet. The fine dark red heads of *Trichinium exaltatus* (Fig. 71) form a fine contrast between the beds of everlastings.

Wherever the ground sinks, forming a depression in these areas, and is likely to be subject to more or less regular floodings, large quantities of salt accumulate. *Zygophyllum* (Zygophyll.) occurs along the margin of such salt depressions and *Trichinium obovatus* (Amar.), a peculiar white-coloured lichen nestles on the bare ground. Species of *Angianthus* (Compos.) form close tufts but the most characteristic species are those of the succulent Chenopodiaceous genus *Atriplex*. Often one finds *Atriplex Drummondii* as the only bush which the barren surface can sustain.

Areas exist where without any demonstrable enrichment of the soil in chloride, one finds fleshy members of the Chenopodiaceae becoming increasingly important in the undergrowth. Between the scattered stiff bushes of *Dodonaea* (Sapind.), *Eremophila* (Myopor.) or *Melaleuca* (Myrt.), the tufts of *Kochia* (*K. villosa* and *K. amoena*) small *Atriplex* or *Bassia* (Chenopod.) species spread out close to the ground. Often a number of species are found near each other, some covered with a silver grey indumentum, others with a light sap-green mantle. None are so important as the above mentioned *Atriplex Drummondii*, whose leafy twigs are directed upwards. They often occur in groups in the light woodlands, enriching the landscape with their colours. I have seen stretches where the rich undergrowth of this member of the Chenopodiaceae and the almost equally blue-white young eucalypts provide the only decorative features of the ground. The impression given by such scenery is difficult to describe. A *Eucalyptu*s woodland of this type occurs for example south of Lake Cowan. The silver *Atriplex* and *Kochia* species, the shiny white trunks of two eucalypts - the light blue-green of *E. salubris*, with its red twigs and the bright green of *E. salmonophloia* - all this in front of a dark background of distant woodlands, provide luster and reflections which are repeated by no other vegetation on the earth.

A peculiar feature of the woodland of the south western Eremaea is the change in flora at places where the bare granite appears at the surface. The rain water runs off the smooth stone and collects round the margins, keeping the soil in a more moist condition. The soil instead of being red-brown as is the case round about it, is rather a pale yellow colour. Spencer-Moore (1900) indeed noted the peculiarity of the flora round these “Gnamma” rocks, and (in Journ. Linn. Soc. XXXIV, 260) lists a large number of species which were exclusive to such spots. The list is repeated here since my own experience supports much of it, although I can not vouch for the accuracy of the whole:-

Nothochlaena distans (Polypod.)
Pleurosorus rutifolius (Polypod.)
Scirpus cartilagineus (Cyp.)
Centrolepis mutica (Centrolep.)
Juncus bufonius (Junc.)
Borya nitida (Lil.)
Peterostylis pyramidalis (Orch.)
Thelymitra longifolia (Orch.)
Thelymitra antennifera (Orch.)
Parietaria debilis (Urtic.)
Grevillea nematophylla (Prot.)
Hakea suberea (Prot.)
Drosera macrantha (Droser.)
Oxylobium graniticum (Leg.)
Mirbelia microphylloides (Legum.)
Stackhousia species (Stackhous.)
Cryptandra petraea (Rhamn.)
Keraudrenia integrifolia (Sterc.)
Kunzea sericea (Myrt.)
Prostanthera Baxteri (Lam.)
Solanum lasiophyllum
Eremophila granitica (Myopor.)
Eremophila alternifolia (Myopor.)
Goodenia hederacea (Good.)
Dampiera lavandulacea (Good.)
Isotoma petraea (Campan.)
Helichrysum semipapposum (Comp.)
Helipterum Manglesii (Compos.)
Podolepis pallida (Compos.)

Eucalyptus-Bestand von eremaeischem Savannen-Charakter.

Eucalyptus loxophleba Benth. — Im Zentrum ein stattliches Exemplar von *Cassytha racemosa* Nees.
Im Vordergrunde reichlich *Triraphis mollis* R. Br. (Gramin.).
Distr. Irwin, Watheroo. — E. Pritzel phot. Dezember 1901.

In discussing this list Spencer Moore notes that the presence of ferns, members of the Cyperaceae, *Parietaria* (Urtic.), the Orchids and *Drosera* can be explained by the presence of adequate supplies of water at these localities. For other species of the list, however, this explanation does not satisfy him, and I must take up the same position myself. Spencer Moore came to the conclusion that edaphic influences of a chemical nature were at work. However, he does not mention that through his list there is a distinct south western trait. Now this is important for out of it we get the fact that the phenomena of the rock plants is only a special case of the edaphic dualism of the entire Eremaean flora.

This is confirmed at all places where the sandy content of the soil increases. The vegetation then always becomes enriched by the addition of new elements and towards the boundaries of the Southwest Province it is exactly these places where the first signs of the south west are to be found. For example if one travels from the Eremaean heights of the Ravensthorpe Range southwards towards the coast one meets a transition zone of this kind. Several low *Eucalyptus* species, *Dodonaea concinna* (Sapin.) and others are present. Types of characteristic of the Eremaea occur together with *Melaleuca glaberrima* (Myrt.), *Oxylobium reticulatum* (Leg.), *Grevillea patentiloba* (Prot.), *Logania stenophylla* (Logan.), *Petrophila fastigiata* (Prot.), all of which are xeromorphic plants of a south western character. In the same way at many other localities there is an exchange wherever both provinces are brought together by edaphic conditions.

b. *Savanna woodland* (Plates XXIX, XXX, XXXI)

On the margins of the Eremaea, often extending into the Southwest Province, the Savanna woodland occurs. It comprises mixed woodland rich in *Acacia*. It is an interesting formation from many points of view. In particular it warrants attention as a counterpart of the eastern Australian savanna woodlands for the essential constituents are low trees of the genera *Eucalyptus* and particularly *Acacia* with an undergrowth of grass and herbs. Shrubby undergrowth is lacking.

One can consider this *Acacia* mixed woodland as the Western Australian savanna woodland and all the more so because the edaphic conditions and the annual vegetative cycle correspond with these features in the east.

In comparison with the extent of the savanna woodland in eastern Australia the development of the savanna mixed woodlands in Western Australia is poor. Its chief bounds are those of the rainfall zone of about 50 cm rainfall and on geographical grounds one would be inclined to group it with the Southwest Province were it not for the fact that its floral nature is predominantly Eremaean.

Two representatives of two of the most important Australian genera are the dominating features of this formation - *Eucalyptus loxophleba* (York gum) and *Acacia acuminata*. *E. loxophleba* is more common in the south than in the north where it gradually loses its characteristic form. It agrees entirely with the type of the Eremaean eucalypts. Its dark green shiny leaves are crowded towards the ends of the twigs. Usually branching starts off either at or very close to the ground and a kind of umbrella-like crown results (Plate XXIV). *Acacia acuminata* also presents a funnel-like contour on its crown (Plate XXXI). It consists of an extraordinarily rich network of branches, but the canopy only consists of a very thin layer of foliage. The young leaf buds are covered with silky hair and in the first half of the rainy season, when they unfold their appearance lends an air of brightness and delicacy to the scenery. Later on the narrow dark green shiny phyllodes generally hang downwards, and in form are surprisingly like *Eucalyptus* leaves. Only the silky hair covering of the young leaf shows on closer observation that we are not dealing with a eucalypt.

In many areas other acacias occur besides this most important one. One of the most important of the southern area is *Acacia microbotrya* which is distinguished from *A. acuminata* by its paler, more blue-green leaves. Its scented flowers appear at the beginning of the rainy season. They unfold during the first weeks of the season so that this species is

Savannen-Wald

von *Eucalyptus loxophleba* Benth. (links und Mitte) und *Acacia acuminata* Benth. (rechts und Hintergrund, die niedrigeren Bäume).
Distr. Avon, Meenaar. — E. Pritzel phot. November 1901.

one of the first to brighten the scenery. There are also species of the polymorphic groups of *Acacia rostellifera* which in many localities share with *A. acuminata* in the formation of light park-like associations. This species is recognized easily by the large leaf which reaches quite unusual dimensions on young individuals. In the drier parts not far from the transition zone between the Southwest Province and the interior, one meets other forms such as *Acacia genistoides*.

There also some of the strongly xeromorphic hakeas attain tree-like dimensions, e.g. *H. Preissii*, and *H. recurva*. These are very curious forms with stiff outwardly projecting branches and spiny spike-like cylindrical leaves which terminate in a sharp point.

The shrubby undergrowth of the formation is very poor, and in this feature we have perhaps the most marked difference from the true south western formations. In the western marginal zones one still sees *Acacia pulchella* or *Acacia Meissneri*, together with some hakeas of marked xeromorphic nature. *Hakea bipinnatifida*, *Pimelea argentea* (Thym.) and, in the north, *Pimelea microcephala* (Thymel.) which sheds its leaf in the dry period are present.

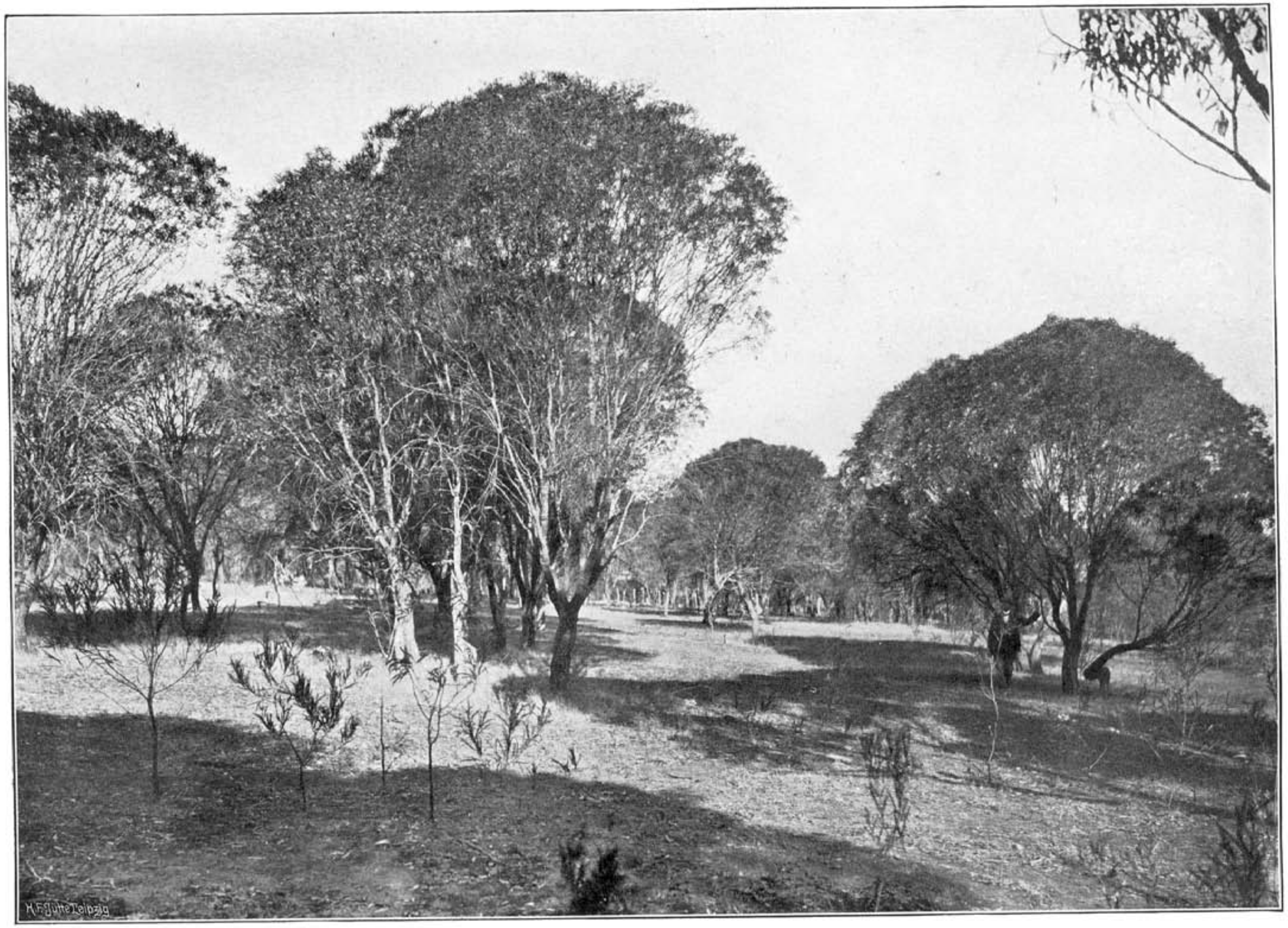
The undergrowth of perennials and herbs is, however, of greater importance, and in the rainy season the ground is pleasantly green. In this connection the grasses are less essential than the annuals with their rosettes of leaves. Mosses - *Funaria gracilis* and *Ceratodon purpureus* gain importance.

Of the perennials the genus *Conostylis* (Amaryll., Fig. 28) is represented by certain species, eg. *C. prolifera*. It is interesting because it is no doubt a south western element of the formation. Its ability to proliferate rapidly renders it able to cover considerable areas in a short time with a grass-like turf. Another character plant of the formation is *Xerotes effusa*, whose rich white flowered inflorescences develop in large numbers from the rhizome. For the rest, the perennial plants are represented chiefly by bulbous growths. Some orchids are usually present, in particular the pretty *Caladenia deformis* which appears to be specially at home in these loamy associations. Its blue flowers remind one of the Anemones of the Mediterranean countries. Small *Hypoxis* (Amaryl.) with yellow flowers, the white flowers of *Anguillaria* or *Wurmbea* (Lil.) and the peculiar *Tribonanthes* species, are not uncommon in the first half of the vegetative season. The droseras too, springing from bulbs, appear in certain forms which are specific to the formation. The small statured *D. bulbosa* appears quite early after the first rains and later on *D. macrophylla*, the most beautiful and the most stately of them appears (Fig. 34F).

As we pass further into the favourable season for the vegetation the more the importance of the perennial herbs in relation to physiognomy diminishes. From day to day the situation varies gradually favouring the annuals. In the beginning particular species are of no account. The unit is the sum total of all the ephemeral grasses and annuals present. They all take part in forming the uniform green mosaic on the soil. Gradually, however, the individual species become more and more obvious.

Following the rising temperature pattern the progress of this development moves from north to south. By July the soft grass of the formation (*Festuca bromoides* for example) has attained full growth in the northern landscapes and the herbaceous flora is already in full blossom. Because of the presence of *Helipterium Lawrencella, H. Manglesii* and *Helichrysum roseum* (Compos.) rose red tints are dominant. But the striking blue of *Erodium cygnorum* (Geran.) is very common while the yellow of *Goodenia* species and social composites, (*Myriocephalus gracilis* and *M. Guerinae*) is effective. Vegetatively all these species belong to the delicate elements of the Western Australian flora just as do the first-comers of the rain flora, *Mitrasacme paradoxa* (Logan.) or *Stenopetalum pedicellare* (Crucif.). These, with their almost hair-like feebly leaved stalks are characteristic of this group. Where the herbaceous growths are less dense and remain shorter, here and there one sees *Triglochin nanum* or *T. centrocarpa* forming extensive communities.

In the second half of the rainy season the herbaceous growths increase considerably in height. Herbs, which produced flowers some weeks before are already ripening their fruit. They will soon be pushed into the background by the taller neighbours which are still growing strongly. The bright green characteristic of the first weeks of the rainy



Savannenartiger Acacien-Bestand auf Lehm zur Trockenzeit.

Acacia acuminata Benth., erwachsene und junge Exemplare.

Distr. Avon, Newcastle. — E. Pritzel phot. Februar 1901.

season is already beginning to fade and the carpet becomes daily more vari-coloured. The everlastings in particular provide gorgeous tints. *Schoenia Cassiniana* with its white or more often rose red inflorescence is still in blossom. Yellow or orange colours are shown by the shiny bracts of *Cephalipterum Drummondii*, *Podolepis aristata*, and the species of *Waitzia* (*W. aurea* and *W. corymbossa*). These are the dominant colours of the herbaceous flora. Where openings occur in this close growth, dwarf annuals always find room for their impoverished existence. One meets the small *Drosera* (*D. glanduligera* (Droser.)) and the low *Didiscus* (Umbell.), tiny *Stylidiums* or *Levenhookia* species (Stylid.), and also the pygmies of the genus *Helipterum* (*Helipterum gracile* for example) with a series of Angiantheae (Compos.). The later these develop, the less foliage they bear and the more the assimilation takes place in the axes of the plants. *Angianthus stricta* or *Podolepis Siemssenia* are good examples of such late comers.

By the middle of October the vegetative life of the undergrowth is over. The leaves are faded and the stems etc have taken on a pale appearance. The masses of Everlastings remain, but everywhere their pappus become visible out of the coloured paperlike involucre, interlacing the formerly so richly coloured flowers with many white threads.

On the Bowes River for example when I visited the formation in November, dull yellow or grey tones completely dominated the undergrowth. The stony loam soil was covered with fallen stems and dead foliage. The mature *Waitzia corymbosa* was present in large numbers. The white haired heads of *Trichinium Drummondii* (Amarant.) on their leafless stems, the grey masses of *Aniganthus stricta* (Compos.), and not least the silver coloured leafless trees of *Jacksonia sternbergiana* (Legum.) (which grow everywhere on the stony cliffs), gave the scenery that touch of general "dried-up-ness" which is so peculiar to the savannas when entering upon their dormant period. Only *Trichinium Manglesii* with its rose red heads preserved a memory of the bright colours that had gone.

Some weeks later little of this picture is left, and the naked brick-hard ground appears generally bare. The wind has blown away the dead grass and withered remains of the foliage. Here and there the last trace of an Everlasting is seen. Otherwise nothing is recognizable of the motley assemblage which adorned the soil at spring time. Only one species flowers at this time - *Calandrinia Lehmannii* (Portulac., Fig. 33). Its foliage becomes active in the rainy months, then from the subterranean bulb the flower stalk rises but it is not until later that the flowers unfold. In the middle of the dry season under the bright sun they look like dazzling stars on the hot soil.

Climbing plants are scarce in this formation, and of epiphytes I have seen only lichens. On certain plant species these however, were rather abundant. Thus in the neighbourhood of the Irwin River the stiff axes of *Acacia genistoides* were quite covered by *Usnea barbata* var. *aspera* and *Physcia chrysopthalma*.

Finally the frequency of Mistletoe species on the trees of this formation needs mention. Their presence here is also paralleled by their occurrence on other comparable savanna areas. In our formation it is the acacias which are particularly attacked by these hemiparasites. *Loranthus quandang* (Plate XXVII) with its flat white, grey, and hairy leaves, and somewhat inconspicuous flowers which unfold in the dry season, is particularly common in the north. A very different type of the genus is represented by *L. linifolius* with terete bright green leaves and startling red flowers. It is more common than *L. quandang*, and is found in the same regions, in fact one may occasionally find both on the same tree.

An important taxonomic feature of the vegetation lies in the fact that the undergrowth is marked by a Pan-Australian character. Many of the most common elements extend from the pasture lands of eastern Australia right across to the west, others are at least related to them. The presence of conditions which are favourable for the annual type of plant is responsible for this and it also explains why some aliens and colonists have made themselves conspicuous here. We shall see elsewhere that favourable conditions for introduced plants, are only rarely present in Western Australia. Their presence here in this mixed woodland formation is therefore the more remarkable. The origin of a number is doubtful, but the foreign origin of others is quite certain. They come from

»**Creek«-Vegetation in der Übergangs-Zone** zwischen Eremaea und Südwest-Provinz.
Casuarina glauca Sieb. (links), *Eucalyptus rostrata* Schlecht. (Zentrum, mit weißem Stamme);
im Vordergrunde *Acacia acuminata* Benth., junges Exemplar (links), *Melaleuca viminea* Lindl. (rechts).
Distr. Irwin, Mingenew. — E. Pritzel phot. Juni 1901.

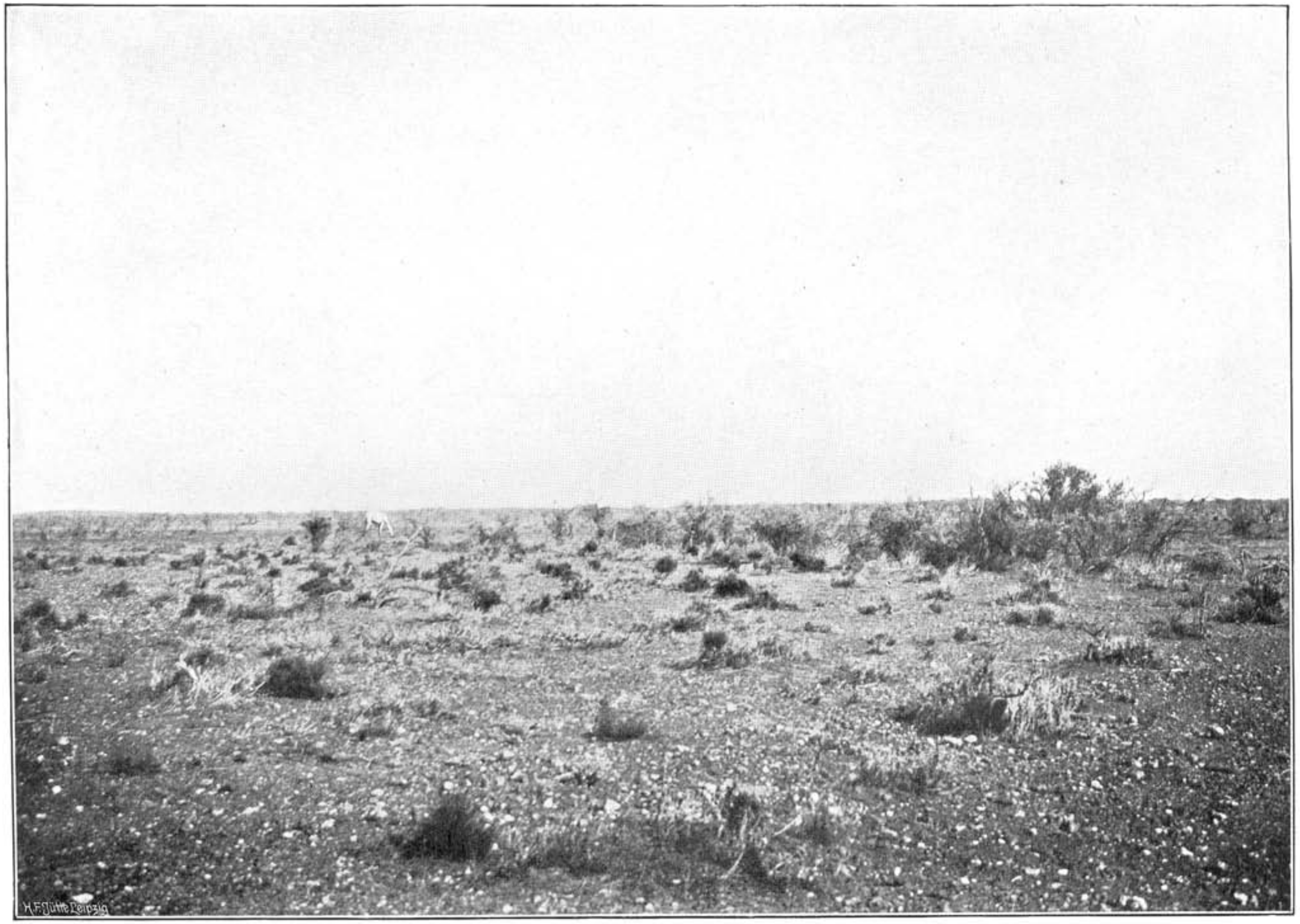
parts of the earth which are climatically rather similar, in particular the Mediterranean countries. Amongst the most noteworthy of these migrants are *Silene gallica*, the grasses *Briza minor*, *Koeleria phleoides* and *Avellinia Michelii*, also *Parentucellia latifolia* (Scroph.) and a couple of *Cotula* species of South African origin. They are often sufficiently common and gregarious enough to attract the eye but none of them approach in importance a migrant from the Cape, known as Cape Weed (*Cryptostemma calendulaceum,* Compos.). I have seen this plant showing an exceedingly strong development on the lower Greenough River on fruitful alluvial soil. The second half of the rainy season there is marked by warm moist weather and the weed grows better than anywhere else in Western Australia. An introduced *Avena* species about 1 m. in height also covers wide stretches and *Lupinus angustifolius* has made itself at home. But *Cryptostemma calendulaceum* has taken such possession of wide areas and forms such pure stands and all so dense that it looks as if they were carefully prepared fields of some valuable plant. The wide distribution which this plant has attained outside the Eremaea makes it appear strange that the Southwest Province has been so incapable of producing its own annuals.

A somewhat strange appearance is taken on by the savanna woodland formation in the vicinity of water. In these regions there is a complete absence of permanent water, but during the rainy season the conditions are favourable enough near periodic collections of water to have produced a marked change on the plants of such places. This consists of a gradual change from the savanna woodland and formation to a completely riparian type vegetation.

The first sign of this change is indicated by an increase in the number of shrubs. In the south it is essentially melaleucas (*M. radula* and others) and also here and there a *Grevillea*, which indicates the presence of water. Richer in species, however, (particularly through its own special products) is the corresponding formation of the most northern landscapes - meeting the Southwest Province at the Murchison River. *Grevillea* species e.g. *G. brachystachya* with slender twigs and narrow leaves form close thickets. *Dodonaea inaequifolia* (Sapind.) with its delicate pinnate leaves is found intermingled with the above. Some types of the real Eremaea are also of importance (*Cassia eremophila*). Amidst the entangled branch work of the shrubs twine graceful lianas which by reason of their ecological and taxonomic characters are very peculiar in the flora of Western Australia. These are *Dioscorea hastifolia* (Dioscor.), *Aphanopetalum clematideum* (Cunon.) and *Clematicissus angustissima* (Vitac.). All three possess without doubt close relation to tropical types and each is the only representative of this group in Western Australia. Ecologically they present similar features. They shed their leaves at the beginning of the dry season and renew them with the commencement of the rains. They are the only shrubs of Western Australia with deciduous foliage regulated by changes in climate. They are confined to the northwest part of the country where the average temperature of even the cool season is high enough to suffice for the vegetative activity of the plants. These plants grow under suboptimal conditions as is indicated by the underdevelopment of organs of vegetative energy, ie. they have small leaves; a feature which is often observed on descendants of tropical lianas when they occur at the very edge of their distribution.

Nearer the bottom of depressions or valleys (Plate XXXII) melaleucas or acacias (in the north) begin to form dense formations. *Myoporum acuminatum* occurs here and there scattered amongst them. Inside these thickets we find casuarinas (*C. glauca*) and the imposing forms of *Eucalyptus rostrata* which is widely distributed throughout Australia as a river-bank form. Finally on the very margin of the water one may observe one or two Cyperaceous plants and *Marsilea Drummondii* which are Australian species.

Many of the streams have cut deep channels and thus while breaking up the monotony of the topography they have also assisted in the diversification of the vegetation. An instructive example of this kind is the valley of the Chapman River where it cuts through the littoral limestone north of Champion Bay. In the wet months a beautiful selection of the rich flora of that region is unfolded there. In the bed of the river one finds tall examples of *Eucalyptus rostrata*. On the slopes a most diverse bush has developed. *Melaleuca radula*, *M. megacephala* and *Chamaelaucium uncinatum* represent the Myrta-



Mulga-Formation der Eremaea.

Vegetation vorzüglich *Acacia*-Arten, *Trichinium obovatum* Gaud. (*Amarantac.*). *Kochia*-Arten (Chenopodiac.).
Distr. Austin, Cue. — E. Pritzel phot. Juli 1901.

ceae. *Acacia rostellifera* (Legum.) is present in the form of great bushes. The imposing *Marianthus ringens* (Pittospor.) twines amidst the *Acacia* bushes showing here and there a cluster of its red flowers. Deeper amongst the above are smaller bushes *Diplopeltis* (Sapind.), *Stylobasium* (Rosac.) and stately *Scaevola*, e.g. *Sc. porocarya*. On the light loamy places of the sunny side of the slopes a luxuriant growth of grass and herbaceous plants is found. They are typical elements of the savanna woodland formation - small annuals and stately everlastings. On the shady side, however, the composites are almost entirely absent. But everything that grows there is much fresher and the grass is more luxuriant. In niches of the moss covered limestone of the shady slopes dainty orchids are hidden away - *Caladenia Menziesii*, with flowers scented like "lilies of the valley" and *Cyrtostylis reniformis* which is very easily recognised by its large thin leaves. It is found far away in New South Wales in exactly similar places. A tissue of the most delicate leaves covers the ground in these niches, made up of the tiny *Hydrocotyle* plants, eg. *H. pilifera*, *H. rugulosa* (Umbell.) and others. *Haloragis nodulosus* (Halor.) will probably also be present. All these are true ombrophyllous annuals which are sustained by the moisture of their shady habitats.

c Shrubland Formations of the Eremaea.

a. Mulga formations of the north (Plate XXXIII)

Somewhere in the neighbourhood of the parallel of 30° S the Eremaea takes on quite a special form. Spencer Moore recognized the importance of the boundary when he traveled from Siberia to Mount Margaret. "As soon as the salt-pans of Goongarrie are passed a complete change takes place in the vegetation. *Eucalyptus* trees become very few in number and are limited to water hollows. They are replaced by Mulga shrubs (*Acacia*) and species of *Eremophila*, Proteaceae, and *Casuarina* etc". (Journ. Linn. Soc. XXXIV, 175)

So far as the observations extend, the Mulga formation replaces the *Eucalyptus* woodlands of the south, along the parallel 30°S. The soil remains pretty much the same. The undulating, often stony, country with glittering salt pans in the shallow depressions retains almost the same character. Evidently it is the last trace of the winter rains which is responsible for the deep changes in the vegetation.

Acacia is now the dominating genus. It occurs in the form of shrubs of about 3 - 5 m. in height, all of which are richly branched with umbrella-like crowns. More rarely they form crowded thickets and usually they are set quite far apart. What particular species are of general importance over the whole Mulga zone and which attain importance in smaller areas if practically unknown. Usually, however, the dominating species are those with vertically standing needle-like phyllodes of a markedly xeromorphic nature (*Acacia aneura*, *A. stereophylla*).

With *Acacia* one meets *Cassia* species more frequently the further north one travels. *Cassia* is an Eremean genus in the strictest sense. The xeromorphic characters are limited to leaf reduction or development of hair integument. The pinnate leaflets are reduced to the needle-like form in *C. artemisioides* and *C. nemophylla*, whilst *C. Sturtii* possesses a more or less thick indumentum or hair covering the leaves. All these species together with *C. Chatelainiana* are widespread components of the Mulga formation.

With the above there are numerous species of *Eremophila* and their beautiful flowers are a feature of the formation. It is not possible to describe them in a general summary because they are so different in appearance and structure. Narrow leaved bushes with bright red flowers (*Eremophila Youngii*) for example, or broad branched shrubs with thick white felt covered foliage as in *E. leucophylla*, are common types which recur in different forms. *E. Fraseri* is, however, quite peculiar. It is a desert bush with rather broad richly lacquered leaves. At the fruiting season it is highly attractive when the calyx has developed into a very conspicuous purple red case round the capsule.

Acacia, *Cassia*, and *Eremophila* are the three leading genera of the Mulga formations. Many others are a little less commonly present - *Dodonaea* (Sapind.) is to be seen in many neighbourhoods. Casuarinas show as dark structures of small obconical form.

Eremaea-Landschaft mit Helipterum splendidum Hemsl.

Im Hintergrunde Acacien.

Distr. Austin, Murrin murrin. — Phot. September oder Oktober 1900.

A few small isolated *Eucalyptus* trees are scattered about but they exert no influence on the uniform bush.

On the other hand another element of considerable physiognomic importance remains to be mentioned, *Brachychiton Gregorii* (Stercul.), the "Currajong". It is a small solitary occurring tree, in the tangle of bushes, but it is easily recognized by the dark green of its leafy crown. The maple like form of its leaf is absolutely peculiar to the Eremaea formation. One notices something strange about it at once, at least in the south western section of the Eremaea which interests us here. It gives one the impression of an unacclimatized guest. Drummond stated that the tree was deciduous. I myself have not obtained any information about leaf fall. It seems probable that south of 30° S (i.e. in the Coolgardie District) the tree never succeeds in flowering.

On the whole it will be seen that there is a big difference as regards the leading elements between the Mulga formation and the *Eucalyptus* formations. The constituents of the lower growths are, however, essentially similar. The distinctive feature of the Mulga is the presence of more or less tomentose perennials or semi-shrubs of the genera *Sida* (Malv.) and *Solanum*. *Sida* species are not nearly so common in the southern landscapes and one misses the large violet flowers of *Solanum lasiophyllum* which are so attractive in the whole Mulga zone. But the silky and succulent *Kochia* (Chenopod.), and striking heads of *Trichinium* (Amar.), the grasses and everlastings, and the annuals with radially growing branches are features common to both the Mulga and the more southern Eremaea scenery. In the dry season these open landscapes appear still more monotonous and often give a more desolate impression than the *Eucalyptus* deserts (Plate XXXIII). The little water channels, noticeable from afar by their borders of *Acacia genistoides*, are quite dried up and only an annual flourishing here and there on the clay bed indicates the advantages of the position. Otherwise all is bare. Grasses and everlastings are no longer visible except where a larger shrub has given some protection and their remains form a kind of encircling wreath of yellow straw around it.

The Mulga zone is the least fortunate of all the Western Australian formations in its rainfall - the rains are more uncertain and irregular than anywhere else. Years may pass without the vegetation changing its desert like appearance. When, however, the land is well moistened with a rich rain it changes with a rapidity that is little short of magical into a flower bed in bloom. Such was the case in 1900. That was a spring time which nature rarely permits there more than once or twice in the course of a man's lifetime. The photograph on Plate XXXIV was taken then, at a place not far from Murrin Murrin in the neighbourhood of Mount Margaret. *Helipterum splendidum* covers whole areas as with fresh snow. Stems are so crowded together that there appears little or no room for the glistening white flower heads.

Such a season would be only experienced a few times in a man's lifetime and thus by moderate sojourn it would be impossible to thoroughly understand the potentialities of the Eremaean vegetation were it not that more constantly favoured places are to be found. At these places the Mulga formation attains its complete development more frequently and regularly. In this respect I obtained important information from the lower courses of the Gascoyne River not far from the shores of Shark Bay.

The character of the Mulga formation not far from the coast at that place is in every way true to the type of the interior. The grey coloured bush complexes still constitute the dominant vegetation on the loamy soil. Stiff *Fusanus spicatus*, *Exocarpus aphylla* (Sant.), with its rigid branches, and *Acacia genistoides* (Legum.) with needlelike phyllodes, most frequently make up the core of these groups which are penetrated by *Trichinium obovatum* (it climbs everywhere between the rigid branches until the very summit of the growth is almost reached) or surrounded by *Rhagodia Billardieri* (Chenopod.), and *Atriplex rhagodioides* (Chenopod.), whose fleshy foliage characterises the deeper sones of the bush. Halophyllous Chenopodiaceae and succulent Zygophyllaceae are quite common. There are places where *Kochia polypterygia* (Chenopod.) covers the surface with unattractive grey. *Eremophila maculata* (Mypor.) occurs in solitary and gnarled form. It is a low bush, but it is rendered conspicuous by the bright red of its flowers.

The plants which cover the spaces between the widely spaced bushes are irregularly scattered. Thus there are areas almost devoid of vegetation while other places are thickly covered with plants, especially small annual composites. Several species of Angiantheae (Compos.) are at home there - humble and lowly herbs from which little flower stalks rise. *Podolepis Lessonii*, *Myriocephalus Morrisonianus* and *Calocephalus* are others which are found, as also is *Cephalipterum Drummondii*, which is most beautiful of all. It often spreads over large areas, colouring them white or yellow. Scattered in the above company one often meets annuals of similar structure belonging to other families eg. *Calandrinia polyandra* (Portulac.) with succulent leaves, legumes such as *Swainsona* and *Lotus australis*, and ephemeral members of the Goodeniaceae.

Along a narrow margin close to the coast where the most northern part of the winter rain region extends, the vegetation is much more rank and luxurious. There are no tall trees, but the bush appears park-like. The isolated clumps of bushes consist always of a community of several species of which the central figure is usually *Acacia leucosperma*, a Mulga type 2 - 3 m shrub. Less frequently a small form of *Eucalyptus microtheca* is found taking its place, mixed with *Acacia* and almost as tall is *Cassia Chatelainiana* (Legum.) whose imposing yellow inflorescences gives it an important place in this vegetative picture. *Abutilon geranioides* (Malv.) projects from the bushy groups; its soft leaves arise from graceful broadened twigs, and its pale yellow flowers hang as pendulous bells. *Boerhavia repanda* (Nyctagin.) a semi-liane type, is often present, as is also *Trichinium obovatum* (Amar.). Deeper still in the entanglement of stems and branches we find the crowded succulent forms of *Rhagodia* (Chenopod.), and, occasionally, *Atriplex rhagodioides*. *Pimelea microcephala* (Thymelaeac.) is also of frequent occurrence.

The undergrowth in the spaces between these bushy groups has become much richer. Grasses and soft herbs form a carpet. In protected places one even finds moss beds (*Funaria hygrometrica*) helping to cover the damp loamy soil. *Cephalipterum* and *Schoenia Cassiniana* (Compos.) are again the most striking types of the community. Yellow goodenias and the deep blue of *Erodium cygnorum* (Geran.) remind one of the *Acacia* “meadows” of the south west. A whole series of intermediate forms lead from imposing plants like *Nicotiana suaveolens* (Solan.) and *Sida brachystachys* (Malv.) down to ground covers (*Tetragonia diptera*) to the smallest herb *Ranunculus parviflorus*. The foliage throughout is of a fresh green colour, soft and mesophytic, quite adapted to favourable rainy season conditions. With the coming of drier conditions it withers and dies.

b. Bush formation on sand.

The vegetation on the sandy land of the true Eremaea is very different from that of the Mulga formation. Not enough is known of the essential features of this psammophyllous community but a visit to several places has made it possible for me to at least point out a few peculiarities.

In the immediate neighbourhood of Coolgardie (to the south for instance) is a group of moderately sized sandhills, whose subsoil is labelled on the geological maps as “superfical deposits”. The plant growth on them is quite open, and everywhere one sees bare patches of bright sand showing through. In contrast to the red soil they carry no trees, or at least none with a trunk higher than 5 m. Even the tallest plants can only be designated as shrubs although here and there one may refer to a *Callitris robusta* as a tree. The dark pyramidal form of this conifer is to be seen now and again, and since it is met with at other but similar localities one can associate its distribution with certain definite localities and conditions. Another species (also characterized by pyramidal or cone-like form) which is somewhat striking is *Grevillea excelsa* (Prot.). Near Coolgardie it is one of the character plants of the district, but at other places it appears to be replaced by other *Grevillea* species which have not been described.

These two leading types - *Callitris* and *Grevillea* are followed in height by an imposing array of shrub-like forms. They form a continuous series so far as stature is concerned, and there is hardly anything in fact so characteristic of the formation as this finely graded series of vegetative dimensions.

Hakea multilineata comes nearest the leaders in height. Its whole architecture is again dominated by the vertical, its twigs stand almost vertically and its rigid sclerotic leaves which are rather broad take up a similar position. Following this plant comes *Melaleuca uncinata* (Myrt.) with terete needle leaves, one of the most familiar types of construction, closely approaching the broom like branching which is such a common feature of the typical Eremaean bush. The graceful appearance of *Eremophila Paisleyi* (Mypor.) is also due to this type of branching. This last mentioned species forms one of the most pleasing pictures in the whole of the Western Australian Eremaea when it is in flower. From a distance it appears like a fruit tree in full bloom.

A repetition of the “funnel” type on a small sale and with many variations is to be observed amongst the lower bush forms, e.g. *Wehlia thryptomenoides*, *Calythrix Birdii* and other members of the Myrtaceae. Scaly members of the genera *Phebalium* and *Eriostemon* may also be present.

The bushes of *Cryptandra parvifolia* (Rhamin.) and *Prostanthera Grylloana* (Lab.) are smaller still. The branching here is more in the direction of width and the rigid spiny branches bear very reduced foliage.

The conditions presented by the Graminaceae in this formation are very noteworthy. *Triraphis rigidissima* (Fig. 64) appears to be an important species. The uncommonly firmly built axes of this species creep horizontally over the ground. Branching takes place in a regular and centripetal manner in such a way that functioning structures - leaves, and flower heads - all stand about equally distant from the middle point of the plant. At the same time new shoots arise at very sharp angles from the middle axes and altogether the whole structure becomes very solid. Long growths thus originate which gradually die off on the inside whilst a slow forward growth of the outer part takes place.

The shade provided by the walls of these banks of grasses protect the most sensitive elements of the formation. One meets in such places examples of *Calythrix* (Myrt.) and in particular the Restionaceous plant - *Lepidobolus deserti***.** This last mentioned species is the extreme outpost of its family in the desert. It is found in a climate which in South Africa would no longer permit of the existence of any Restionaceae. Under these circumstances it is particularly interesting to observe how the hardy species of the interior adapt themselves to their environment in Western Australia.

About 125 km north of the locality of this community, I have seen a very similarly constituted community. It only seems somewhat enriched by the occurrence of *Codonocarpus cotinifolius*, that rare member of the Phytolaccaceae which has been referred to before. Its main structural features remind one of *Grevillea excelsa*.

In the north there is also a surprising number of plants which, by the character of their whole distribution, suggest that they have affinities with the interior of Australia. Hair covered perennial-like forms of the Lachnostachydinae, eg. *Lachnostachys*, *Newcastelia*, and *Hemiphora*. To these may be added *Stackhousia megaloptera* (Stackhous.), *Velleia Daviesii* (Good.) and others forming a class which begins to overshadow the groups more akin to the south west. The real ericoid small shrubs are gradually lost and the traces of the south western forms become more and more faint.

d Halophytic formations of the salt-pans.

Throughout all the riverless tracts of Western Australia (and thus throughout the entire Eremaea) and in the Southwest Province within the small triangle between Moore River and Cape Riche one finds deposits of saline material in the hollows and depressions. When the regular rains of the winter months prove adequate there depressions sometimes form a continuous wide expanse of water. At other times they appear as a number of unconnected pools. In either case the water is brackish. The hollows are surrounded by dull looking melaleucas, e.g. *M. thyoides*, *Casuarina glauca*, and other bushes with scanty foliage. On the salt pans themselves vegetation is usually only found round the very margins where the salty solution is less concentrated and where the soil becomes dry at times. It consists of thin societies of bristling *Salicornia* species. Here and there, little groups of fresh green annuals (*Triglochin* species, eg. *T. mucronata* and

T. striata) cover the intervening spaces, but they are very short-lived, and when the dry season approaches they soon fade to a straw yellow or brown. In the end their remains are almost unrecognizable and are covered with glistening salt crystals.

Further to the east and more towards the interior the salt pans become more numerous and larger. They are usually dry there or are filled with treacherous mud. It is only the relatively heavy rains of moist years which provide them with standing water. They appear like ice covered lakes in the *Eucalyptus* landscapes of the southern Eremaea framed by dark woodland and the wilderness of bush. In the northern part where trees and often shrubs are lacking there is nothing to hide their lifeless nakedness. Over wide areas there, the earth is completely free from plant growths, but at other places here and there an isolated *Salicornia* or a few other succulent plants of the family Chenopodiaceae may occur. Very rarely a tuft of grass is found in these solitudes and when it does one always finds that it is either rooted in a hollow or in heaped up drift-sand, where the deleterious salts can not collect in high concentrated form.

PART V

The Flora of extra-tropical Western Australia and it's classification.

CHAPTER I. FLORISTIC SUBDIVISION OF THE REGION

To correctly interpret the interesting floristic features of south-western Australia, the extensive use of statistical data is required. Since, however, such data are as yet inadequate, the best one can do is to provide a suitable foundation to enable a critical study of the facts. I have therefore examined and assessed all my data so as to achieve a uniform standard. The fact that these figures may be subject to considerable change in the future does not affect their usefulness. This was made clear by J. D. Hooker[1] when he said "it is not from a consideration of specific details that such problems as those of the relationships between Floras and the origin and distribution of organic forms will ever be solved, although we must eventually look at these details for proofs of the solutions we propose".

The division of extra-tropical Western Australia into two distinct regions i.e. the Eremaean and the Southwest Province, has so far received most attention. Their approximate boundaries were first recorded by Ferdinand von Müller. In several of his publications he refers to the importance of a line running from Shark Bay to the west side of the Great Bight, as separating the two Provinces.

This line coincides, more or less , with the 30 cm isohyet which divides the arid interior from the coastal region. This line is also important from the standpoint of land settlement since it also marks the limit of the area where wheat can be successfully grown. This will be the subject of more detailed comment later, when we are discussing questions of zoogeographical distribution[2].

It follows from the above that the biological boundary between the Eremaean Province and the Southwest Province is essentially determined by climatic factors. However it must be pointed out that other influences may modify or even completely replace climatic factors. Edaphic factors for instance are particularly effective. In Western Australia they are often responsible for the blurring or even the complete obliteration of the boundary between the two Provinces.

The fixing of this line, Shark Bay to Great [Australian] Bight by F. v. Müller has retained its importance over a long period because it was the only base available for the floristic division of the Provinces of Western Australia. The plant geographical notes provided by collectors, and which were communicated in Bentham's Flora Australiensis, were very limited and in fact little more than raw data. Because of this I felt that I should devote particular attention to the distribution of species. Unfortunately, however, my observations were still rather incomplete and so I must content myself with the somewhat provisional review which I communicated in Diels and Pritzel "Fragmenta phytogr. Austral. occid." (Englers Botan. Jahrb. XXXV, 56).

As set out there, the extra-tropical region of Western Australia may be divided into 8 Districts, the characteristics of which can be summarized as follows:

a. SOUTHWEST PROVINCE

1. **Irwin** District (annual rainfall ranges from 50-20 cm). Well developed coastal bush is present. Extensive shrub heaths occur on sandy soil. An Eremaean type flora is present in lower-lying areas.

2. **Avon** District (annual rainfall ranges from 60-25 cm). Various types of *Eucalyptus* community are present. Associated with them we have both Eremaean and south-western floral types. In many of the depressions and valleys the soil is rather salty. On the gravelly hills or on sandy soils open shrub heaths are present.

1 J.D. Hooker in "Introductory Essay" p. III

2 See B.B.H. Woodward, Zoogeographical provisional Sketch Map of Western Australia. In Guide to the Western Australian Museum. Perth 1900.

3. **Darling** District (annual rainfall ranges from 100-60 cm). The countryside is hilly and gravelly with communities of *Eucalyptus redunca* and *E. marginata.* In addition swampy alluvial soils are present bearing light woodland. On sandy soil coastal bush is also present.

4. **Warren** District (annual rainfall varies from 130-80 cm). Forests of *E marginata* and *E. diversicolor* occur, while open woodland is present on swampy alluvial soils.

5. **Stirling** District (annual rainfall ranges from 80-30 cm). Woodlands consisting of *Eucalyptus redunca* and *E. occidentalis* are present, together with various other communities of shrubby eucalypts and shrub heaths on sandy soils. In low-lying areas the soil tends to be salty.

6. **Eyre** District (annual rainfall ranges from 60-30 cm). This District is similar in character to the Avon District but differs in the taxonomic character of its components.

b. EREMAEAN PROVINCE

7. **Coolgardie** District (annual rainfall ranges from 30-15 cm). Very open woodland areas comprised of various species of *Eucalyptus* are present on loamy soils. In low-lying areas salty soils are present. On sandy soils xeromorphic shrub heath vegetation occurs.

8. **Austin** District (annual rainfall ranges from 25-15 cm). This District requires much more study. Many different shrub formations are present on loamy soils. Several species of *Acacia* are very conspicuous. In addition topographical depressions with salty soils occur.

In the following sections the above summary outline of the Botanical Districts is expanded and detailed descriptions provided.

a. The Southwest Province

1. The Irwin District

Character: Annual rainfall ranges from 50-20 cm. Well-developed coastal bush vegetation and extensive sandy shrub heaths are present. The flora of the valleys appears Eremaean in character. The number of endemic species is quite high.

Boundaries: We consider that the northern boundary of the Irwin District should end at the south end of Shark Bay. This was established by F. v. Müller's own investigations. In the list of species which he collected near Freycinet Harbour there is still a high percentage of south-western types. From the mouth of the Gascoyne River to the north, however, these with a few exceptions, are absent, and the flora becomes completely Eremaean.

The eastern boundary is not yet quite fixed. A good line to take, however, is the railway line which runs to the Murchison Goldfields in an easterly direction from the coast. Where it crosses the Greenough River one is surrounded by extensive sandy landscapes. A boundless shrub heath with typical south-western flora is found there. As one travels further east, however, the flowers steadily become sparser and more depauperate. At about 65 km from the coast both sand heath and shrub heath come to an end. *Eucalyptus loxophleba* and species of *Acacia* unite in forming open associations and the red loamy soil is visible everywhere. It is here that the boundary between the Southwest Province and the Eremaea becomes evident.

The southern boundary of the Irwin District is also only vaguely defined. It may be said to coincide with the northernmost distribution of *Eucalyptus redunca* in its tree habit of growth.

Vegetation.

The vegetation in the whole area is sharply segregated. This is conditioned essentially by edaphic factors. Thus Eremaean types predominate on loamy soil, often with independently developed features, while on sandy soil the south western character

Fig. 72. Die floristische Gliederung des extratropischen West-Australiens in acht Bezirke.

Zur Ausfüllung dieses schematischen Fachwerkes sollen im folgenden die einzelnen Distrikte etwas näher geschildert werden.

prevails.

The most northern part of the Irwin district is characterized by almost total floristic sterility. Very tall dunes, up to 60 m in height are present. These are mostly devoid of any vegetation. Only rarely do we find patches of ground covered with grey-green shrubs. Early French expeditions which explored the archipelago of Shark Bay and later the botanist explorer, Allan Cunningham emphasized the barren nature of the islands.

Only further south in the vicinity of the Murchison River, does the vegetative cover commence to show some increase in density and in variety.

Along the coast, bushland occurs which can only be distinguished with difficulty from the corresponding communities of the more southern districts. *Banksia attenuata* and *B. Menziesii* play the chief role. Small plants like *Synaphea polymorpha* (Prot.), *Lyginia barbata* (Restion.) and *Casuarina humilis* occur in the undergrowth. One would say that the community was lacking in character, were it not given some individuality due to the presence of certain members of the Myrtaceae, e.g. *Melaleuca megacephala* and *Scholtzia capitata.*

Certainly there are also places which have denser and more varied vegetation. There are also places where one finds much that is peculiar. The closely crowded coastal woody growths occur here. *Eucalyptus erythrocorys* occurs as the dominant tree providing shade for the undergrowth. *Hakea* species which grow almost to slender tree size are also present. This has been referred to earlier. We have also discussed earlier the effect of the favourable combination of high rainfall and mild winter temperatures which results in the coastal country of the Irwin District being unique among the Western Australian Districts.

Light sand woodlands bearing *Banksia prionotes* and the shorter *Banksia attenuata*, together with *Hakea lissocarpha, Acacia idiomorpha* and other *Acacia* species together with *Hibbertia hypericoides*, and others, follow on as we move inland from the coast. Passing still further into the interior, a zone is reached in which *Nuytsia* is common. The most striking species here, and one which dominates the scenery, is *Macrozamia.*

These shrub zones are very narrow indeed along the Murchison River, but as we travel south they gradually become broader. On the landward side they are bounded everywhere by extensive zones where sand heath and loamy vegetation are interspersed. The sand heath is the more extensive and is the more topographically monotonous of the two in general appearance. It is however very much richer in the number of species present. The loam country shows more topographic variation. It appears to show a greater richness in form and variety. Thus in one place it is a rough undulating country with outcrops of coarse rock-rubble; in another a smooth surface covered in the spring with a carpet of green and by bright everlastings in early summer after the rainy season has ended.

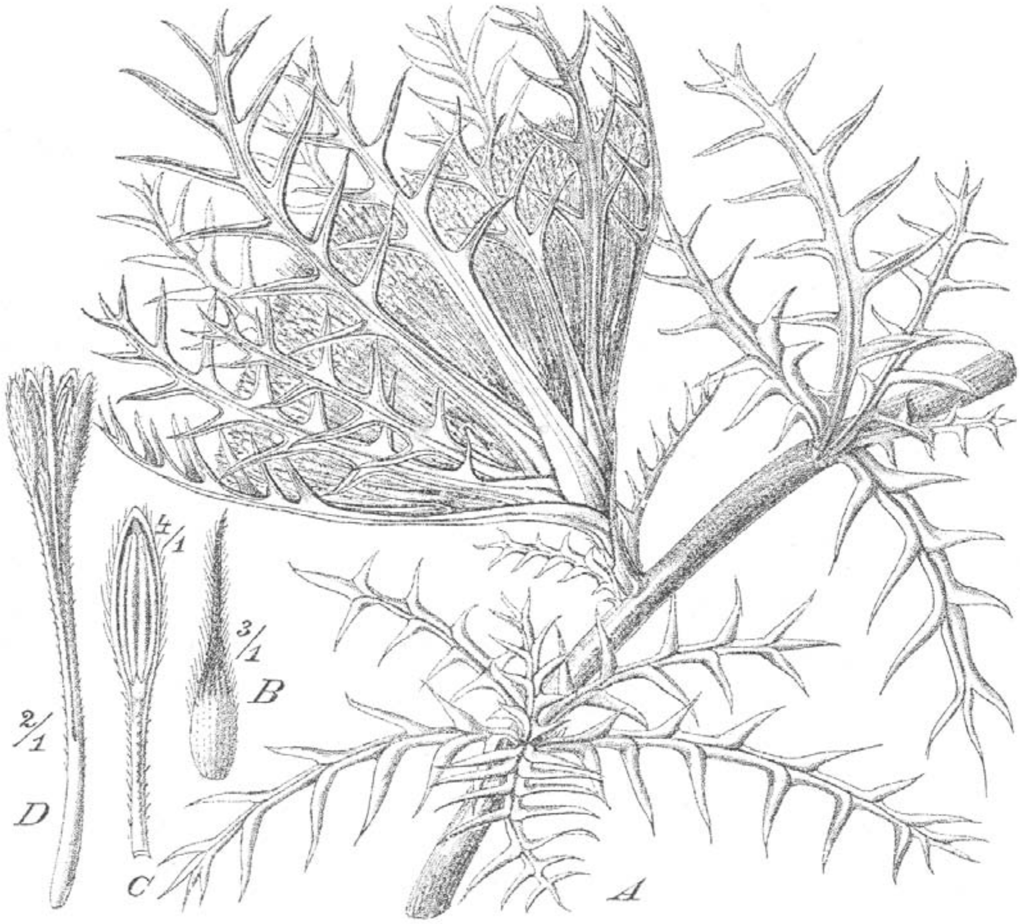


Fig. 73. *Dryandra Fraseri* R. Rr., eine Charakter-Spezies im Distrikt Irwin: *A* Zweig mit Blüte. *B* Deckblatt. *C* Oberer Teil eines Blütenhüllblatts. *D* Blütenhülle. (Nach Diels und Pritzel.)

To some degree a pure Eremaean flora has taken possession of the soil. It is partly mixed with species endemic to the region, e.g. unusual grevilleas, *Aphanopetalum, Clematicissus* and many other less conspicuous members of the undergrowth which show a purely south-western facies, e.g. many species of Orchids are present.

Floristics

The characteristic floristic features of the district have been indicated in the previous section and the Eremaean nature of the loam country emphasized. There now only remain to be mentioned those floristic features which serve to distinguish this District from the others. Endemism is particularly important and we may note the following endemic genera: *Emblingia* (Cappar.), *Aphanopetalum* (Cun.) *Pentaptilon* (Gooden.) and perhaps *Stylobasium* (Rosac.). We may also mention those genera which contain large numbers of endemic species, e.g. *Commersonia* (Stercul.) *Geleznowia* (Rutac.), *Beyeria* (Euphorb.), *Darwinia, Verticordia*, *Thryptomene, Scholtzia, Eremaea* (Myrtac.), *Persoonia* (Proteac.), *Halgania* (Borrag.), *Calocephalus* and *Angianthus* (Compos.)

There are also many other similar groups so that we can say that the Irwin District is particularly rich in endemic species. Thus, according to my figures (which I consider only to be relative) there are 811 species currently known, of which 37% are endemic to the Irwin District. This high percentage is not apparent in any of the other Districts.

The number of different forms which one observes growing within a small area is very large. Because of this high concentration of closely related types in a small area, the number of species endemic to the Irwin District is truly remarkable. The sand shrub heaths are particularly rich in such curious forms. In the northern part of the Irwin District for example a small sandy stretch occurs which contains many endemic species. This small Eldorado was discovered by Drummond as he traversed the old track between the Bowes and Murchison rivers. The species he collected had never been collected and described before. He specifically mentions “the great sandplain to the north of the Hutt River” [Kalbarri] as the locality of interesting discoveries. These include *Acacia latipes* (Leg.), *Banksia Victoriae, B. sceptrum, B. Lindleyana, Verticordia oculata, V. stelluligera, Scholtzia uberiflora,* and *Phymatocarpus porphyrocephalus* which he was the first to see.

It is an unusual community of original auctochthonous plants situated surprisingly close to the boundaries of the District. It appears to embody the effects of the whole gamut of stimuli operating on the south-western flora. Curiously enough these species gradually disappear one after the other as one approaches the coast. At Baker’s Well the flora is no longer as rich in species and the coastal bush is pretty ordinary.

According to our present-day knowledge just over 800 species have been identified in the small Irwin District. It is still only partially investigated and no doubt many more new species remain to be discovered. Only in the two most closely studied districts (Darling and Stirling) have higher figures been recorded. The flora of the Irwin District is thus one of the richest in Western Australia. The intimate mingling of Eremaean and Southwest elements in the Irwin area is an important factor in producing the overall result. Of still greater importance may be the factors creating the conditions favouring progressive endemism. Finally also the climatic conditions must be considered. The warm winter not only favours progressive endemism but may also help to sustain the lianes (*Clematicissus* and *Aphanopetalum*) which originated from the tropical groups, and are so rare in the west.

2. The Avon District.

Character. The annual rainfall varies from about 60-25 cm. A variety of *Eucalyptus* communities with an undergrowth consisting of partly Eremaean and partly Southwestern flora, occur. Many depressed areas and gullies show salty soils. Open shrub heath vegetation is present on sandy soils and the gravelly hillsides.

Boundaries. The boundaries of the Avon district are still vague and further study is required. I am fully aware here of the very provisional nature of my outline. Considerable difficulty was experienced in finding a natural boundary between the Avon and the

Stirling districts. To the north a natural boundary is provided by *Eucalyptus redunca* while to the south-east the limit of the Jarrah forms a useful boundary. Whether the extension of the district to the north and to the coast is really natural can only be decided by further investigation.

In the more central regions of the Moore River the boundary can be mapped with greater accuracy. A line from Yatheroo towards Wannamal as far as Woorooloo running from the north-west to the south-east marks the boundary with the neighbouring Darling district.

The eastern boundary is determined by the relation between the Eremaean loam country and features of the Southwest Province. In this connection the 30 cm rainfall isohyet is critical as it marks the boundary of the area where the Eremaean component becomes dominant.

Vegetation.

In so far as the vegetation is concerned the small coastal area included in the Avon District is similar to that of the neighbouring Darling District. Further discussion therefore scarcely seems warranted here. This also holds true for the sandy shrub heath which presents much the same features as those in the Irwin District. These sandy shrub heaths occur only in the northern and eastern parts of the area. Stands of eucalypts inter-mingle with Eremaean eucalypts just as they do in the Irwin District. Along the railway from Perth to Kalgoorlie (which gives an excellent traverse of the Avon District), one may observe the progressive deterioration in the vegetation as one travels eastwards from the Avon River.

As one travels further in the arid interior, the number and extent of the salt pans increases. However, they never become as large as those in the Eremaea proper.

In the west the sandy shrub heath vegetation becomes less obvious being replaced by Eremaean-type eucalypt woodlands which reach their maximum height and development in the Avon River area. The tall-trunked *E. salmonophloia*, which was more common further to the west is now rarely seen. Mixed woodlands of *Eucalyptus loxophleba* and *Acacia acuminata* still occupy extensive areas, although now greatly reduced as this area is now developing as an agriculturally important part. This is the wheatbelt zone of the country. The wheat is grown on the lower ground while vineyards are planted on the hill slopes.

Finally, along the western boundary of the district we come to the area dominated by *Eucalyptus redunca.* Its white trunks characterize the dry woodlands of the gravelly hill country. Very little grass is present beneath it and the undergrowth consists of light sclerophyll scrub. This bush which frequently extends beyond the borders of the Wandoo as a richly mixed shrub association, covers the low rounded hills of the Moore River area. The gradual change of these communities from one into the other, can be followed very clearly as one travels from the Avon River district *via* Newcastle and Toodyay northwards to the Moore River.

One such interchange is met with on the way towards Mount Anvil. It consists of *Acacia* parkland and a White Gum woodland. The *Acacia* parkland occurs on the red loam of the lower lying areas. The associations can be recognized from a distance by the curious crowns of the two dominant species, *Acacia acuminata* and *E. loxophleba.* These resemble one another to such an extent externally as to appear to be related. Where the soil is gravelly one immediately finds *E. redunca*, associated with stiff glaucous xeromorphic types of bush such as *Hakea glabella, Daviesia incrassata, Acacia pulchella* and *Bossiaea rufa,* interspersed with everlastings composites.

On travelling still further north-west one passes completely into the western facies of this *E. redunca* woodland. *E. loxopheba* and *Acacia acuminata* are now only present in rich loamy depressions. *E. redunca* and *E. calophylla* constitute the co-dominant species, the former mostly on the gravelly hillsides and the latter on deep sandy depressions. The undergrowth is much more varied in this zone than it is further east. The following genera and species are commonly present on the forest floor; *Hakea lissocarpa, H. myrtoides, Acacia pulchella* and other *Acacia* species, *Daviesia* species and *Gompholobium* *calycinum* (Legum.), *Leschenaultia biloba* (Gooden.) (with its bright azure blue colour) and very luxuriant *Grevillea synaphaea*, *Grevillea vestita* and *Dryandra nivea* patches on the forest floor. Now and then one encounters specimens of grass-trees and *Macrozamia.* On the sides of the track winding through the dry, gravelly hills to the Moore River one finds dense stands of *Dryandra Kippistiana* or *D. polycephala.* These are most curious forms and quite foreign looking. They perhaps remind one of thistles but with much coarser growth and branching. These plants are typically present in the open scrub communities which become more and more common and extensive as the Wandoo woodlands thins out as we approach the Moore River.

Future botanists in Western Australia will no doubt find the study of these bushland communities very rewarding. It is not certain whether there are as many proteaceous species here as there are at King George Sound area or on the slopes of the Stirling Range but at least the colour and variety of flowers in the north west of the Avon District is greater than in the south. At Moore River there are at least a dozen species each of *Petrophila* and *Isopogon* with highly coloured flowering heads. *Calythrix* (with red flowers), *Acacia* (with bright yellow flowers), *Conospermum* (Proteae.) (*C. glumaceum* and *C. densiflorum*) with white and blue flowers, are all crowded together as in a garden bed. The intense azure blue of *Comesperma scoparium* (Polygal.) between the soft pink of *Guichenotia* and *Thomasia* (Stercul.) together with the varied whitish tints of *Grevillea, Hakea* and epacrid species, all combine to form symphonies in colour. The whole provides an excellent example of what can be achieved by vegetation in the mass-production of flowers. This production is probably only equalled in one other place in the world, namely the south-west of the Cape [South Africa]. Even there it is limited to a few specific areas.

Floristics.

The geographic position of the district is responsible for considerable vegetation interchange between north and south. Because of this there are few endemic genera and the number of endemic species is much smaller than it was in the Irwin District. The number of flowering plants present in the Avon District is currently estimated as being about 725. Of these about 23% are considered to be endemic to the District. This figure of 23% will no doubt however be considerably reduced in the future as botanical exploration continues.

Endemism is more marked in some genera than in others. Genera such as *Gastrolobium* (Legum.), *Boronia* (Rutac.), *Thomasia* (Sterccul.), *Conospermum, Dryandra* (Proteae.) and others which are prominent amongst the plants characteristic of the District. Because of their abundance in species they provide a high proportion of endemic types. All the above genera provide valuable examples of that progressive endemism which is such an important feature of the flora of south-western Australia. It shows its strongest development in those Districts with a steep climatic gradient. The Avon District is one of these. Its rainfall varies between 60 and 25 cm and shows division into a series of very uniformly graded and narrow zones.

3. The Darling District.

Character. Annual rainfall varies between 100-60 cm. The country is hilly and gravelly bearing woodlands of *Eucalyptus redunca* and *E. marginata.* Swampy alluvial lands together with light woodlands on sandy soil and coastal scrubs are also present.

Boundaries. The Darling District essentially includes almost all the distribution-area of *Eucalyptus marginata*, although their boundaries do not actually coincide. This species forms the extensive Jarrah forests which cover the hills of the south-western edge of the plateau.

The northern and eastern boundaries were indicated when defining the boundaries of the Avon and Stirling Districts. The whole of the Swan River system is included in the Darling District. Fine examples of *Banksia grandis* are found growing as far north as Gingin, while *Eucalyptus calophylla* associations are found growing on the northern side of the Moore River near Watheroo. In the deep south, the appearance of Karri (*Eucalyptus diversicolor)* and of *Podocarpus Drouyniana* provide sound evidence for the separation of a new District.

Vegetation.

The Darling District is crossed transversely by the rivers which run from the slope of the plateau to the sea. Their valleys provide excellent profile through the different aspects of the vegetation.

The entrance to the Swan River is dominated by dunes which rest on recent limestone foundations. Now and then the tops of the dunes are covered with drifting sand and no vegetation is present. Between the dunes however, the broad crowns of *Eucalyptus gomphocephala* may be seen. This tree dominates the entire coastal area of the District. It often forms pure stands of woodland just inland from the sandy coast and provides shade for a whole host of low shrubs and shade loving shrubs. Further inland again from the coast but still on the limestone foundation it is succeeded by a wilderness of shrubs. No trees at all are present. Among these shrubs we see *Templetonia retusa, Dryandra floribunda, Hakea trifurcata, Melaleuca Huegelii* and *Acacia pulchella* all different in the form of their leaves but similar in a certain stiffness of habit.

Inland from the zone of the littoral limestone the sandy coastal zone begins. In width this varies from 15 - 30 km and it separates the plateau from the sea. On this coastal plain one see the first examples of Jarrah trees with their broad spreading crowns. The undergrowth is richer due to the greater abundance of species of *Banksia* such as *B. Menziesii* and *B. attenuata* and because also of the occurrence here and there of species of *Casuarina, Adenanthos, Jacksonia* and *Nuytsia.* These open communities are characterized by a dull blue-green colour. At the beginning of the rainy season the undergrowth is dominated by white flowering shrubs (members of the Epacridaceae) and by the ubiquitous *Hibbertia hypericoides.* A variety of bulbous plants and herbs fill the intervening spaces. These are followed later on by a number of leguminous species bearing red and yellow flowers. At the end of the winter wet season the pale red inflorescences of *Petrophila linearis* (Proteac,) dominate the scene for a while. These are followed finally by floriferous members of the Myrtaceae such as *Calythrix, Melaleuca* and *Scholtzia.*

In places where the land falls away forming moist depressions myrtaceous bushes form the dominant undergrowth. *Melaleuca Preissiana* is the main plant present, while *Adenanthos obovata* (Prot.) and *Melaleuca lateritia* (Myrt.) with their striking red flowers are commonly present. There are considerable differences between the vegetation here and that characteristic of the extensive alluvial areas of the south coast. Thus the beautiful *Beaufortia sparsa* (Myrt.) the tall ears of *Evandra aristata* (Cyper.), the hygrophilous species of the genera *Hakea* and *Banksia,* together with a number of the smaller members of the Epacridaceae do not occur at all on the alluvail plain of the Swan River.

Further towards the east of the Swan Plain, near the foot of the plateau, clayey depressions occur. Here unusual dwarf-like specimens of these species are frequently present. A detailed account of the genera and species present is given earlier.

On the first foot-hills of the scarp and on the coarse gravel, the sclerophyll scrub which dominates the higher ground makes its appearance. It is seldom completely open and as a rule consists of scattered eucalypts forming the upper storey. It gives an impression of open parkland. In the vicinity of the Swan River one frequently comes across impressive specimens of the Red Gum, *Eucalyptus calophylla.* From a distance they look rather like large oak trees. Specimens of *E. redunca* are also present but these are neither as tall nor as stately as the Red Gum.

During the rainy season the number of flowering species in the undergrowth is so high that the ground appears completely covered over. The different species are so intermixed that it is not possible to single out any particular one.

As we ascend the scarp to the plateau the number of trees increases. The woodland form of Jarrah becomes more and more common until it becomes the dominant type. In the first months of winter the yellow flowering *Dioscorea hastifolia* may be seen clambering over the rocks. As we go higher it it disappears. Many other species which were present at lower elevations also disappear. Finally we reach the top of the plateau, an equilibrium of the vegetation is reached and the same species are present over wide areas. At least this is true in so far as the closed communities of *Eucalyptus marginata* forest are concerned. *Xantorrhoea Preissii* and *X. gracilis* are commonly present, as is *Macrozamia.* This plant grows much more luxuriantly and bears larger fruits here than on the coastal plain. The description of the community given earlier outlines the main features. The commonest species, among the many that are present, may be listed as follows:

Loxocarya pubescens (Restion.)	*Marianthus candidus* (Pittospor.)	*Hibbertia montana* (Dillen.)
Anigozanthos Manglesii (Amaryll.)	*Acacia alata* (Legum.)	*Pimelea sylvestris* & other spp. (Thymel.)
Agrostocrinum stypandroides (Lil.)	*Acacia nervosa*	*Xanthosia peltigera* (Umbellif.)
Isopogon formosus (Prot.)	*Acacia pulchella*	*Xanthosia candida* (Umbellif.)
Adenanthos barbigera (Prot.)	*Gompholobium polymorphum* (Leg.)	*Leucopogon verticillatus* (Epac.)
Persoonia longifolia (Prot.)	*Daviesia cordata* (Legum.)	*Scaevola striata* (Gooden.)
Hakea spp. (Prot.)	*Kennedya coccinea* (Legum.)	*Stylidium* spp. (Stylid.)
Grevillea spp. (Prot.)	*Boronia ovata* (Rut.)	*Olearia paucidentata* (Compos.)
Dryandra nivea & other spp. (Prot.)	*Trymalium Billardieri* (Rhamn.)	
	Tetratheca spp. (Tremandr.)	

This list, typical of the Swan River area, applies with little modification also to the more southern parts of the Darling District. It also holds good for the eastern parts of the Jarrah area. It is only when a change occurs in the dominant tree forms, e.g. on the far side of the hills, that any significant alteration occurs in the nature of the undergrowth.

In terms of area the greater part of the Darling District is covered by this uniform Jarrah forest. While it is true that *E. redunca*, (the type characteristic of the Avon District) does occur occasionally, it is never present as a pure stand or community of any size. The Jarrah forest therefore appears as a rather uniform landscape, influenced by relatively uniform climatic conditions. It shows a strong but not a very rich floristic development.

The flora of the District, however, does not lag very far behind that of the Avon and Irwin Districts. This is in part due, apart from the more extensive investigations that have taken place in these other Districts, to the great variety of habitats which exist on the plateau and coastal margin.

Floristics.

The Darling District, like that of the neighbouring Warren District, is separated from the eastern boundaries of the Southwest Province by the buffer-like Districts of Avon and Stirling. Because of this there is a considerable amount of interchange with the surrounding areas. This is reflected in the smaller number of endemics. Out of about 875 species only 22% are endemic. However, this number is mainly due to the greater number of flowering species occurring in the more northerly parts of the District, where many peculiar species have developed.

Because of the above, the floristic conditions in the Darling District show much less in the way of special adaptations or individual tendencies than do the Irwin, Avon and other bounding Districts of the Province. The Darling District has a purely southwestern flora. All the important types of the latter are present. None, however, stand out in so far as the development of any new features is concerned. Eremaean elements are numerous in the coastal communities where they are in fact typical of that area and do not appear anywhere else.

Both of these features namely the paucity in the variety of species in the south western types, and the lack of Eremaean elements, may be traced to climatic conditions. In contrast to the differences found in the more inland Districts the range of temperatures and of rainfall are of no real importance in the Darling District. The rainfall for example only ranges between 100 and 60 cm per annum.

4. The Warren District.

Character. The annual rainfall varies between 130-180 cm. Forests of *Eucalyptus marginata* and *E. diversicolor* are present. Swampy alluvium soils carry an open bush.

Boundaries. The Warren District forms the extreme south-western part of the State and is bounded on two sides by the sea. It is characterized by extensive forests of *Eucalyptus diversicolor.* In these forest areas other typical species are also present. To the north, the District ends with the phasing out of the dominant species and merges into the Darling and Stirling Districts.

Vegetation.

As compared with the Darling District, the vegetation here is more exclusively dominated by *Eucalyptus* woodlands and forests. This genus also provides the attractive scenic highlights of the area, covering as it does the lower elevations and valleys through which numerous perennially running rivers reach the sea. The flora of the coastal region is also more uniform, being chiefly confined as it is, to the very swampy or marshy open areas where Myrtaceous shrubs together with members of the Restionaceae, play the main part.

The coastal communities naturally provide little that is new in the way of species. *Eucalyptus gomphocephala* does not occur along the south coast. It is replaced by *Agonis flexuosa* (Myrt.). This species with its weeping willow-like habit, gives a quite characteristic look to the whole of the littoral vegetation.

The moist, low-lying areas which dry out only towards the end of summer are, as in the Darling District, the habitat of the large melaleucas such as *M. Preissiana* and *M. rhaphiophylla.* A new feature is introduced, however, by the frequent occurrence of *Banksia littoralis* with its grey stems and reddish-yellow cones. *Banksia grandis* is, however, rarely present in these low-lying alluvial areas. On the other hand, shrubby species of *Melaleuca, Agonis* and *Kunzea* (Myrt.) are frequently present. *Jacksonia furcellata* (Legum.) is so common in occurrence that it is quite a feature of the vegetative scene.

The best insight into the nature and characteristic features of the forests is obtained from the more northerly parts of the District. Such an area is present along the road which runs in a south-easterly direction from the Blackwood River via Lake Muir. Between Balbarrup and Deeside one passes through some fairly dense forest. The nature of the undergrowth here reflects the character of the Warren District. Very many fine specimens of *Banksia grandis* and *Xanhorrhoea Preissii* are present together with *Podocarpus Drouyniana* (Taxac.), *Persoonia longifolia* (Prot.) and *Hakea oleifolia* (Prot.). These constitute the main species and their occurrence here suggests that the climate is equable and favourable. The slender tall forms of *Banksia, Persoonia* and *Hakea* show up well in this area. *Dasypogon Hookeri,* which is endemic to the lower Blackwood River area, also shows characteristic features. In particular it differs from the more widespread *D. bromeliifolius* in its overall longer size. The plants may be up to 3 m high and bear leaves up to 90 cm long. Where weathered outcrops of rock occur, lichens such as *Sticta billardieri* and *Cladonia verticillata,* together with various mosses, grow on the exposed southern face of the rocks.

Not far from Lake Muir, the first traces of south eastern elements appear, eg. *Johnsonia lupulina* (Lil.) and *Xanthosia tenuior* (Umbellif.). It becomes increasingly apparent to the observer that he is standing where three floristic Districts meet, namely the Darling, Warren and Stirling.

Apart from the above occurrences there is not much variation in the floristics of these widespread forests. If a visiting botanist were to get his first impressions of the floristics of Western Australia from this area he could well ask in surprise where the vaunted extraordinary richness and variation of the flora of the country did in fact occur.

However, provided one is acquainted with other florstic Districts of the country, the observer still remains impressed by the ecological characters of this District. This is expressed in particular by features such as the elongation of the internodes and the presence of soft mesophytic foliage in so many species. Few plants in this moist District show the xeromorphic features which are so common elsewhere.

Floristics.

The fact that the Warren District is so closely ringed about by other Districts means that there is little individuality in species content. Most of its species are also present in the Darling District. At the same time, however, it should be noted that many of the groups which are usually rich in species in the Southwest Province are poorly represented. There are however a few exceptions to this. In the genera *Boronia* (Rut.) and *Pimelea* (Thymel.) for instance the number of species is greater than elsewhere, due to the strong development in this favorable environment of hygrophytic or at least very mesophytic species.

The Warren District is as yet, however, insufficiently explored and this appears to be the main reason why its flora is quantitatively well below that of the other Districts. So far, only about 550 species have been recorded. But perhaps we should not expect too much from closer investigation since it is well known that from the species point of view, the Warren District is one of the poorest in the Southwest Province. It supports the general view that when temperature is equable and associated with a high rainfall the degree of diversity in temperature floras is significantly reduced.

The same principle applies in an even more pronounced fashion insofar as endemism is concerned. Like the Darling District, the Warren District, being surrounded by other areas is badly situated for the development of progressive endemism. The climate is also unfavourable and as a consequence the Warren District has by far the smallest number of endemics (6%). Among the endemics that are present, however, there are some that are indeed remarkable. Perhaps the most well-known is *Eucalyptus ficifolia.* This is related to *E. calophylla,* but is distinguished from it by the bright red colour of its stamens and its more slender fruit. The habit of this beautiful species is very restricted being confined to a small and relatively inaccessible area between Irwin Inlet and the Shannon River. It occurs on the gentle slopes of hills and on sandy humus-deficient soils near the coast. On the northern hill slopes this eucalypt develops only to shrub size, while on the southern slopes facing the sea it grows to tree-like stature. I have been told that it blooms approximately only every fourth year, but when it does, it is as if the hillsides were covered with red fire.

5. The Stirling District

Character. Annual rainfall 80-30 cm. Woodlands consisting of *Eucalyptus redunca* and *E. occidentalis* are present together with associations of various other species of eucalyptus and shrub-heaths on sandy soils. In depressions and low-lying areas the soil tends to be salty.

Boundaries. On the west and south sides, the Stirling District is bounded by Jarrah and Karri forest. At the south-eastern extremity, however, there is such an intermingling of floral elements, that it is very difficult to determine with any certainty where the boundary with the well known flora of King George Sound region really lies. There are so many more species from the eastern part of this area that I had someimes been inclined to incorporate this area into the Stirling District. However, the decision to make its southern boundary at the Stirling Range was finally decided by the marked enrichment of the King George Sound region by elements from the Warren District.

The northern and eastern boundaries also proved difficult to define and are still somewhat unsatisfactory. This is because our knowledge of the flora of the areas which are crossed by the Stirling boundaries is still inadequate.

Vegetation. The Stirling District crosses many rainfall isohyets and this is responsible for the considerable diversity shown in the flora. This diversity is further enhanced by geomorphic conditions. The Stirling District is the only one of those in extra-tropical Western Australia which possesses mountains worthy of the name. These run approximately from east to west and consequently are at right angles to any moist southern sea breezes. There are two parallel ranges, the Perongerup [Porongurup] Range and the Stirling Range. The former is closer to the coast, the sea being only 35 km away. Although the Perongerup Range is not very high, nevertheless it has a markedly favorable influence on the local climate near the coast. The climatic variations in the neighbourhood of the Stirling Range, with its greater height (over 1,000 m in parts) are still more marked. There are very considerable differences between their lee and windward slopes, even though, on the average, they are further away (about 80 to 50 km) from the coast. The effect on climate would, of course, be much greater were it not for the fact that the range is broken up into isolated massifs separated by low valleys. The overall effect of this is thus to modify the climate to only a relatively slight extent. Only fairly well-marked contrasts are obvious.

In the flatter plateau country forming the north-west part of the Stirling District, open woodlands of *Eucalyptus redunca* are present. There is considerable similarity to the Avon District which would be most striking were it not for the frequent occurrence (but in different types of associations) of the unusual Flat-topped Yate (*Eucalyptus occidentalis*). The *Eucalyptus redunca* also continues to be present as the dominant tree to about Tenterden. By the time we reach Kendinup however, the Jarrah has already become the dominant tree. This is despite the fact that several Stirling District plants such as *E. tetragona* and *Leschenaultia formosa* are still common.

The types of vegetation characteristic of the more southern and richer areas of the Stirling District become particularly obvious when we travel in a north-easterly direction from King George Sound towards the inland town of Norseman. Continuing along the road from Albany we pass through vegetation types which appear to be adapted for growth on granitic soils. *Agonis marginata* bushes may be seen occurring between rocky outcrops. Communities of the small *Eucalyptus cornuta* with its peculiar velvety mossy covering of *Campylopus bicolor,* may also be seen. The presence of these two species usually means that the large-flowered *Anthocercis viscosa* (Scrophul.) will be found growing in the vicinity. The shrub-covered slopes of the hills carry a mixed woody community of which the chief members are *Banksia grandis,* tall growing species of *Persoonia* and large leaved *Hakea* species. In other parts the Jarrah is the dominant tree and provides adequate shade for the strongly developed undergrowth. Here amongst other plants we may see the sweet-scented *Acacia myrtifolia, Logania vaginalis,* several delicate members of the Restionaceae and other low-growing, soft-leaved plants growing closely together.

Behind the hill-like dunes of the southern coast lies a swampy plain. This is covered with a dense bright-green alluvial vegetation which from a distance looks rather like a meadow. Members of the Myrtaceae such as *Agonis, Leptospermum, Beaufortia sparsa* (Myrt.) and many others from this family, together with *Hakea linearis* (Prot.) and a whole host of epacridaceous species are the main types present. In rather more flat and barren areas stiff upright restionaceous plants stand out. Here and there, permanent deep fresh-water lakes together with shallow stretches of water occur.

As we travel further inland the trees, such as *Eucalyptus marginata* and *Casuarina Fraseriana,* which grow closer together on poor sandy soils, tend also to become taller. The undergrowth shows marked xeromorphy and is not demonstrably richer in species. *Jacksonia horrida* and *J. spinosa* (Legum.) are the only species present which give character to the vegetation. As soon as the brown gravelly "ironstone" is reached however, there is a dramatic change. A great increase in the diversity of shrubs becomes evident. This is particularly evident in the family Proteaceae, and the following genera and species can often be collected growing in close proximity.

Petrophila longifolia
Petrophila divaricata
Petrophila squamata
Isopogon formosus
Conospermum flexuosum
Conospermum petiolare
Adenanthos procumbens
Dryandra Baxteri
Dryandra cuneata
Banksia Brownii

Members of the Proteaceae are in fact the pride of the flora of the King George Sound area. Even where *Eucalyptus marginata* and *E. calophylla* grow very densely together the undergrowth still shows many unusual species.

These plants provide beautiful scenic effects along the shallow channels which drain off the water during the rainy season. In such situations we commonly find the large-leaved shrubs of *Trymalium Billardieri*, *Acacia nigricans* (with its delicate pinnate leaflets) and a great mass of *Pteridium aquilinum.*

As one approaches the Perongerups, the vegetation shows a great increase in the number and vigour of the species. In the forests, giant trees of *Eucalyptus marginata* and *Eucalyptus calophylla* occur while lush growths of *Pteridium* and *Adiantum aethiopicum* intermingle on the damp forest floor. *Leucopogon verticillatus* is seen growing at its best. There is unfortunately no road crossing the Perongerups from east to but according to notes by F. von Müller imposing communities of Karri trees (*Eucalyptus diversicolor*) flourish in fertile valleys on the moist southern side.

As we travel north-east from the Perongerup Range the character of the vegetation shows little or no change for the first 5 km or so. Further north, however, the first low-growing eucalypt (*E. decurva)* appears although its occurrence is rather sparse amongst the tall *Eucalyptus marginata* and *E. calophylla*. The undergrowth here consists of species, such as *Verticordia habrantha* (Myrt.), which we have not seen before. Soon specimens of *Eucalyptus tetragona* begin to be visible. These, because of their pale green leaves, present rather an odd appearance.

The forest rapidly becomes more open and the low-growing eucalypts become more dominant forming small thickets here and there. In the communities of small bushes (which we must already consider to be sand heath vegetation) many new species are present. Among these we may note the yellow flowering *Verticordia helichrysantha* (Myrt.) and the bluish-red blossoms of *Melaleuca exarata.* The curious-looking *Goodenia phylicoides* which also occurs, is more reminiscent of certain Mediterranean-type labiates rather than of its Western Australian relatives.

The Kalgan River flows through this sand heath where pockets of almost pure sand are interspersed with small areas of loamy soil. In the river valley some excellent specimens of *Eucalyptus redunca* (which incidentally is at almost the southernmost limit of its range here) are present.

Once the Kalgan River is crossed we become increasingly conscious of the Stirling Range which rises abruptly from the plain. At first the vegetation growing on the gravelly sands shows little change but as soon as the road actually enters the range and rises gradually to the top of the pass, we see, under the influence of the higher rainfall, a return to the picture presented further south.

The pass appears as a peculiar deep depression between the mountain peaks which rise to elevations of about 1000 m. The flora is strikingly reminiscent of that of the south coast. Very tall and often stately specimens of *Eucalyptus marginata* and *Eucalyptus calophylla* constitute the main features of the scenery. The south coastal character of the vegetation referred to above is indicated by the presence of such species as *Banksia grandis, B. attenuata* (Prot.), *Xantorrhoea Preissii* (Lil.), *Daviesia flexuosa* (Leg.), *Adenanthos obovatus* (Prot.), *Stirlingia latifolia* (Prot.) and *Xanthosia rotundifolia* (Umbell.) together with the very delicate *Caladenia serrata* (Orchid.). The frequent occurrence also of *Pteridium* is a further indicator of the milder summer climate here.

The pass also provides an excellent opportunity to observe how the peculiar chain of the Stirling Range reacts to the meteorological conditions. The condensation of aerial moisture on the peaks provides a most striking factor. Often when it is quite clear below, misty cloud covers the upper regions until about midday. This phenomenon occurs not only in the rainy season and in transitional periods but also during the summer months. Thus at these upper elevations the coastal type climate is repeated and its effect even enhanced.

The influence of the weather on vegetation also becomes quickly apparent when one commences to climb the mountain. A sub-xeromorphic type of vegetation dominates the lower slopes which reminds us once again of the Kalgan area. The more or less uniform scenery of the shrub-heaths is, however, enlivened here by the presence of taller elements such as low-growing Jarrah trees and tall shrubs such as *Hakea Baxteri, H. cucullata* and *Lambertia ericifolia.* All three of these exert an unusual physiognomic effect due to their upright habit of growth.

On most of the steep hillsides the rough stoney soil is covered with thick scrub. Many of the species present, e.g. *Darwinia Hookeriana* (Myrtac.), *Agonis floribunda*

(Myrtac.), *Andersonia patricia* (Epacrid.), *Adenanthos filifolius* (Proteac.) and *Isopogon Baxteri* (Proteac.) are endemic to this mountain range.

As one approaches the 750 m contour and nears the mist-covered region the bushes (which are now rarely more than 2 m high) become much more crowded. The species tend to be identical with, or at least closely related to those found on the coast near King George Sound. Therefore as well as a climatic convergence, there is a very close floristic analogy. The following is a list of species which I collected on Mount Tulbrunup [Toolbrunup]:

Banksia Brownii (Prot.)	*Dryandra formosa* (Prot.)	*Beautortia decussata* (Myrt.)
Banksia coccinea	*Dryandra mucronulata*	*Kunzea recurva* (Myrt.)
Banksia grandis	*Hakea florida* (Prot.)	
Banksia Solandri	*Isopogon latifolius* (Prot.)	

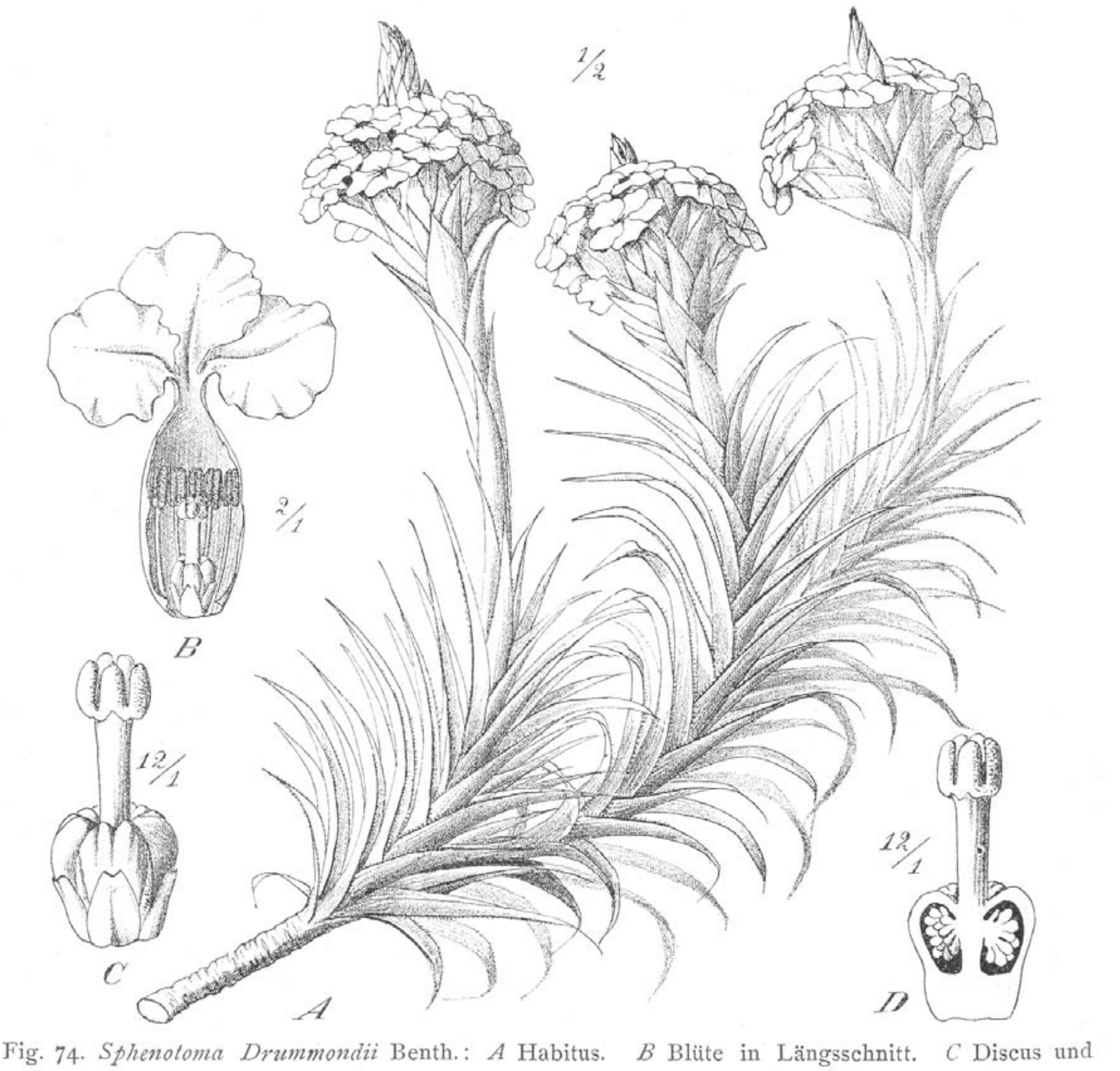


Fig. 74. *Sphenotoma Drummondii* Benth.: *A* Habitus. *B* Blüte in Längsschnitt. *C* Discus und Gynaeceum. *D* Gynaeceum in Längsschnitt. (Nach DIELS und PRITZEL).

This collection, both in general and in detail, resembles that of the flora of the King George Sound area. The bush here provides a mass of coloured flowers at the end of the rainy season.

Both close to and at the tops of the peaks there are massive, rocky breastworks. In niches between the rocks beautiful endemic species such as *Oxylobium retusum* (Legum.) and *Hypocalymma myrtifolium* (Myrt.) occur. In their respective genera they are distinguished by their large leaves and showy inflorescences. Scattered amongst them we find *Leucopogon unilateralis* (Epacrid.) which with their decorative white crowns, are as pretty as our *Erica.* In openings between the rocks on the exposed summits *Leucopogon gnaphalioides* (Epacrid.) and *Monotoca tamariscina* (Epacrid.) are present. In more sheltered areas the steep walls are covered by the tall *Sphenotoma Drummondii* (Epacrid., Fig. 74). This is similar in appearance to certain species of saxifrage. It is one of the very few true rock plants which has been produced by the flora of south west Australia

The flora at the actual summit of the Stirling Range (1,000 m) does not show any marked difference from that found lower down the mountain. Essentially the same genera and species are present here as on the plain below. With regard to endemic species, I found nothing to indicate that their characteristics were conditioned by the environment at these altitudes. Neither could I find any typical species showing variation in form. Even *Sphenotoma Drummondii,* whose growth-form appears to be most indicative of high elevations, was also found growing without any change in habit or form, near isolated rocks at the foot of the range. In south- western Australia therefore, no alpine flora has developed. Likewise no true mountain flora has been produced.

Looking north and east from the summits of the Stirling Range we see a panorama which is quite a contrast to the woodland scenery observed towards the south coast. The differences are already apparent even in the immediate foreground on the northern slopes. Instead of the brightly-coloured mixed vegetation dominated by numerous genera of the Proteaceae, we see a rather uniform community dominated by *Eucalyptus Preissiana.* The dull blue-green of its foliage sets the colour tone for the northern slopes. In places the rocky outcrops are completely bare or at best only very sparsely covered by xeromorphic perennials such as *Dampiera eriocephala* (Gooden.). It is only in the small gorges of the mountains that the presence of dark-green stripes indicates that there the shrub vegetation is thicker and more crowded.

Looking north from the foot of the range, trees are still present where moisture is still adequate. One can also see that the dark-appearing mass of vegetation with its black-green canopy consists of almost pure stands of *Eucalyptus occidentalis.* These dark-appearing strands of vegetation look just like blood vessels spreading as it were, through the country. Elsewhere they appear as islands of dark vegetation. Clear to the far horizon the basic colour remains that of the grey-green of the arid sandplains with their shrub heath vegetation.

The track north-east from the Stirling Range winds through this landscape which alternates between copses of *Eucalyptus occidentalis* and shrub heath. One frequently finds *Casuarina glauca* and *Acacia acuminata* associated with the stands of *Eucalyptus occidentalis.* Apart from these species, woody undergrowth is rather scanty at such places. Grasses are abundant on these loam soils and many annuals and perennials are also present. Everlastings, for instance, are particularly prominent during the favourable period of the year.

Edaphic variation is responsible for marked changes in the nature and appearance of the shrub heaths. Noteworthy among the multitude of small shrubs present are epacrids, *Verticordia, Baeckea* species and *Conospermum* (Prot.). The upper storey consists of shrubby eucalypts, e.g. *Eucalyptus tetragona* and *E. decurva* or the slender bushes of *Lambertia inermis* (Prot.).

Floristics:

The Stirling District is distinguished floristically by the large number of species present and by its high degree of endemism.

Some genera which show marked conservative endemism e.g. *Baxteria, Cephalotus* and perhaps *Actinodium* (Myrt.) may be shared also with the adjacent Eyre District. At the present time the Stirling District contains 393 endemic species which is one of the highest numbers in all the Districts. This relative figure (32%) is equaled only by the Eyre District so far, and only surpassed by the Irwin District.

The number of species found in the Stirling District is suprisingly large. It is somewhere about 1250. This figure is too large to be the result more througher investigation, although it is true that the Darling and Stirling Districts are the best known botanically of any of the Western Australian regions. Rather on closer examination the high number comes from the polymorphism of certain floral groups.

It is the typical Western Australian genera which stand out in this respect, e.g. *Brachysema, Oxylobium, Chorizema* and *Latrobea* of the Leguminosae; *Darwinia, Agonis* and *Kunzea* of the Myrtaceae and *Petrophila, Isopogon, Hakea, Dryandra,* and in particular, *Banksia,* amongst the Proteaceae. *Banksia* shows a most extraordinary development in the King George Sound area and its species provide the characteristic plants of that locality. The genus *Stylidium,* together with members of the Epacridaceae, are also most important here. The Stirling District has in fact provides, for members of the Epacridaceae, the most favourable habitat in the whole country. Thus according to my tables the number of species of epacrids in the different Districts are as follows:-

Irwin 17	Darling 37	Stirling 81
Avon 23	Warren 16	Eyre 54

The epacrids, like many other species which are characteristic plants of the Stirling District, appear to be favoured by the climatic pattern which is due to the proximity of the south coast - one of the effects of which is the shortening of the really dry period of the year. This, to some extent, would explain the high numbers of species found here as against the lower number found in the other Districts.

Another favourable factor, which is also evident in the case of the Irwin and Avon Districts, is the great variation in the volume of rainfall which is received in different parts of the District. This varies from 80 to 30 cm.

Finally the physiography of the country, with its mountains, hills and plains, plays a larger part in providing a wide variety of conditions and habitats for plant development than in any of the other south-western Districts.

6. The Eyre District.

Character. Annual rainfall 60-30 cm. This shows many similarities with the Avon District but differs in the taxonomic character of its components.

Boundaries. The Eyre District extends eastwards along the south coast from the Pallinup River. It includes the area where the rainfall exceeds 30 cm. It is thus a long narrow area stretching from west to east and gradually becoming narrower. The western boundary is somewhat vague, while the eastern one is situated just on the far side of Israelite Bay. The approximate position of the northern boundary was determined by observations made at Phillips River and north of Esperance. It more of less coincides with the rainfall isohyets of 30-25 cm.

Vegetation. In the western part of the District there is, as in the Avon District, an edaphically conditioned duality in the vegetation. In the Eyre, the granite country has an Eremaean type vegetation, with tall-stemmed woody growths in the wide valleys, low lying areas and creeks, occuring where loamy soil is present. On the other hand on the low sandy hills the south-western shrub heath predominates. This is more obvious in areas where the vegetation is sparse and depauperate. In other places where a certain amount of clay is present the vegetation is denser and shows a particular composition. This is due to the frequent occurrence of certain genera, e.g. *Lysiosepalum* (Stercul.), *Gastrolobium* (Legum.), *Acacia* spp., *Melaleuca, Thryptomene australis* (Myrt.), and *Pseudanthus virgatus* (Euphorb.).

This kind of pattern becomes clear as one travels along the road from the Stirling Range to the Phillips River. East of the Pallinup River on the sandy shrub heaths, species of *Eucalyptus,* met earlier in the Stirling District, and of which *Eucalyptus tetragona* is the most striking, occur. Two of the most beautiful genera of the Myrtaceae, are represented by *Verticordia habrantha* and *Calythrix brachyphylla* are also present on this sandy soil. In comparison with the Irwin or even the Avon District, there is no mistaking how much more frequent their occurrence is in the Eyre District than it is in the south-east parts of the State. It is also interesting to observe how many rigid and more or less unapproachable members of the family Proteaceae one meets. Examples include *Hakea* *corymbosa, Grevillea concinna,* and *Banksia Caleyi.* The markedly xeromorphic *Daviesia pachyphylla* (Legum.) is also present.

The rocky gravelly stream beds of Jacup Creek lead into a vegetation which is completely Eremaean in character. While it is true that *Eucalyptus occidentalis* still remains the dominant tree and that granite exposures are still overgrown by the lichen *Parmelia conspersa,* nevertheless the undergrowth is very different. The understorey contains *Eucalyptus spathulata,* and *E. calycogona* as well as *Acacia ixiophylla, Eremophila Phillipsii* (Myopor.), *Beyeria Drummondii* (Euphorb.) and *Dodonaea ptarmicifolia* (Sapind.). Further inland, in the vicinity of the West River, another facies which includes *Dodonaea pinifolia* (Sapind.), *Fusanus spicatus* (Santal.) and *Myoporum acuminatum* (Myopor.), appears on the scene and the effect is even more convincing. The gently undulating sandplains, however, extend in between. They are of great interest to the botanist because of the constant change in species, which appear and disappear with great regularity without any change in the uniformity of the landscape.

After passing to the east of Jacup Creek, rather unexpectedly, one comes across *Nuytsia floribunda* (Loranth.) on the higher slopes of the hills. *Adenanthos cuneata* (Proteac.) also occurs frequently. The curious legume, *Daviesia reversifolia,* becomes rarer and rarer and finally disappears altogether. This sand flora accompanies the road eastwards to near the Phillips River and presents a picture of a mixture of characteristic species which occur and re-occur over wide stretches of country. They include plants such as *Gastrolobium spinosum* and *G. spathulatum* (Legum.), the thick-leaved *Boronia crassifolia* (Rutac.), the tall *Anigozanthos rufa* (Amaryll.), the delicate *Oligarrhena* (Epacrid.) and the stiff, blue-grey *Eucalyptus tetragona.*

In the eastern part of the Eyre District the road north from Esperance to Norseman runs at right angles to the long axis of the District. At the coast there is a zone about 6 km wide where the vegetation is quite luxuriant. Limestone and granite occur in close proximity and often interchange. The granite hills resemble those of the King George Sound area, with *Agonis flexuosa* (Myrt.) and *Anthocercis viscosa* (Scroph.) commonly present. Other characteristic species such as *Xerotes collina* (Lil.) also commonly occur. Further north again, we pass into the region of the sandplains. In between, in low-lying regions, we see shallow lakes. The water they contain is either fresh or slightly brackish. Where the soil is swampy, *Melaleuca Preissiana* is present, together with other well known members of the King George Sound flora. *Banksia occidentalis* flourishes along the margins of swampy or moist depressions. The shrubby sand-heath shows many species, e.g. *Xantorrhoea Preissii* and *Macrozamia Dyeriana.* Further north again the grass-trees gradually disappear and at about 25 km from the coast *Macrozamia* also cut out. The water in the lakes and ponds now also tends to become more salty. While the sand flora still shows some south-western features as far as 45 km inland from the coast, plants such as *Nuytsia floribunda* now appear only rarely. *Lambertia inermis* is present in large clumps which reach a greater height than do those at the foot of the Stirling Range, and in fact often reach tree-like stature. *Eucalyptus tetragona* is another which is frequently present. At about 40 km or so from the coast, the sand flora, although essentially unaltered in character, begins to show some peculiar and markedly endemic forms. These include *Isopogon alcicornis, Banksia petiolaris, B. media, B. speciosa, Hakea adnata* (Prot.) and *Eucalyptus tetraptera.* The appearance of all these interesting species in this restricted zone shows a striking parallel with the Irwin District where under similar conditions an analogous phenomenon was observed.

Having passed through this floristically rich and interesting zone one observes that the vegetation rapidly becomes more uniform. While *Eucalyptus tetragona* is still sporadically present, many other southern plants are now missing. The greater variety of plants hitherto present is now reduced to the monotonous uniformity of a mixed community of *Eucalyptus* species. We pass through some other patches of more or less bare sand bearing some xeromorphic plants and then the soil tends to become a firmer mixed loam type again. Finally about 60-70 km in from the coast the boundary of the Eremaea is reached. Imposing specimens of *Eucalyptus salmonophloia* appear and one enters upon the eucalypt woodlands of the Coolgardie District.

Floristics. Knowledge of the flora of the Eyre District is still inadequate. So far as we can judge at present it has, as might be expected, a close relationship with that of the Stirling District. About 760 species have so far been identified, of which approximately 33% are endemic. This is a similar percentage to that recorded for the Stirling District. These endemics also largely belong to the same families as those which have produced new species here as in the Stirling District. The genera *Daviesia* (Legum.), *Melaleuca* (Myrtac.) and the genera of the family Epacridaceae (which reaches its highest development in this District) have more or less equivalent numbers of species to those of the Stirling District. The previous table lists 54 species in this family for the Eyre District. Besides this, to mention only important features, many specialized forms of the family Sterculiaceae, e.g. *Lasiopetalum,* certain groups of *Baeckea* (Myrt.), the genera *Logania* (Logan.) and *Microcorys* (Lab.) have set their distinctive mark on the taxonomy of the Eyre District.

On the other hand a whole series of negative features is present. Many genera and species which are very common in the Stirling District show considerable reduction here. Examples include *Drosera* and *Dryandra* (Proteac.). For the Stirling and the Eyre Districts the number of *Dryandra* species drops from 20 : 6.

b. The Eremaean Province

7. The Coolgardie District.

Character. Annual rainfall 30-15 cm. Very light woodland on loamy type soil bearing a variety *Eucalyptus* communities. The soil in low-lying areas is salty. On sandy soils, xeromorphic shrub heaths are present.

Boundaries. The boundary of the Coolgardie District, which borders on the Southwest Province i.e. to the west and south, follows roughly the 30 cm isohyet. Inside this line, the communities of eremaean type flora, exceed those of the communities growing on sand. These latter communities tend to show south-western affinities. The northern boundary may also be fixed geographically as was pointed out by Spencer Le Moore (Journ. Linn. Soc. XXXIV 173). He noted that as soon as one crossed the area of salt pans near Goongarrie the vegetation changed completely marking the northern boundary of the Coolgardie District. He expresses his views as follows : “Since Goongarrie lies so close to the parallel of 30° S. Lat. and since the change in the vegetation is so marked there, I have taken this parallel as the boundary between the two floras.” Spencer Moore also considered that the rarity of *Eucalyptus*, in the region beyond Gooongarrie, as compared with their much more frequent occurrence to the south, was the most outstanding difference between the Coolgardie and Austin Districts. While this is of course, quite an important point he also pointed out that a great percentage of the plants which he found south of 30° were either specifically or generically, but mostly specifically, different from those which occurred further north. Spencer Le Moore also provided a list of species which were endemic in each of the two botanical Districts (p. 241-242). He regarded this as further evidence that the floras of the two Districts were distinct. On balance, although the evidence is somewhat sketchy and perhaps not quite correct now, as it appeared to be then, his assessment is essentially sound.

With regard to the question as to whether the northern boundary of the Coolgardie District runs strictly west-east, north-west or nor-nor-west, Le Moore found himself in something of a quandary (p. 173 *loc.cit.*). However he finally adopted the view that it tended to bear north in the western part of the District. I disagree with this, firstly on empirical grounds. In the Irwin District the 30° parallel practically defines the northern limit of distribution of the taller *Eucalyptus* species, while the Geraldton - Cue railway line which runs more or less parallel to 28.5° S., does not pass through any *Eucalyptus* landscapes. These observations lend support to the view that the boundary between the two Eremaean Districts is represented by the 30° S.

On theoretical grounds also, there appears to be little support for Spencer Le Moore’ s belief that the boundary curves slightly to the north in the western part of the

District. His view is essentially based on the assumption that it would be similar to the boundary of the Southwest Province. This assumption, is however incorrect, as the effect of the winter rains on the interior does not run parallel with their influence in the coastal region. As the isohyets show, it is the rains from the south coast, which almost exclusively determine the winter rains in the Eremaea. Because of this we must conclude that the boundary between the Coolgardie and Austin Districts runs almost exactly west to east.

Vegetation.

The vegetation of the Coolgardie District depends largely on the southern winter rains which in the District are, however, quite low and very unreliable. In many respects the physiognomy of the vegetation resembles that of the Avon District. An interwoven mosaic of shrub heath and *Eucalyptus* woodlands is commonly present. The reddish soil which dominates the Coolgardie area is the habitat of the *Eucalyptus* species. As a consequence the true shrub heath only occupies a much smaller area.

The *Eucalyptus* communities which dominate the firm red soil have been described earlier. Often 5 - 6 species of this genus are present together with species of *Acacia* and *Melaleuca*, all of these appear very similar, almost as if they were closely related species. Excellent examples of these communities may be seen in the vicinity of Southern Cross. *Eucalyptus salubris* and *E. celastroides* are the dominant tree species, while in the shrubby undergrowth *Fusanus acuminatum* (Santal.), *Hakea Preissii* (Prot.), *Acacia, Eremophila* and members of the Myrtaceae are most strongly represented. Towards the east the red soil is increasingly interspersed with widespread sandplains which spread as far as the eye can see. In the spring these are covered with masses of brightly coloured wildflowers. Examples of such sandplains, with their large numbers of different species, may be seen close to Bronti, east of Koorarawalyee and even near Boorabbin. The high number of species indicates that a prominent feature of the Southwest Province has infiltrated deep into the Eremaea. Various members of Proteaceae together with *Verticordia* (Myrt.), *Stylidium, Hibbertia* (Dillen.), *Tetratheca* (Tremand.), and many other similar genera are present. They all show a great variety of xeromorphic modifications. The unusual Myrtaceous genus *Balaustion*, is floristically characteristic of these barren Eremaean heaths. It is in fact only a small, very drought-resistant species, a residuum from the plenitude of the south-west, which is still able to survive here. Most can not survive the arid conditions. The capriciousness of the climate and the unreliability of the rainfall exacerbate the conditions. In 1900, rainfall well above the average was experienced and as a consequence the sand heaths of the central Coolgardie District bloomed profusely. This effect is generally restricted to areas much further to the west. In 1901, when, on the other hand, very little winter rain occurred, the flowering of the shrub -heath was only half what it was in the preceding year. Many buds failed to develop, drying off on the twigs.

In the *Eucalyptus* woodlands the same climatic instability with all its consequences, was met in the shrubby undergrowth and in the ephemeral herbs which brighten up the area in spring. As a consequence it is exceedingly difficult to provide a general description of the vegetation which applies to the whole of the Eremaea.

Near the bustling gold towns of Kalgoorlie and Coolgardie the vegetation picture is greatly modified by the practice of cutting timber for use in the mines. Once beyond these areas, on the strongly loamy or stony ground, uniform *Eucalyptus* communities dominate the scene. This in many places also carries large numbers of white, or silvery saltbush (*Chenopodium, Atriplex Drummondii* and many others. Where the ground becomes more sandy, species of *Casuarina* make their appearance as do also many species of *Acacia* and many other shrub-like species. They all show the same peculiar drab grey-green colour. The vegetation scene in fact reminds one of the “scrub” vegetation as described in South Australia. Although this latter area is hundreds of kilometers distant, nevertheless the fundamental nature of the vegetation remains the same. The shrub desert, with all its frustrations of lack of tracks, lack of rain and its more or less impenetrable dense growths, stretches away into the distance. It was this type of plant community which, for so long, inspired feelings of horror and despair in the minds of the pioneers of Australian exploration.

Floristics. The regions of the Western Australian Eremaea cannot, as yet, be properly compared with those of the –south west because their exploration and documentation is so incomplete. The number of species which I have collected in the Coolgardie District i.e. about 500, can only serve as a rough guide. It is for instance, considerably less than the number collected for the Warren District in the deep south-west of the State. I feel sure, however, that in due course the Coolgardie District will turn out to be as rich in species as the Warren. On the other hand I believe that it will never match the number of species which are present in the inner Districts of the Southwest. Province.

The following genera may be mentioned as being among those characteristic of the Coolgardie District : *Eucalyptus* (many species) , *Lachnostachydinae* (Verben.), and *Eremophila* (Myopor.). Among the Compositae the genera *Helipterum* and *Helichrysum* are prominent. In addition to the above a conspicuous Eremaean floristic feature is the strong development of the families Malvaceae and Chenopodiaceae. Their development however, is not as impressive as it is in the more northerly Austin District. These features however, appear to be less important than the reduction of the number of typically south west families, genera and species such as the Podalyrieae, Proteaceae, *Hibbertia, Pimelea* and many others. The family Myrtaceae appears to be the only one which has retained some degree of plasticity in this environment. The genus *Micromyrtus* for instance has developed a whole series of endemic species. The unusual genus *Balaustion* is also endemic in this District

8. The Austin District

Character. The annual rainfall varies from 25-15 cm. A number of different shrub formations are present on loamy type soils. Species of the genus *Acacia* play a prominent role. Soils in the barren low-lying areas are usually salty. Relatively little is known about this District.

Boundary. The boundaries were discussed earlier when dealing with those of the Irwin and Coolgardie Districts.

Vegetation.

From what little we know of the character of the vegetation of this District it appears to be the most uniform of all the regions of extra-tropical Western Australia. The large *Eucalyptus* communities are absent while the shrub-heaths are present only to a very limited extent. I know of only one example from the Menzies near the southern border of the District. Here I recorded the presence of *Callitris robusta* (Pinac.), several species of *Eremophila*, *Codonocarpus cotinifolius* (Phytolacc.), and the grass *Triraphis rigidissima.* These indicate affinities with the true shrub heath which is present near Coolgardie. The presence on the other hand of *Stackhousia megaloptera* (Stackhous.), *Cryptandra parvifolia* (Rhamn.), *Casuarina humilis* (Casuar.), and *Grevillea didymobotrya* (Prot.), all elements which clearly belong to the south-west, is interesting.

The hard reddish soil of the Austin District is essentially dominated by Mulga scrub. eucalypts are few and far between, species of *Acacia* are universally dominant, while eremophilas with their beautiful flowers, are fairly common and add variety to the physiognomy of the scene. The undergrowth varies being determined largely by the favourableness of the season. For the rest may I refer to the description summarizing our limited knowledge of this little known area given earlier (beginning of Part 4). To the north the District passes into the area of summer rainfall. To what extent the vegetation is influenced and to what extent it takes on the character of tropical Australia is as yet unknown.

Floristics. In agreement with the lack of variety in the vegetation of the Austin District, the number of species is also markedly fewer than in other areas. The current number is about 300 but no doubt this will be increased by further collecting. However it is most unlikely that it will alter to such a degree as to alter the basic relation with other Districts.

The endemic species reach 26% of the total. There are many indications that this figure will not appreciably alter, in any case it will not increase. There are no barriers which prevent communication with the northern and eastern neighouring provinces so that the exchange of floral elements can occur without hindrance. On the other hand there are no special climatic or edaphic peculiarities present in the Austin District. One cannot see, therefore, any factor which would provide a stimulus for the development of new species. Consequently I am inclined to believe that the relative number of endemic species in the Austin District, will on further investigation be diminished rather than increased.

The floristic position of the Austin District in the Eremaea is indicated by its geographical position, and is further strengthened by the northern influences. We may note that members of the family Malvaceae tend to become more numerous while in this more or less treeless area, *Sterculia Gregorii* (Stercul.) plays a greater part. Species of the genera *Swainsona* and *Cassia* (Legum.) (particularly the latter) with their beautiful flowers, are commonly met with, while *Loranthus* is more common and two species of *Canthium* (Rub.) occur. *Marsdenia Leichardtiana* is also a species which grows more abundantly here. All of those mentioned are northern species which are invading the flora.

Among the true Eremaean elements, members of the family Chenopodiaceae (*Kochia, Bassia*), show excellent development and diversity as does also the genus *Trichinium* of the Amaranthaceae. The species of *Eremophila* also form an impressive element in the flora of the District. Most of them are of quite a different nature from those of the Coolgardie District. Thus the shrubs show less branching but a much greater growth in width. A more strongly developed hairy covering is present over the whole shoot and the inflorescences are mostly not as rich in flowers. To compensate for this, however, the individual flowers are much larger and their colours usually brighter. Even the calyx which occurs now and then in the family in corolla-like form takes part in this tendency. In *Eremophila Fraseri* the calyx, with its gorgeous red colour appears to have become the most essential part of the perianth.

CHAPTER 2 ELEMENTS OF THE FLORA OF WESTERN AUSTRALIA

I. Southwest Province

a. Pan-Australian Elements

Pan-Australian elements of the Southwest Province are here defined as those species which commonly occur in at least the extra-tropical area of Australia. Because of the range of climatic variation over this wide area the number found in the Southwest Province is relatively small.

They fall into three categories of very different rank.

1. Pan-Australian species. These are members of the lowest rank which are distributed over almost the whole of Australia.

2. This comprises examples drawn from the Eremaean flora which in reality are foreign to the Southwest Province and consequently must be regarded with considerable reserve as being representative of the Pan-Australian elements at all.

3. Pan-Australian genera or sections. These are members of higher rank which possess representatives in almost all parts of Australia. The degree and nature of representation may be very different in different places.

1. Pan-Australian Species.

Because of the great climatic contrasts between coastal and inland Australia only a small number of species show universal distribution. They are almost all annuals or epigeous ephemeral plants which owe their wide distribution to the elasticity of their requirements. Typical examples include the following :

Anguillaria dioica (Lillac.)	*Poranthera microphylla* (Euphorb.)	*Wahlenbergia gracilis* (Campan.)
Dianella revoluta (Lillac.)	*Myriophyllum* spp. (Halorag.)	*Vittadinia triloba* (Campan.)
Bulbine semibarbata (Lillac.)	*Hydrocotyle hirta* (Umbell.)	*Cotula* spp. (Compos.)
Caesia parviflora (Lillac.)	*Centella asiatica* (Umbell.)	*Senecio* spp. (Compos)

This list is valuable when one is considering the question of the overall independence of the Australian flora. It contains essentially pure Australian species with only a few cosmopolitan forms. This provides evidence that the palaeotropical species, which are so common in eastern Australia, are not old long established inhabitants of the continent. They did not arrive here early enough to be able to cross the Eremaean region.

2. Types of the Eremaea.

The types which have migrated from the Eremaea into the Southwest Province can, as indicated above, only indirectly be regarded as Pan-Australian. This matter will be discussed in the Chapter dealing with the Ermaean flora.

3. Pan-Australian Elements of higher rank than species.

Quite a large proportion of the south-western flora consists of genera which have invaded the whole of Australia and have developed subdivisions which are adapted to the physical peculiarities of the different regions. The two most important genera, namely *Acacia* and *Eucalyptus*, as well as a number of somewhat less important genera, fall into this group. The following list includes most of those involved.

Thysanotus (Lil.)	*Sterculiaceae* (numerous genera)	*Hydrocotyle* (Umbell.)
Casuarina (Casuarin.)	*Hibbertia* (Dillen.)	*Anthocercis* (Scrophul.)
Grevillea (Prot.)	*Jodinium* (Viol.)	*Opercularia* (Rubiac.)
Hakea (Prot.)	*Pimelea* (Thymel.)	*Lobelia* (Campan.)
Cassytha (Laur.)	*Darwinia* (Myrtac.)	*Goodenia* (Gooden.)
Podalyriae (Legum.)	*Baeckea* (Myrtac.)	*Scaevola* (Gooden.)
Acacia (Legum.)	*Melaleuca* (Myrtac.)	*Stylidium* (Stylid.)
Comesperma (Polygal.)	*Eucalyptus* (Myrtac.)	
Ricinocarpus (Euphorb.)	*Myriophyllum* (Halorag.)	

The way in which these genera are distributed in Australia is also important for the proper understanding of the overall vegetation pattern The essential ways in which they are distributed in south-western Australia are illustrated excellently by the genus *Eucalyptus*. They may be arranged in the following five categories (in Diels and Pritzel, Fragma. Austr. occ., p 434)

"I. Pan-Australian Series: These are species present in Western Australia but which also occur (or very closely related forms of them do) in eastern Australia *E. rostrata* and its close relations in the gallery [riparian] woodlands, constitute examples.

II. Eremaean Series. Members of this Series include species which are generally widespread in the Eremaea of the southern half of Australia, and are also still characteristic in the Western Australian portion of the Eremaea. Examples include : *E. calycgona, E. gracilis, E. uncinata, E. oleosa* and *E. dumosa.* Of these species. *E. uncinata* is rather isolated in Western Australia and shows little polymorphism. On the other hand the rest of the species listed are rich in forms or varieties. It appears that in Western Australia many types e.g. *E. salubris* and others, have become independent and have developed very characteristic features.

III Closely related West-East Series. Western Australian species, e.g. *E. marginata* which are distinctly related to certain eastern forms appear here. This species, together with *E. patens, E. todtiana,* and *E. buprestium,* constitute a group which is otherwise undeveloped in Western Australia.

IV Western Australian Series not closely related to eastern groups but which have developed richly in Western Australia. This applies particularly to the series Cornutae of Bentham and the relationship of *E. redunca* which might well be genetically linked to it.

V Western Australian Series which are geographically isolated and which contain only one or at most only a very few representatives (forms) in Western Australia. From the data we have it appears that there must be a considerable number of species which come into this category. Not only are there species present from the inland region such as *E. pyriformis,* and *E. tetraptera,* with *E. Forrestiana; E. Preissiana*, and *E. tetraptera* with *E. eudesmioides*, but also important species from the south-western coastal region such as *E. calophylla* with *E. ficifolia, E. diversicolor, E. gomphocephala* and *E. erythrocorys*. The further relations of these species are for the most part quite uncertain. However, in several examples links with northern Australian types may be traced."

We can see from the above tabulation how the Pan-Australian genera stand so far as their constituents i.e. their Sections and species are concerned. A general distribution naturally breaks down almost everywhere. Limitations of different kinds arise which are of tremendous value to us as evidence of the plant geographical relationships in extra-tropical Australia. We meet with the relationships indicated for Eucalyptus everywhere - at first in the other Pan-Australian genera, later in the groups with disjunct areas of distribution and finally also in the annexed endemics of higher rank.

I. Our first group in the case of *Eucalyptus* comprises the real Pan-Australian Series, represented by *E. rostrata.* In other genera or sections of genera, parallel cases occur. Thus for example in *Thysanotus, Grevillea* (§ Hebegyne), *Cassytha,* in the Podalyrieae, *Acacia* Sect. Juliflorae, in the group of related forms to *Acacia salicina, Jonidium, Pimelea* (*P. microcephala)* in most of the *Myriophyllum* species and in *Goodenia.*

II. Groups which are in general distributed in the Eremaea of the southern half of Australia. This subdivision includes numerous Pan-Australian genera. such as *Casuarina, Grevillea* (Prot.) (*G. Huegelii*), the terete-leaved *Pubiflorae* in the genus *Hakea* (Prot.), *Cassytha* (Laur., e.g. *C. melantha*), several groups of *Acacia, Comesperma* (Polgal.) (*C. scoparium*), *Poranthera* (Euphorb.) (*P. ericoides*) , *Jonidium* (Viol.) (*J. floribundium*), several species of *Melaleuca* (Myrt.), *Prostanthera* (Labiat.) (*Prostanthera serpyllifolia*), certain types of *Anthocercis* (Scroph.) and *Lobelia* and finally *Goodenia* and some species of *Senecio,* have to be included in this subdivision.

III. Western species which are closely related to certain eastern forms. In the case of *Eucalyptus* there are relatively few such species. In certain other genera, however, they are more numerous and obvious. They are mentioned here because they are the first examples we have seen of a geographical disjunction of which we shall see much more later. Typical examples are as follows:- *Casuarina* § Trachypitys, *Hakea* § Congynoides (Prot.), also *Acacia myrtifolia* (Legum.), *Comesperma volubile* and *C. calymega,* also *Hibbertia* (Dillen.) § Hemihibbertia and § Pleurandra, in the case of *Pimelea Gilgiana* (Thymelaeca.), its relationship to the eastern species *Pimelia glauca, Darwinia* with the members related to *Darwinia diosmoides,* some species of *Hydrocotyle* (Umbell.) and *Opercularia* (Rubiac.). Also in the genus *Scaevola,* § Pogonanthera and in *Erechthites* (Compos.).

IV. Western series which are not closely related to eastern forms but are strongly developed in Western Australia. This endemic class possesses as far as the genus *Eucalyptus* is concerned a very typical representation of the group Cornutae. Other pan-Australian genera are also present, but are in fact so numerous that I can only mention a few here. They are particularly noticeable in the Grevilleoideae; *Grevillea,* § *Leiogyne,* § *Eriostylis* and § *Manglesia.* They are also present in the development of *Hakea* in the Southwest Province. Good examples are also provided in the Podalyriaeae, *Acacia,* (§ Pulchellae); *Hibbertia* (§ Hemipleurandra Dillen.); the polymorphic section *Malichostachys* in *Pimelea* (Thymel). There is also the *Rinzia* group in *Baeckea* (Myrt.), the Capitatae section in *Melaleuca;* also in the genera *Microcorys* and *Hemiandra* (Labiat.) and the striking Rhynchangium group in the *Stylidium* (Stylid.).

V. Western Australian series which are geographically isolated and which include only a few forms. This category of endemics, the extent of which appears to be subjective (in terms of stystematics), is not very large. However, many of the Sections which are enumerated earlier contain a few unusual species; *Grevillea* for example contains several, e.g. *G. bipinnatifida, G. Drummondii, G. Wilsonii* and *G. quercifolia.* Examples also occur in the Podalyrieae, in *Hibbertia verrucosa* (Dillen.) in *Melaleuca violacea* (Myrt.), *Hydrocotyle homalocarpa* (Umbell.); *Anthocercis viscosa* (Scrophul.), together with other examples.

The conditions given under headings II – V are repeated again in members of higher rank and are of greater importance. They will therefore be discussed in detail later.

The discussions on Pan-Australian genera provide sufficient stimulus to warrant closer study of the question of their extra-tropical occurrence, the nature of their grouping in Australia and their mode of occurrence in the Southwest Province.

With respect to this occurrence valuable material is provided by the condition of occurrence and distribution of members of the Sterculiaceae. The following information is provided by Pritzel (in Diels and Pritzel, Fragm. Austr. occ., p 365).

"The family Sterculiaceae is a predominantly tropical one, but it has developed sections in the southern hemisphere, particularly in South Africa and Australia. These sections of the family are linked to the more temperate climatic conditions and exhibit their vegetative differences from their numerous tropical relations in their low shrub-habit of growth. In South Africa the chief genus is *Hermannia*. In Australia the Buettnerian genera *Rulingia* and *Commersonia* as well as the endemic Lasiopetaleae are present.

The Sterculieae of Australia show close relationships with their tropical Asiatic counterparts, where the Australian genera are present, and where they show a strong development. In Australia, Sterculia has developed an endemic section in the subgenus *Brachychiton*, where species relate more to the character trees of the dry tropical regions. In the Eremaea it is true that some species do cross the Tropic of Capricorn towards the South.

In general, however, the members of the Sterculieae are restricted to the more tropical regions in Australia. The small number of representatives of the Helictereae and Hermannieae found in Australia are either species invading the extreme north of the continent from the Asiatic tropics or are at least very close relatives of these.

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The Australian genera *Rulingia* and *Commersonia* are also included with the moist-tropic subfamily, Buettnerieae. In agreement with their different habitats these Buettnerieae have developed considerable changes in their vegetative forms. As a consequence they are now very unlike their tropical relatives. *Commersonia echinata* which is present in Queensland and New South Wales, may be regarded as the base form or at least as a direct link. It is distributed throughout the whole Malaysian-Australian monsoon region and is a true tropical growth. At the same time it presents resemblances to the other species of *Commersonia, Rulingia* and *Commersonia* represent genera derived from the tropical Buettnerieae, showing a marked reduction in petals, a more pronounced shortening of the staminal tube and a reduction in the number of the fertile anthers.

The Lasiopetaleae are very closely related to the previous groups and as a consequence are only separable from them with difficulty. The large Sterculiaceous genera of the temperate parts of south western Australia and south eastern Australia, namely *Thomasia, Lasiopetalum,* and *Guichenotia* show the greatest differences in flower structure from the tropical Buetternerieae - the petals being reduced to rudiments or completely suppressed. The stamens are definitely five in number and staminodia or a staminal tube, rarely present. In all these conditions the genera *Keraudrenia, Seringia* and *Hannafordia* are less definite and are consequently nearer to the Buettnerieae. This feature is also confirmed by the geographical distribution, in that, like the Buettnerieae, they possess a more Eremean or northern distribution."

From this it appears that the family Sterculiaceae is a group which has invaded Australia from the North and then developed further within the continent."

Unfortunately our other data are very rarely as precise as in this family. At the same time the morphological differentiation in other groups indicates the operation of similar factors.

Amongst these groups are Acacia and Eucalyptus which we may consider as the most important of Australian genera. The geographical distribution of the genus *Acacia* favours the theory of the tropical origin of the genus and Pritzel in his careful researches on the Western Australian Acacias (Diels and Pritzel, Fragm. Austr. occ., p.276) has actually indicated the probability that the main line of origin of the Australian Acacias would be found in one, or in a few more or less isolated forms which have entered Australia from the north or north-west.

In the case of *Eucalyptus* the data suggests that the group from which the genus in Australia originated in the north-east belonged to that old region which has influences New Caledonia and even New Zealand (*Metrosideros* and *Xanthostemon*) In north-eastern Australia one also finds *Angophora*, a type which, when compared closely with *Eucalyptus*, looks to some extent like the original type of the genus.

Engler[1] has shown how a similar origin and course of development holds good for the Rutaceae-Boronieae, a group which, all things considered, is likewise to be regarded as Pan-Australian. He states that "it is quite certain that the Boronieae are nothing more than Xanthoxyleae (Evodiinae) which have undergone greater modification and which have extended in Australia and also in New Caledonia (they occur also in New Zealand although only one species has so far been recorded there)."

In relation to the above it is interesting to note that many Pan-Australian genera extend to the Malaysian Region or at least to New Caledonia. *Thysanotus* (Lil.), *Casuarina*, *Grevillea* (Prot.), *Cassytha* (Laur.), *Hibbertia* (Dillen.), *Jonidium* (Viol.), *Baeckea* (Myrt.), *Melaleuca* (Myrt.), *Anthocercis* (Scroph.), and *Stylidium* (Stylid.) are some examples of this class. They possess, of course, different characteristics.

These show the lines of communication of Australia with the rest of the world so far as some of its most representative plant groups are concerned. They are of value, as providing the foundation for a knowledge of these important cases where the origin of true Australian types is not to be sought in the middle of the present area, but is excentrically situated in the northern part. This appears to be the case for *Acacia*, the Rutaceae, Sterculiaceae and for *Eucalyptus*.

4. The Character of the Pan-Australian Genera in Western Australia.

The conditions and general development of the Pan-Australian genera in Western Australia fall into two categories. Either the level of development of the genus remains almost the same over the whole of the continent or a progressive alteration occurs which takes it beyond that stage.

In the first case there may be a considerable change in vegetative appearance (morphology), in the second case considerable adaptational change and variation in the floral structure may appear, although what we may call the morphological ground plan, remains unaltered. There appears to be no tendency to advance beyond the eastern or central Australian conditions. Examples of the first case are *Casuarina, Cassytha* (Laur.), *Acacia, Jonidium* (Viol.), *Pimelea* (Thymel.), *Hydrocotyle* (Umbell.), *Anthocercis* (Scroph.) and *Opercularia* (Rubiac.).

Of more importance for the evaluation of the south western Australian flora, is the series of genera in which progression has taken place within the Southwest Province. We may cite some examples to indicate how this type of process works.

A simple case is provided by reduction in the flower, in particular the androecium. The small group of the Triandrae in the genus *Thysanotus* (Lil.) is exclusively south-western and is without doubt derived from the form with six stamens. In other groups the reduction affects the gynoecium and limits the number of ovules. This we can see in the genus *Melaleuca*, where there is a tendency to reduce the number of ovules to one in each compartment of the ovary. This is clear in the sub-series, Palidiflorae and leads

1 A. Engler, über die geographieche Verbreitung der Rutaceen. Abhdl. K. Preuss. Akad. Wiss. Berlin 1896. p. 14.

finally to the genus *Conothamnus* which possesses the minimum number. The same progression can also be observed in *Dampiera* (Gooden.). This genus it is true, also occurs elsewhere than in south western Australia, though it is very probable that it originated in the south west. Pritzel (in Diels and Pritzel Fragm. Austr. occ., p. 574), stated that "the family Goodeniaceae in many respects reached the climax of its development in the genus *Dampiera* with its many species. The reduction in the gynoecium seen in the other genera of the Goodeniaceae, leads in *Dampiera*, to the typical condition of a single loculus and a single seed (with the exception of the two species in the *Dicoelia*). The calyx is completely rudimentary and the differentiation of the divisions of the corolla into three petals serving as an attraction-device, and two peculiarly modified petals apparently serving for protection of the stamens and gynoecium, has become a characteristic of the genus. In addition to this the fusion of the anthers is always complete. Through the combination of all these progressions (found also to a certain extent in other genera of the Goodeniaceae), *Dampiera* for instance, is regarded as one of the most advanced genera in the family. On account of its positive features the genus makes a more striking impression than does *Goodenia* for instance".

As indicated above, the case of *Dampiera* is characterised by progression in all parts of the flower. Here in the one case we have features which rarely occur together.

Instead of leading to purely quantitative reduction many progressions lead to greater functional specializations. Examples are found in the Prostantheroideae group of the Australian Lamiaceae[1]. The genus *Prostanthera* which illustrates the most primitive condition in the morphology of the androecium, has attained a very diverse vegetative development in eastern Australia. In Western Australia it extends through the Eremaea to its boundaries but remains always far from the real Southwest Province. Its place is taken there by the genera *Hemiandra, Hemigenia* and *Microcorys*, which have evolved beyond *Prostanthera* by the partial modification of the anthers.

A similar change in presented by the Section Candollea (of Labillardière and later writers) of the Western Australian Dilleniaceae. It can be distinguished from the Pan-Australian *Hibbertia* by the grouping of the stamens into five bundles. This arrangement of stamens first developed in south-west Australia. It evidently originated in the vicinity of *Hibbertia montana* whose polymorphic group still maintains a very important position. The androecium of Hibbertia montana shows several similarities with the basic structure of *Candollea* (*Hibbertia*).

One must also include as an example of progression the style structure in the Proteaceae, in the sections Manglesia (*Grevillea*) and Manglesioides (*Hakea*) which have developed a series of species in Western Australia.

Finally we can study another form of progression in the Myrtaceae-Chamaelauceae which affects the form of the whole flower. In the genus *Darwinia* we have a primitive species with crowded flowers where the participation of the bracts in anthobiological functions is only slightly stressed. This type belongs, to a certain extent, to eastern Australia. One species, however, (*D. diosmoides*) extends across into Western Australia. As we go further westward more complex forms become dominant in which the bracts become more and more corolla-like until finally the highest point of this development is reached in *Darwinia macrostegia* and its relatives. These possess beautifully coloured involucral bracts. Thus in *Darwinia* we see a very marked advance in floral biology made within the Southwest Province. This is all the more important since a parallel is found in the progressive modelling of the protective whorls of the flower in the related genus *Verticordia* (Fig. 75). Here also we find a certain tendency extending through a genus in Western Australia and gradually becoming more and more complete.

These represent cases of an essentially different kind from those showing reduction in flower parts. Both should, however, be considered together here for they provide a great deal of evidence for the progressively wider development of many Pan-Australian groups in the region of the Southwest Province.

1 See Diels and Pritzel, Fragm. Austr. occ. p. 525.

b. Disjunct Elements

The connection indicated between the members of the Pan-Australian genera is accentuated by the type of distribution in the disjunctively distributed genera.

The flora of the Southwest Province contains a very considerable number of such cases. Their relations with the east of the continent proves more enlightening and more versatile, than one might have first expected.

For all of these genera the Eremaea acts as a zone of separation between the western and the eastern areas. The extent of this separation zone, however, is very different in the various cases. The geographical position of the eastern portion of the area likewise varies. According to this we may distinguish three categories.

I. That eastern area which is markedly much more northern than the south western area, i.e. somewhat north of 25° S. lat. in the tropical north east : - North Eastern Types.

II. That eastern area which lies somewhere about the same latitude as the south western, i.e. between 25° and 35 ° S. lat. in eastern New South Wales.

III. That eastern area which lies more southerly than the south western, south of 35 ° S. lat. in Victoria, Tasmania and the euronotic region of South Australia.

Classes II and III are however, very frequently combined constituting a single category: - South Eastern Species.

I. North Eastern Types.

The following genera found in the Southwest Province are the most important examples of the north eastern types:

Borya (Lil.)	*Burtonia* (Legum.)	*Keraudrenia* (Stercul.)
Haemodorum (Haemod.) partially	*Jacksonia* (Legum.)	*Verticordia* Sect. Catocalypta (Myrt.)
Persoonia Sect. Pycnostyles (Prot.)	*Isotropis* (Legum.)	*Calythrix* (Myrt.)
Brachysema Sect. Leptosema (Legum.)	*Labichea* (Legum.)	*Breweria* (Solan.)
	Albizzia (Legum.)	
	Diplopeltis (Legum.)	
	Byblis	

In addition to these there are smaller groups within more extensive genera, e.g. *Stylidium*.

These genera vary greatly in the extent of their area of distribution and the measure of their disjunction. The conditions are clearly shown in the well developed and taxonomically uniform group represented by the genus *Jacksonia* (Fig. 76). The Leguminosae-Podalyrieae as a whole are characterized by such relationships. E. Pritzel (in Diels and Pritzel Fragm. Austr. occ., p.217) has this to say regarding this type. "There are some genera whose area of distribution extends to tropical northern Australia, but as such they are essentially absent in the temperate east and southern Australia. For example: *Brachysema, Burtonia, Isotropis, Jacksonia* and *Gastrolobium*. On the other hand, these genera are strongly developed in the west and especially in the dry parts of the northern districts joining the central Eremaea. There is a distinct relationship between the species present in these districts and those of tropical northern Australia. This applies in particular to species of *Isotropis, Jacksonia* and *Brachysema*. Species which extend from that tropical area to the temperate West across the Eremaea are *Gastrolobium grandiflorum* and *Isotropis atropurpurea*."

The genera of the other groups follow the *Jacksonia* scheme. In many cases, however, lack of information regarding the tropical interior means that details of the degree of disjunction can not be determined with certainty.

Thus in the case of the very important species, *Borya nitida* in Western Australia up to the present time, the only other species is *B. septentrionalis* , which is found only in a very limited area between Trinity Bay and Rockingham Bay in north eastern Queensland. It grows there in edaphically very similar habitats to those of its very closely related sister

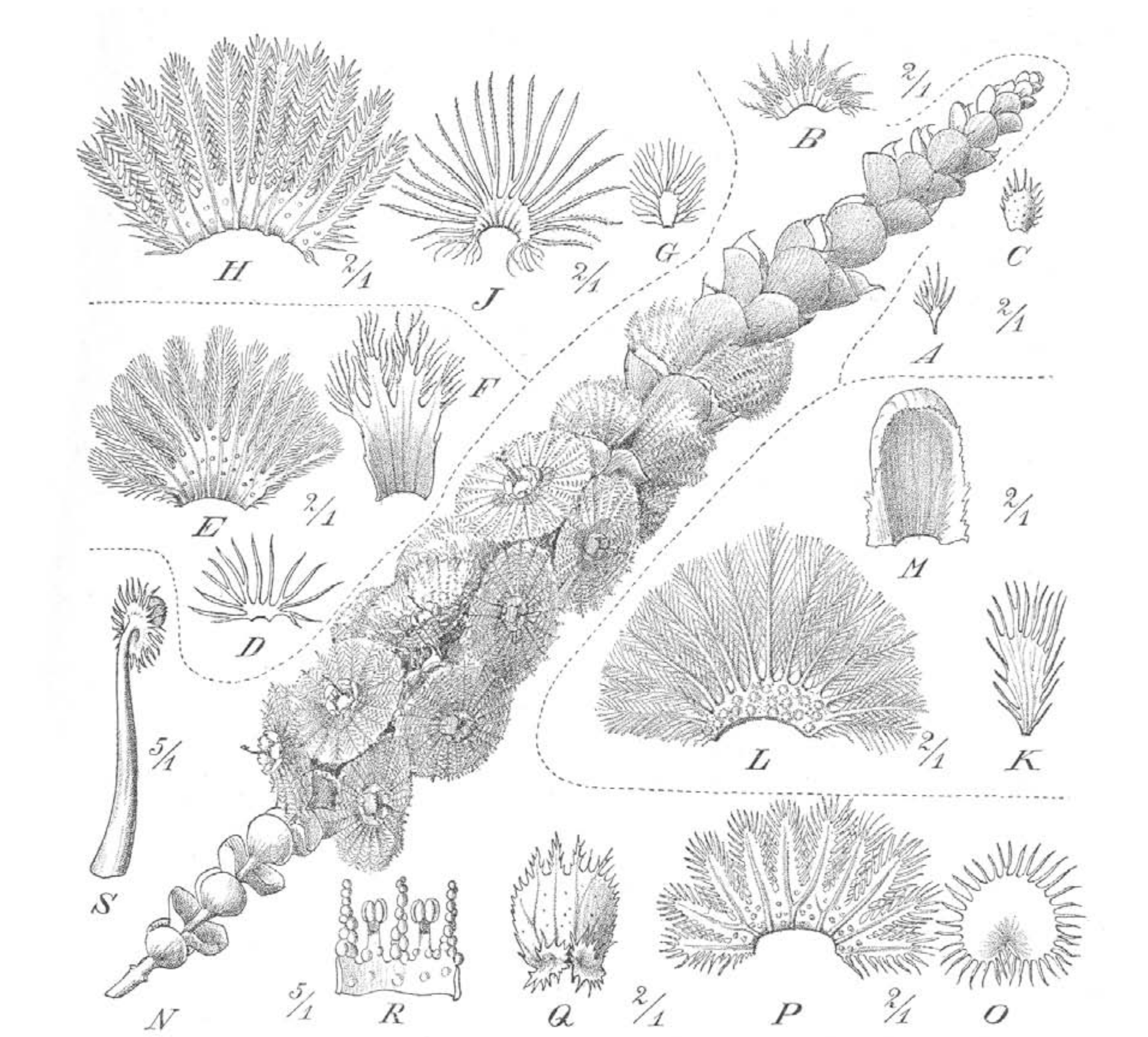


Fig. 75. *Verticordia* DC.: *A—C V. spicata* F. v. M.: *B* Kelchabschnitt, *A* Kelchanhängsel, *C* Blumenblatt. — *D—F V. ovalifolia* Meissn.: *E* Kelchabschnitt, *D* Kelchanhängsel, *F* Blumenblatt. — *G—J V. oculata* Meissn.: *H* Kelchabschnitt, *G* Kelchanhängsel, *J* Blumenblatt. — *K—M V. grandis* Drumm.: *L* Kelchabschnitt, *K* Kelchanhängsel, *M* Blumenblatt. — *N—S V. Muelleriana* E. Pritzel: *N* Habitus eines blühenden Zweiges, *P* Kelchabschnitt, *O* Kelchanhängsel, *Q* Blumenblatt, *R* Teil des Staubblatt-Tubus, *S* Griffel. (Nach Diels und Pritzel.)

species of the south-west of Australia. If it is not found more widely distributed in other intervening areas, *Borya* must surely be the most disjunctive species of all belonging to this group.

The areas occupied by these groups provide one of the surprises of the Australian flora. Many obscure problems are indicated here. We can scarcely invoke climatic factors since the regions concerned occur under contrasting climatic conditions. On the one hand we have the region of the real summer rains, and on the other the district of marked winter rain. It is possible that edaphic factors play an important part in influencing distributions. The case of *Borya* seems to favour this interpretation. Other northern Australian examples of this group include psammophyllous plants. How far similar features apply to the remaining cases will remain undetermined until we know something more of the ecology of the northern Australian species.

One thing is certain, however, from the nature of the two areas of distribution. This is that for the exchange between the east and west of Australia there must have also been at some earlier time, a connecting pathway in the north. To what extent this pathway is still open today will only be known later. The solution of this question is dependent upon wider exploration and opening up of the more northern parts of the Australian interior.

II. South Eastern Types.

The class of the south eastern types is very much more extensive. Here certain features of plant distribution in extra-tropical Australia are presented with greater clarity.

For a better understanding we may first study the northern types belonging predominantly to New South Wales of Southern Queensland. The larger section (the genera distributed between the parallels of 30° and 40° S, can then be studied. Finally we may refer briefly to the elements belonging to the most southern section.

1 Northern Subdivision.

The genus *Philotheca* (Rutac.) illuminates the transition from the previous category, that of the north eastern types, to the south eastern one. The West Australian species [*Philotheca hassellii*] which is characterized by the disappearance of one of the loculi from the anther. Because of this it approaches very closely to the species *Ph. calida* present in north-east Queensland. In addition to this there is another species present in New South Wales in eastern Australia.

Other representatives of the south eastern types in the northern sub-class are:

Dioscorea (Dioscor.)	*Xylomelum* (Prot.)	*Actinotus* (Umbellif.)
Petrophila (Prot.)	*Aphanopetalum* (Cunon.)	
Lambertia (Prot.)	*Chorizema* (Legum.)	

It should be noted that this small list includes only the most striking examples of the class, which enable one to draw reliable conclusions.

Dioscorea and *Aphanopetalum* are hydrothermic tropical lianes in eastern Australia. In the wider sense they are members of the Malaysian element of the Australian flora. This is very rich in species in the above region and even forms true rain forests (Part 1). In Western Australia the above types are practically the only examples of this important floral element. They occur only in the warmer parts of the Southwest Province coastal region, between the Murchison and Murray Rivers. Here in winter time the temperature on an average never falls as low as it does in the deep south. Growing with them also one finds *Clematicissus*. Taxonomically this is somewhat isolated, but otherwise in terms of this present point of view, it is similar to the above.

The three Proteaceaous genera listed above, i.e. *Petrophila, Lambertia* and *Xylomelum*, illustrate the disjunction very well, and provide excellent examples of this group. To them the genera *Isopogon* and *Conospermum* may also be added although they extend further southwards. Their full eastern development, however, occurs north of the latitude 35° S. It is difficult to say why these genera which are so richly developed in Western Australia should show such poor development in eastern Australia, and why they are so geographically limited. The same holds good for *Chorizema*. This Leguminous genus agrees with the above mentioned Proteaceous genera in so far that its eastern representative (*Ch. parviflorum*) is very closely related to many West Australian species. The same thing is evident in the genus *Logania* in so far as the species *L. pusilla* is concerned. This species grows in the Sydney region but shows no close relationship with any species other than with *L. serpyllifolia* of far distant Western Australia.

The genus *Actinotus* is distinguished by the possession of an intermediate area of distribution between the widely separated segments of its area of distribution. (But it also has a species in west Tasmania). Contrary to expectation, a species (*A. Schwarzii*) of this genus, has been found in the Macdonnell Ranges in Central Australia. It is a solitary example, but nevertheless it is of great value. The existence of this species on the mountains of the desert-like inland region is doubtlessly due to local conditions, where water is available. One might speculate that the drying of the interior has led to the loss of the species from the surrounding districts.

Fig. 76.

2 General South Eastern Subdivision.

The following Western Australian types which also have a general distribution in south eastern Australia may be noted. Their area of distribution is interrupted by the Eremaea:

Stypandra (Lillac.)
Burchardia (Lillac.)
Laxmannia (Lillac.)
Patersonia (Irid.)
Orchidaceae (num. spp.)
Banksia (Prot.)
Clematis (Ranunc.)
Cassytha (Ranunc.)
Drosera (Sect.Polypeltes)
Marianthus (Pittosporac.)
Billardiera (Pittospor.)
Gompholobium (Legum.)
Sphaerolobium (Legum.)
Viminaria (Legum.)
Daviesia (Legum.)
Aotus (Legum.)
Pultenaea (Legum.)
Hovea (Legum.)
Hardenbergia (Legum.)
Kennedya (Legum.)
Boronia (Rut.) § Pinnatae
Boronia (Rut.) § Terminales
Crowea (Rut.)
Asterolasia (Rut.)
Tetratheca (Tremandr.)
Amperea (Euphorb.)
Kunzea (Myrt.)
Callistemon (Myrt.)
Haloragis § Oppositifoliae
Xanthosia (Umbell.)
Leucopogon (Epacrid.)
Mitrasacme (Logan.)
Logania (Logan.)
Lagenophora (Compos.)
Leptorrhynchus (Comp.)

The above imposing list contains many form-series which are important in relation to the flora of extra-tropical Australia outside the Eremaea. A characteristic picture of the kind of distribution is supplied by the genus *Banksia* (Fig. 77). In spite of the fact that *Banksia*, so far as we know, is not present in the southern half of the region between 135° and 126° E. long., the genus is developed in both disjunctive segments of the area. It also appears better developed in the west than in the east, or at least it shows greater vegetative diversity in the former part.

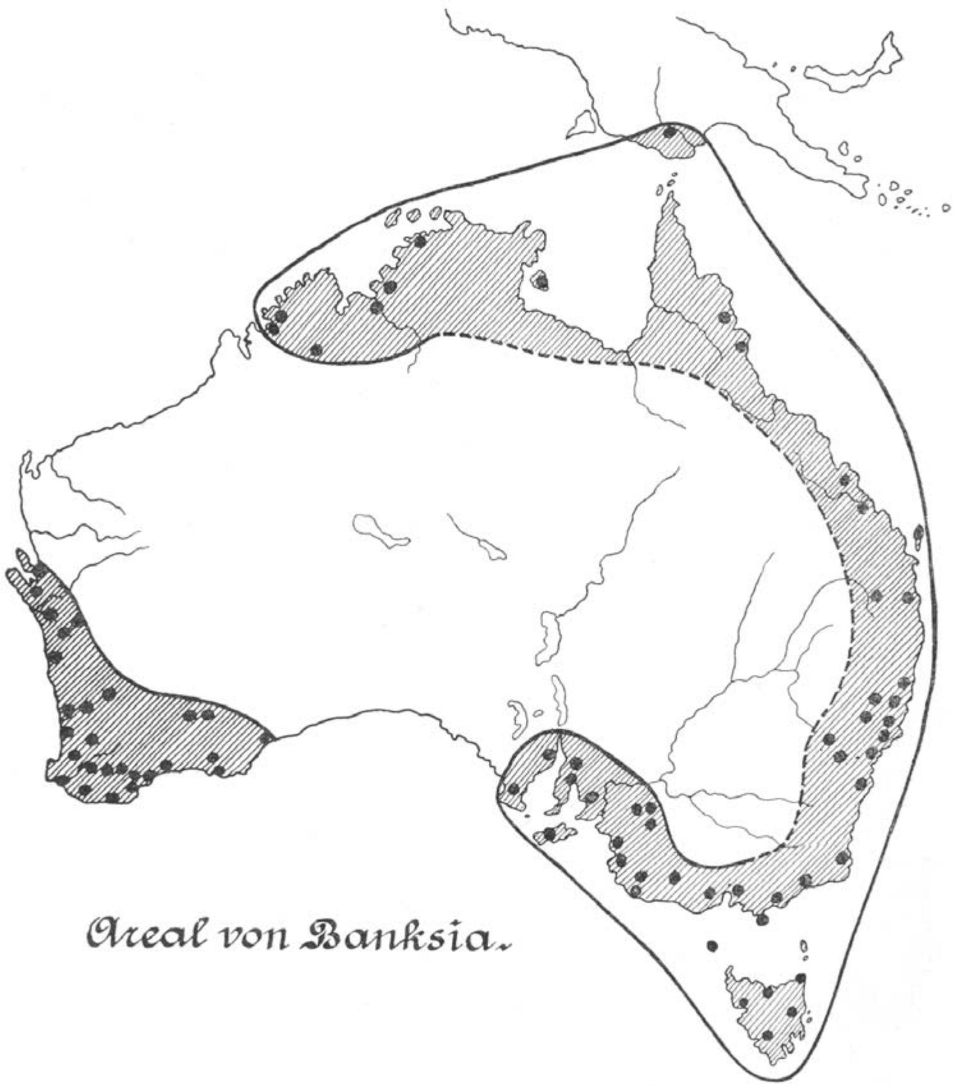


Fig. 77.

It seems quite general in this group for the degree of development of the genera to be unequal in the two areas where they occur. *Banksia* (Prot.), *Drosera* § Polypeltes, *Sphaerolobium* (Legum.) *Daviesia* (Legum.), *Tetratheca* (Tremandr.), *Leucopogon* (Epacr.) and some others are decidedly richer in the south western area, while *Clematis, Pultenaea* (Legum.), *Mitrasacme* (Logan.) and others show more diversity in the south east.

The species of the two areas are frequently very closely related. In the Orchidaceae more than twenty species of the east and west are so similar in structure that they are usually reckoned as being conspecific. The same applies for species of *Stypandra* (Lil.), *Burchardia* (Lil.) *Clematis, Viminaria* (Legum.), *Mitrasacme* (Logan.), and others. In *Patersonia* (Irid.), we find on this side the same kind of flower structure as over there. This is true also of *Banksia*. In *Trachymene* (Umbell.) an interesting division of the genus has taken place in the two areas, the section Dendromene being strongly developed in the east, whilst it is uncommon in the south eastern districts of Western Australia. On the other hand the section Platymene is developed predominantly in Western Australia, being only representerd in the east by *T. heterophylla* which really occupies a special place since it is morphologically intermediate between the two sections.

If one takes into account the degree of disjunction in this group, in connection with the conditions of relationship amongst the species, the importance of the southern route for the exchange of species between the east and west stands out very clearly. Its importance is still more clearly shown in the next subdivision - that of the southern types.

3 Southern Subdivision.

The southern subdivision has been defined earlier in this chapter. It contains the genera which are common to the west and east, but which are only fully developed south of the 35° parallel in the east. The following genera may be mentioned:

Calectasia (Lillac.)	*Cheiranthera* (Pittospor.)	*Brachyloma* § Lobopogon (Epacr.)
Adenanthos (Prot.)	*Lhotskya* (Myrt.)	*Astroloma* (Epacr.)
Drosera § Erythrorhiza	*Styphelia* § Soleniscia (Epacr.)	*Acrotriche* (Epacr.).

The relative degree of representation or development in the areas of distribution shows the same differences as those in the previously discussed groups. In the genera *Adenanthos* and *Astroloma* the west is much the richer while in other genera, numerically the relations are more equal.

Fig. 78.

So far as relationships are concerned we again find a strong tendency to resemblance which may extend to con-specificity of species. Examples of such are *Calectasia cyanea* and *Astroloma humifusum.*

Thus in this subdivision one finds most clearly indicated the degree of resemblance between the two southern corners of the Continent. This feature is clearly seen throughout the section of the south eastern types. An active exchange must have taken place between the two areas. At present the traffic for most genera would seem to be prevented by the hinterland of the Great [Australian] Bight. The problem of the path of communication is therefore a question of floral history and can only be solved along such lines.

From this point of view the importance of the Epacridaceae in the southern subdivision may warrant closer study of one of its genera. The genus *Acrotriche* has been referred to by E. Pritzel (in Diels and Pritzel, Fragm. Austr. occ., p. 479), as follows :

- “The species of this natural genus are shrubs of the coast hills of south-east Australia extending as far west as Kangaroo Island. Further west again there follows a great stretch across the Bight where they have never been observed as yet. The genus only reappears when the south coast of Western Australia is reached on the far side of Cape Arid, where granite hills again border the coast. Two species identical with those east of the Bight occur here, together with a closely related one. It is thus a characteristic example for the relationship between the flora east of Spencer Gulf and that of the south coast of Western Australia from King George Sound to Cape Arid. It is best explained on the assumption of the existence at some time of a direct communication right across the Great Bight. The resemblance of the geological structure of these parts of the south coast lends support to this theory.”

The above fits in, mutatis mutandis [with suitable alterations], with information provided by the other genera of this group. Very close floristic relations still exist between both these districts separated by the Great [Australian] Bight. It is expressed in the fact that many genera and species are common to the two districts. Amongst these the following may be mentioned:

Daviesia incrassata (Legum.)
D. pectinata (Legum.)
Pultenata tenuifolia (Legum.)
P. vestita (Legum.)
Eutaxia microphylla (Legum.)
Kennedya prostrata (Legum.)
Lasiopetalum discolor (Stercul.)
L. parviflorum (Stercul.)
Leucopogon Woodsii (Epacr.)
L. Richei (Epacr.)
L. australis (Epacr.)
Astroloma humifusum (Epacr.)
Logania vaginalis (Log.)

A series of cases where the closest affinity exists may be appended directly to the above. A good example, according to Pritzel (Fragm. Austr. occ. p. 379), is furnished by the relationship between *Lasiopetalum cordifolium* of the west and *L. Schulzenii* of the east. “The east Australian species is limited to the eastern side of the Great Australian Bay [Bight] but is so closely related to *L. cordifolium* of the south eastern part of Western Australia, such that if the Great Bight did not penetrate so deeply to the north it would be considered to be the most easterly type of the western species”. The following pairs of species exemplify the very same conditions:

West	East
Xerotes rigida	*Xerotes longifolia*
Xanthorrhoea Preissii	*Xanthorrhoea quadrangulata*
Drosera rosulata	*Drosera Whittakeri*
Cheiranthera filifolia	*Cheiranthera linearis*
Styphelia melaleucoides	*Styphelia pusilliflora*

c. Endemic elements

Taking the Australian genera as usually defined today, we find that Western Australia has 85 endemic genera. This number is made up of very different members. It is necessary therefore to arrange the individual elements into natural groups. The measure is provided by their taxonomic position. Naturally there is always something arbitrary in the result but this is inevitable. Following these lines the genera fall into three groups[1]:

1. Isolated genera or generic groups, without recognisable connections. Endemics of the first order.
2. Genera with indirect connections to Pan-Australian series. Endemics of the second order.
3. Genera with direct connections to the Pan-Australian series. Endemics of the third order.

1. Isolated genera. Endemics of the first order.

This very important class comprises 30 genera, as follows : -

1 Note: The genera *Onychosepalum* (Cyper.) and *Isandra* (Scrophul.) have not been noted because I have not studied them myself and am unable to express a satisfactory opinion on their position without doing so.

Reedia (Cyper.)
Evandra (Cyper.)
Lyginia (Restion.)
Ecdeiocolea (Restion.)
Anarthria (Restion.)
Dielsia (Restion.)
Dasypogon (Lillac.)
Calectasieae (Lillac.) with:
- *Kingia*
- *Baxteri*
- (*Calectasia)*

Conostylideae (Amaryll.) with:
- *Phlebocarya*
- *Tribonanthes*
- | *Blancoa*
- | *Conostylis*
- | *Anigozanthos*
- | *Macropodia*

Nuytsia (Loranth.)
Simsia (Prot.)
Synaphea (Prot.)
Franklandia (Prot.)

Emblingia (Embl.)
Cephalotus (Cephalot.)
Eremosyne (Saxifrag.)
Stylobasium (Rosac.)
Calycopeplus? (Euphorb.)
Psammomoya (Celastr.)
Clematicissus (Vitac.)
Balaustion (Myrt.)
Anthotroche (Solanac.)
Amblysperma (Compos.)

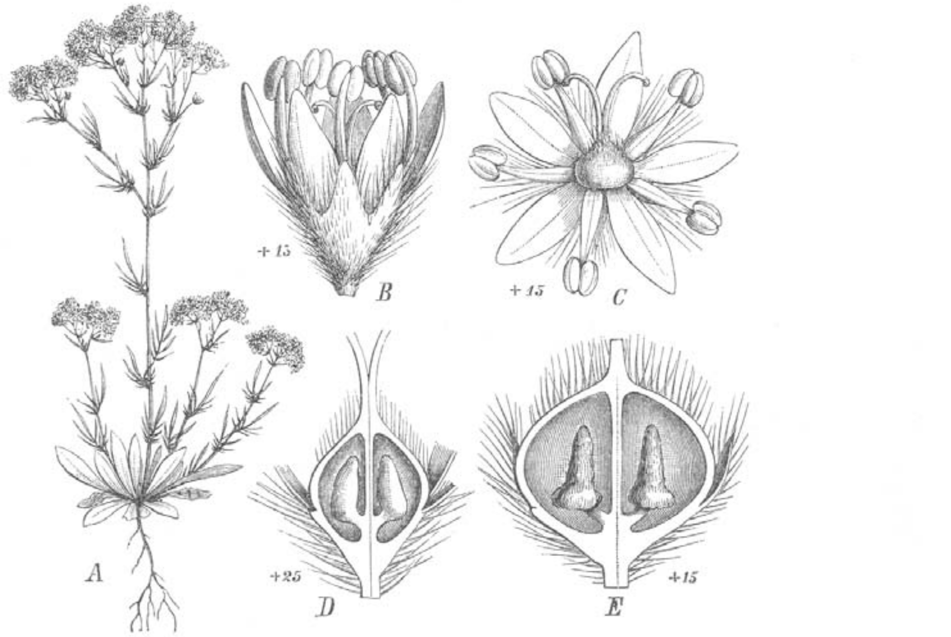


Fig. 79. *Eremosyne pectinata* Endl., monotypische, in Südwest-Australien endemische Saxifragaceen-Gattung: *A* Habitus, *B* Blüte, *B* Blüte ausgebreitet, *D* Fruchtknoten im Längsschnitt, *E* Frucht im Längsschnitt. (Nach ENGLER.)

Of these genera a few show signs of links with other Australian form-groups. eg *Dasypogon* and *Balaustion.* Most of these, however, possess no close relation of any kind in another part of Australia or in other parts of the world (if one excepts the Conostylideae where *Lanaria* (of the Cape) and *Lophiola* (of Atlantic North America) seem to enter into relationships with this otherwise pure Western Australian group. The linkage between the *Amblysperma* and the Brazilian *Trichocline* should also be noted.

The development of most of these endemics in Western Australia is very restricted. Almost half of them may be said to be monotypic: *Reedia, Ecdeiocolea, Dielsia, Kingia, Bateria, Blancoa, Macropodia, Nuytsia, Emblingia, Cephalotus* (Fig. 80), *Eremosyne* (Fig. 79), *Clematyicissus, Balaustion* and *Amblysperma.* The following show a somewhat greater, but still very restricted development: *Evandra, Dasypogon, Phlebocarya, Franklandia, Psammomoya,* and *Anthotroche.* Somewhat richer in forms are the genera *Anarthria, Tribonanthes, Anigozanthos, Simsia* and *Synaphea*, but only one - *Conostylis* belongs to the really polymorphic genera of the Southwest Province.

By and large the general distribution agrees with this. The genera *Tribonanthes, Conostylis, Anigozanthos, Simsia* and *Synaphea* and perhaps also the less well known genus, *Calycopeplus* are represented throughout the Southwest Province. In their range of forms they reflect the diversity of the environmental forces to which they are subjected.

The other genera are more restricted in distribution. We do not, however, know with absolute exactness where the boundaries lie.

Ecdeiocolea, Emblingia, Stylobasium and *Clematicissus* are characteristic of the more north western part of the Province. *Macropidia* occurs south of this area. Owing, however, to its close connection with *Anigozanthos* this genus cannot really be classed as equivalent to the others. Between the Moore River and King George Sound (the wettest region and in some respects the nucleus of the whole Province) one finds the home of several endemics:

Dasypogon	*Blancoa*
Kingia	*Amblysperma*
Phlebocarya	

Further to the south as we travel towards the south coast, the areas where *Baxteria, Eremosyne, Franklandia* and *Cephalotus* occur, follow in succession. These four genera are decidedly peculiar amongst the endemics of the region. However, to illustrate how far we are still from knowing the exact distributions of even these striking examples we may take *Cephalotus* (Fig 80.).This is by far the most famous of all the south-western Australian autochthonous plants. Its area is usually stated to be very small and from the literature one finds that it only occurs on King George Sound. As a matter of fact it extends westward at least as far as Deep River. No one has followed it yet to the East, but one assumes that it grows near Esperance Bay since that was where Labillardière who first described it made his collections. Unfortunately he does not specify the actual locality of his discovery. If this species does occur as far East as Esperance, the area (although but a narrow strip of coastal country) extends across 5-6^{o} of longitude.

The inner dryer landscapes of south west Australia are poorer in isolated endemics but *Psammomoya* and *Anthotroche* are found on the sand heaths of the Avon District. *Balaustion*, a small myrtaceous shrub which grows closely pressed to the ground and has flowers like small pomegranate flowers, occurs further to the east. It in fact penetrates far into the Eremaea and may be collected as far east as Coolgardie.

To properly understand south western Australia, it is essential to know the mode of distribution of the endemics. They are present to as larger or smaller degree in all botanical districts but they are not strikingly more abundant in one than another. One never comes across any particularly favourable localities or centres of endemism and nothing like a kind of asylum for relicts. On the contrary the distribution is predominantly even. This is a reflection of the continuity in the grading of all the environmental conditions, both in the present and the past.

2. Endemics of the Second Order

By endemics of the second order we understand those genera which have relations in other parts of Australia but which at the same time are always separated from them by considerable morphological differences. These relations are sometimes Pan-Australian genera (perhaps *Calothamnus* for example represents such a case) but often they are restricted to the south western quarter of the continent and may be conceived as types taking the place of our south western endemics. In this group I consider there are about 23 genera:

Loxocarya (Restion.)	*Chorilaena* (Rut.)	*Phymatocarpus* (Myrt.)
Chaetanthus (Restion.)	*Diplolaena* (Rut.)	*Cosmelia* (Epacrid.)
Hydatella (Centrolepid.)	*Platytheca* (Tremandr.)	*Andersonia* (Epacrid.)
Arnocrinum (Lil.)	*Tremandra* (Tremandr.)	*Sphenotoma* (Epacrid.)
Hodgsoniola (Lil.)	*Actinodium* (Myrt.)	*Diaspasis* (Gooden.)
Johnsonia (Lil.)	*Hypocalymma* (Myrt.)	*Pentaptilon* (Gooden.)
Agrostocrinum (Lil.)	*Calothamnus* (Myrt.)	*Pithocarpa* (Compos.)
Sollya (Pittosp.)	*Regelia* (Myrt.)	

All these genera belong to families or tribes which are amongst the characteristic elements of the flora in the whole of extra-tropical Australia.

Their development in Western Australia like that of the members of the previous group, is not extensive. There are some monotypic genera here also, e.g. *Hodgsoniola, Platytheca, Cosmelia, Diaspasis* and *Pentaptilon*. The majority is oligomorphic. *Hydatella, Johnsonia, Arnocrinum, Agrostocrinum, Sollya, Tremandra, Chorilaena, Sphenotoma* and *Phymatocarpus*. The remaining genera - *Diplolaena, Hypocalymma, Calothamnus, Andersonia,* and *Sphenotoma* are the members of the group which are distributed in several districts or throughout the whole Southwest Province. They are correspondingly diversified in their development. *Hydatella* as an aquatic plant seems to occur wherever permanently fresh water is available.

If one leaves these richly developed genera with their extensive areas of distribution on one side, one sees again the limitation which was marked in the case of the endemics of the first group. *Pentaptilon* is widely distributed in the north. More to the south, somewhere between the Murchison and Swan Rivers one finds *Arnocrinum*. From the Swan River region and the Avon River down far to the south east, *Johnsonia, Agrostocrinum* and *Sollya* occur. Nearer to the south coast follow *Chorilaena, Platytheca* and *Sphenotoma*. *Actinodium, Cosmelia* and *Diaspasis* are completely southern but their areas of distribution, while partially overlapping, do not completely coincide. It is only in a small section of the district around King George Sound that all six occur together.

Compared with the endemics of the first order there is a slight tendency to favour the southern landscapes.

3. Endemics of the third order.

The endemics of the third order have less marked qualities. The connection with a Pan-Australian group is unmistakable. They may be regarded as off-shoots which have only branched off from the stem elements in Western Australia.

This group contains approximately 30 genera:

Diplopogon (Gramin.)	related	to	*Amphipogon*
Acanthocarpus (Lil.)	”	”	*Lomandra*
Stawellia (Lil.)	”	”	*Laxmannia*
Epiblema Orchid.)	”	”	*Thelymitra*
Dryandra (Prot.)	”	”	*Banksia*
Tersonia (Phytolacc.)	”	”	*Codonocarpus*
Jansonia (Legum.)	”	”	*Brachysema*
Latrobea (Legum.)	”	”	*Pultenaea*
Nematolepis (Rutac.)	”	”	*Phebalium*
Geleznovia (Rutac.)	”	”	*Eriostemon*
Guichenotia (Stercul.)	”	”	*Hannafordia*
Lysiosepalum (Stercul.)	”	”	*Thomasia*
Chamaelaucium (Myrt.)	”	”	*Darwinia*
Wehlia (Myrt.)	”	”	*Lhotzkya*
Scholtzia (Myrt.)	”	”	*Baeckea*
Beaufortieae (Myrt.)	”	”	*Melaleuca*
Conothamnus (Myrt.)	”	”	*Melaleuca*
Lamarchea (Myrt.)	”	”	*Melaleuca*
Eremaea (Myrt.)	”	”	*Melaleuca*
Schoenolaena (Umbell..)	”	”	*Xanthosia*
Coleanthera (Epacrid.)	”	”	*Styphelia*
Conostephium (Epacrid.)	”	”	*Astroloma*
Needhamia (Epacrid.)	”	”	*Leucopogon*
Oligarrhena (Epacrid.)	”	”	*Leucopogon*
Microcorys (Labiat.)	”	”	*Prostanthera*
Mallophora (Verben.)	”	”	*Dicrastyles*
Physopsis (Verben.)	”	”	*Dicrastyles*

Hemiphora (Verben.)	"	"	*Pityrodia*
Verreauxia (Gooden.)	"	"	*Scaevola*
Anthotium (Gooden.)	"	"	*Dampiera*

In so far as the individual genera are concerned we find the same conditions prevailing in this group as in the former one: *Epiblema, Jansonia, Lamarchea, Needhamiella, Oligarrhena, Mallophora, Physopsis* and *Hemiphora* are to be named as monotypic genera. Species and form development is limited in *Acanthocarpus, Stawellia, Tersonia, Nematolepis, Geleznovia, Nematolepis* [sic], *Lysiosepalum, Wehlia, Conothamnus, Schoenolaena, Coleanthera, Verreauxia* and *Anthotium*. Pleomorphism is greater in *Guichenotia, Chamaelaucium, Scholtzia*, the Beaufortieae, *Eremaea, Conostephium* and *Microcorys*. In *Dryandra* it is especially evident. This genus is perhaps the most interesting and the most difficult of all the endemic genera of Western Australia. As it forms "a network of forms with the most diverse combinations of characters[1]".

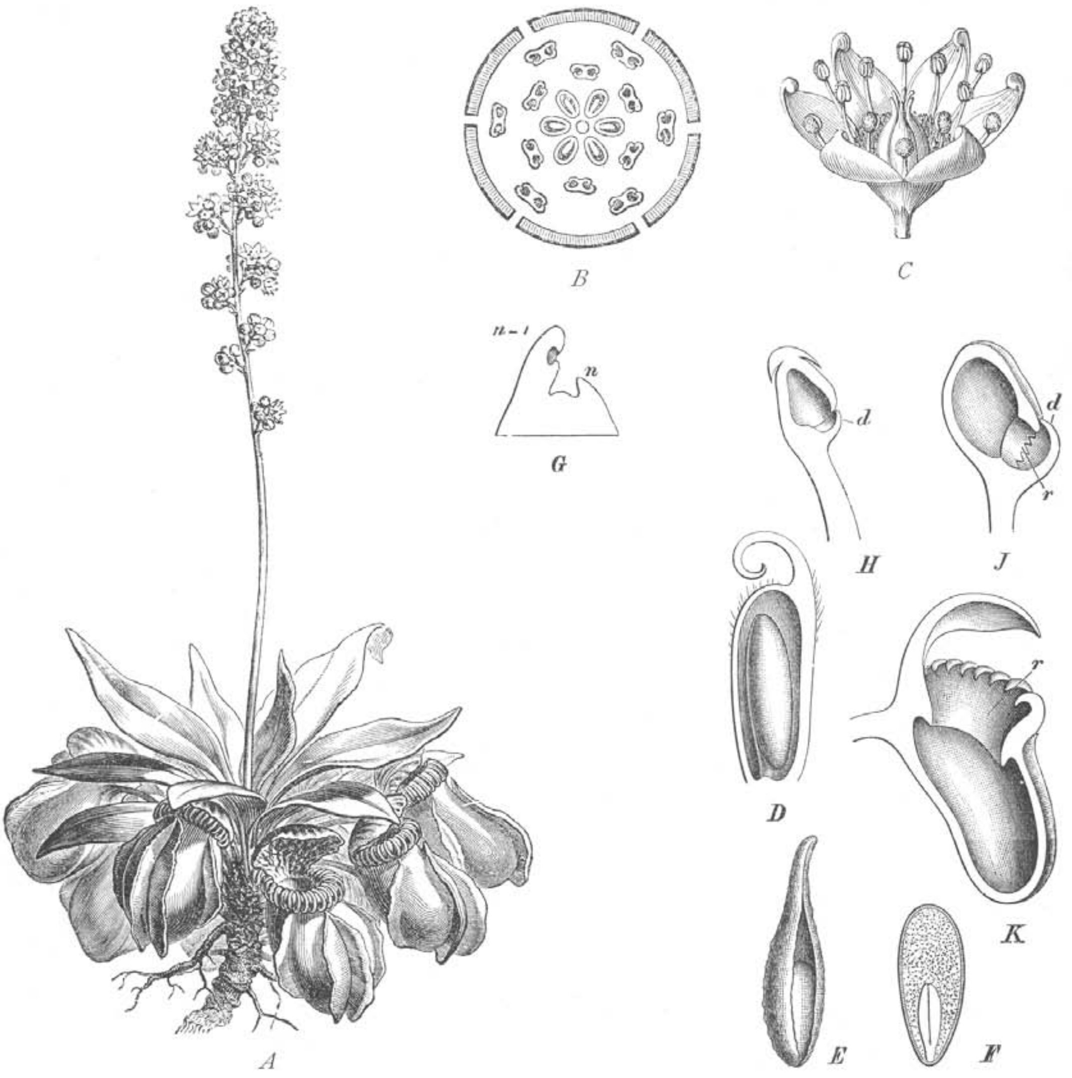


Fig. 80. *Cephalotus follicularis* Labill., eine der eigentümlichsten monotypischen Endemismen Südwest-Australiens: *A* Habitus (der Stengel ist in der Natur gewöhnlich erheblich länger als hier dargestellt!), *B* Diagramm der Blüte, *C* Blüte, *D* Carpell im Längsschnitt, *E* Früchtchen, *F* Samen im Längsschnitt, *G—K* verschiedene Stadien der Blatt-Entwickelung. (*A—C* nach

If one considers the characteristic and distinguishing features of this endemic group one becomes aware of certain similar tendencies. These are expressed in several

1 Diels and Pritzel, Fragm. Austr. occ. p. 170.

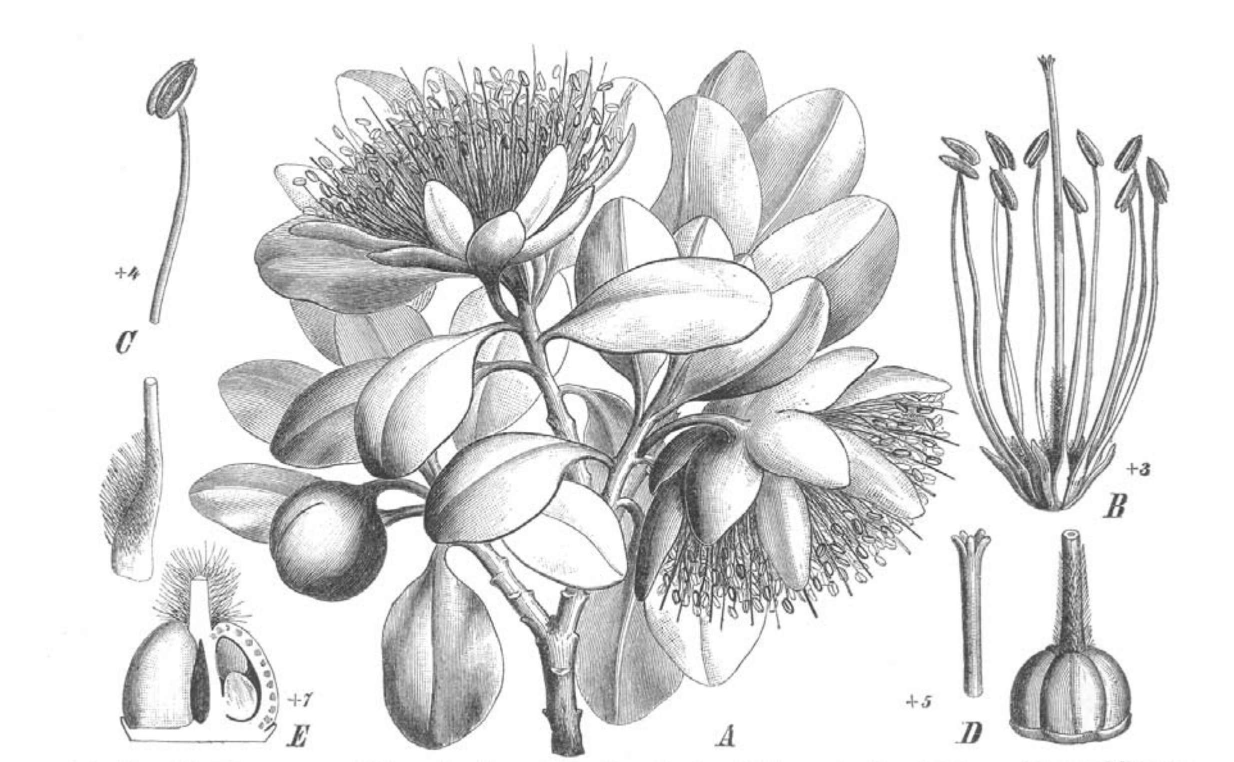


Fig. 81. *Diplolaena grandiflora* Desf.: *A* Zweig, *B* eine Blüte mit den kleinen Blumenblättern und den langen Staubblättern, *C* Staubblatt, *D* Gynaeceum, *E* Fruchtknoten. (Nach Engler.)

members in a manner not seen in the previously discussed groups. These tendencies are often revealed as being biologically helpful, or as morphological progressions.

One biological feature for example is that of the apparently protective device developed for the young flower by involving wider and wider circles into its service. This is illustrated by the heightened development of the involucre (Fig. 81), or of the calyx (Fig. 82). These features occur in several of our genera and to a certain extent characterize them. Such is the case in *Jansonia, Geleznovia* (Fig. 82), *Lysiosepalum, Guichenotia* and *Eremaea*. In *Dryandra* the shortening of the inflorescence together with the development of an involucre are essential features which separate the genus from *Banksia*.

Other genera are distinguished by morphological progressions.

In the genus *Nematolepis* (Rut.) we note the fusion of the petals. In *Coleanthera* (Epacrid.) the anthers are fused together, a feature not observed in related genera. *Stawellia* (Lil.) shows reduction in the number of stamens, and the flowers have become dioecious. *Oligarrhena* (Epacrid.) and *Hemiphora* (Verben.) are characterized by the reduction of the stamens to two. In *Scholtzia* (Myrt.) the number of ovules is reduced to two and in *Conothamnus* (Myrt.) to one. The Labiate genus *Microcorys* is characterised by the differentiation of the anthers which are no longer made up of two complete halves as in *Prostanthera*, but of one fertile half - the lower one is modified and is sterile. These are all progressive features in the organographical sense and since it is this kind of modification which characterizes a large part of the elements of this class of endemics, it indicates their nature quite clearly. They are off-shoots, “new twigs on old stems”, which have only developed in Western Australia.

Their origin or evolution naturally has no influence on distribution. Consequently the areas of distribution of these genera present similar features to those of the other endemics treated above.

Several tend to be northern forms - in particular *Geleznovia, Acanthocarpus, Scholtzia* and *Eremaea* which never occur south of the Murray River. In the west – i.e. in the coastal landscapes - this also holds good for *Chamaelaucium, Guichenotia* and *Verreauxia*. But in the Swan River neighbourhood these genera move inland from the coast. They avoid the wettest part of the area passing inland towards the south. Here *Chamaelaucium* and *Guichenotia* penetrate to the dry south-east coast while *Verreauxia* becomes lost in the far interior.

A more southern distribution is shown by *Jansonia, Latrobea* and *Schoenolaena*. It is only, however, east of the Frankland River that a new and very powerful development takes place with the appearance of *Nematolepis, Lysiosepalum*, the noteworthy trio - *Coleanthera, Needhamiella* and *Oligarrhena* and the uncommon polymorphic genus *Microcorys*, which appears to continue into the far interior.

In the greater part of the Southwest Province *Conostephium* is present, but far more important for the whole region is *Dryandra* whose constitution and distribution has already been discussed.

The interior regions provide more endemics for this category than for the first two classes. We have already shown that *Guichenotia, Verreauxia* and *Microcorys* extend into the interior but we must add four other genera, namely *Wehlia, Mallophora, Physopsis* and *Hemiphora*. These may be considered as creations of the sandy wastes of these landscapes. They are all found close to the boundary between the Southwest Province and the Eremaean Province. They occur in the region of winter rainfall but are collectively related to the Eremaean elements. They have the variable appearance shown by such Eremaean types as they approach the regions of winter rainfall.

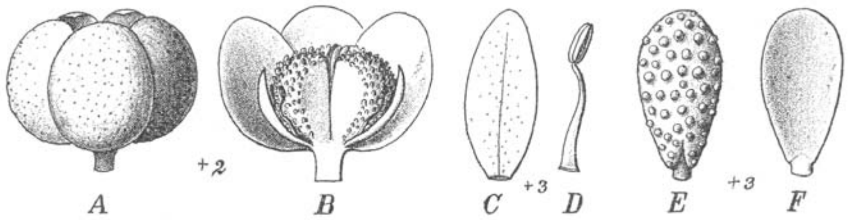


Fig. 82. *Geleznovia verrucosa* Turcz.: *A* Blüte mit den großen Kelchblättern zur Zeit der Fruchtreife, *B* dieselbe Blüte nach Entfernung zweier Kelchblätter, *C* Blumenblatt, *D* Staubblatt *E* Laubblatt von unten, *F* von oben. (Nach ENGLER.)

d. Naturalised Colonists

The Western Australian flora has also, and quite naturally through the presence of man, been invaded by aliens. As far back as 1840 Drummond stated in his letters that foreign weeds were spreading in the Colony. Most of them came from Cape region [South Africa] and from the eastern states of Australia. In some cases, e.g. *Hypochaeris*, one can trace exactly how they came and how they spread through the country. Most of them, (eg. *Anagallis arvensis, Heliophila pumila* (Crucif., Cap.) and *Romulea rosea* (L.) Eckl. (Irid., Cap.) have not as yet multiplied to any really great extent. They occur close to the towns and along the older traffic routes. Only a few of these invaders are really common. *Briza maxima* for example is common in the natural and original formations while *Cryptostemma calendulaceum* (Comp., Cap) in places - particularly in the north - covers whole fields entirely with their yellow ray flowers. Other species are only locally developed to any extent and give one the impression of being garden escapes – e.g. *Psoralea pinnata* (Legum.) from the Cape at King George Sound, or the wild roses in the open woodlands of the Blackwood River region. I have not observed any really marked effect of these introduced species on the native vegetation.

II. Eremaean Province

The elements of the Eremaean flora fall into several categories. To a certain extent they belong to groups which according to relationship and distribution can be traced from the north. There is in addition a considerable percentage belonging to polymorphic groups which have originated in the Eremaea. Finally there are some constituents which appear to have come from the surrounding coastal regions. Examples of these three sections will be discussed in the following pages. Final results are not available as it is impossible in many cases to judge the relationships and correct position of the species concerned.

a. Northern Elements

Members of this group have come apparently from the north.

In his description of the tropical Australian flora, Hooker (Fl. of Aust., p. XXXVIII on) gives a long list of species which extend from Australia into tropical countries. In addition to these there exists a considerable number of genera which may be taken as tropical elements in Australia. They differ, however, among themselves in-so-far as the degree of further development within Australia is concerned, and the extent of their influence on the neighbouring winter rainfall regions.

1. The species of *Loranthus*, particularly in the western Eremaea, show relationships with the north. Throughout Australia they become rarer as we travel south, and they are completely absent in Tasmania.

2. The Santalaceae (Part 4, Ch. 3) are relatively uniformly distributed over the Australian continent. Many species traverse the entire Eremaea without interruptions of any extent, e.g. *Fusanus spicatus, Choretrum glomeratum* and *Exocarpus aphyllus*. Notwithstanding this, however, there is a slight tendency to favour the east where some species of *Santalum, Omphacomeria* and several distinct species of *Exocarpos* are found. Since the western parts of the area have little to balance this and present no primitive forms, we may assume that the centre for the Santalaceae also lies in the north east. The close relations of the Malaysian-Indian Santalaceae as well as the fact that members of the Anthoboleae of Australia appear to be descendant types, provides further support for this assumption.

3. The Phytolaccaceae resemble the Santalaceae in so far that the biggest development of the group is found in the Eremaea and the more primitive forms are found to the east. The west possesses a number of derived types (*Gyrostemon subnudus,* species of *Didymotheca* and *Tersonia*), while on the other hand, in the east polycarpic species of *Codonocarpus* occur.

4. The two Eremaean members of the Pittosporaceae of our region are without doubt eastern types which extend over the whole Eremaean area without specific change.

5. Several genera of Leguminosae - eg. *Crotalaria, Indigofera, Glycyrrhiza, Cassia* and related forms - resemble the Malvaceae and the Tilliacean genus *Corchorus* in that as real tropical elements they are developed predominantly in the northern Eremaea. Some show little variation in form, e.g. *Glycyrrhiza*, but others have developed a variety of forms and belong to the character plants of the warmer Eremaea, eg *Cassia, Sida* and *Hibiscus*.

6. I place the Australian Sterculiaceae also amongst the tropical elements. Their development in Australia is nevertheless so important that they have already been discussed in detail.

7. *Didiscus* (Umbell.) is a predominantly Western Australian Eremaean type. Its general distribution points to a north eastern origin.

8. *Halgania* (Borrag.) may be regarded as a descendant of a palaeotropical Boraginaceous type embodied in *Trichodesma*. It has spread far over the Eremaea and developed an adaptively ordered network of forms.

b Autochthonous Elements

These very important elements, which disclose nothing about a foreign origin, appear to have developed in the Eremaea itself out of types which are no longer in existence.

1. Amongst these I include the Amaranthaceae. This is, however, at the same time a kind of transition to the preceding group (northern elements). They are true Eremaean plants and many typical species extend right across the Australian dry region. But in contrast to the Myoporaceae; and other families, the Amaranthaceae shows no impor-

tant development in the south. Its main centre lies in the north, probably in the north western tropics, where new and peculiar forms are still being discovered. In the south on the other hand *Trichinium* and *Ptilotus* are distinctly rare.

2. The preference for the north is not so evident in most other types in this category. Very many important components such as the Chenopodiaceae, Cruciferae, Portulacaceae, *Templetonia* (Legum.) *Swainsona* (Legum.), Zygophyllaceae, *Dodonaea* (Sapind.) - at least to a large extent, *Loudonia* (Halor.), *Brunonia* and many genera of Composites in the Eremaea (*Calotis, Brachycome, Olearia, Minuria, Angiantheae, Helichrysum* - several species, *Waitzia, Helipterum* and *Podolepis*, pass more or less uniformly over the southern parts of the Eremaea.

3. Other groups are characteristically massed in the south west. Morphologically they show that they have originated or been stimulated to vigorous development there. An example is provided by the family Myoporaceae. I have studied the genus *Myoporum* and discussed the conditions of the more progressive groups as follows (Diels and Pritzel, Fragm. Austr. occ., p. 535.): "The progressive evolutionary changes in the corolla and ovary seem to have reached completion in the southern half of the Australian continent. This is particularly true in parts where the dry areas of the interior most closely approach the coast (South Australia and easterly parts of Western Australia). The northern half of the continent is poor in Myoporacean types, and also in the most northern parts of Western Australia they are poorly represented." Several sections in Bentham's grouping extend in relatively unaltered form over the whole of Australia through the Eremaean region. "But it is only in South and Western Australia that the relationship between these types themselves, and between the main components of the Family, becomes closer."

A similar condition holds good for the Frankeniaceae in which an unmistakeable progressive development has taken place in the western parts of the Eremaea. I have made the following statement regarding it in Fragm. Austr. occ., p. 388: "There are a number of well defined species in the boundary regions of the Eremaea, particularly where the influence of the winter rains is felt. There are three ways in which these endemics become modified. First there is the crowding together of the flowers (such as occurs in so many endemics particularly of Western Australia). Then we have reduction of the number of whorls to two, (as in the *Frankenia tetrapetala* group). Finally there is a strong reduction in the number of ovules, obviously independently arrived at in several species. The endemic *Frankenia* species of Western Australia are therefore characterized by features which suggest earlier modification. Whether or not the modified species developed from older species still in existence is impossible to say."

In this connection the so called Verbenaceae of the Eremaea must be mentioned –the Lachnostachydinae and the Chloanthinae. The origin of the both groups involved here is obscure. In the case of the Lachnostachydinae we find that in addition to the more widely spread genera *Newcastelia* and *Dicrastylis*, other types are present in the south west area of the Eremaea. The Chloanthinae have developed two secondary centres of development - one on the western margin of the Eremaea and in the transition zone to the Southwest Province, the other in the north east of the whole area.

The family Compositae has also produced several developmental centres in the western part of the Eremaea. Genera involved here are *Waitzia* and *Helipterum* and also those groups out of which *Schoenia* and *Cephalipterum* have been differentiated.

c. Intrusion of Eremaean elements into the Southwest Province.

The Southwest Province includes certain formations in all its boundary districts which are characterized by their Eremaean facies. This is most evident in depressions carrying a heavier soil with a loamy or clay substratum. It is through channels and valleys that many representatives of the Eremaea invade the Southwest Province. Some of them extend far into the south western floral zone, so that both floral types are represented in the vegetation. Such species are nevertheless to be looked on as wandering members of the Eremaean flora and in most of the south western districts they disappear altogether. Owing to their direct connection with the Eremaea, however, they need no further discussion here.

On the other the importance of the Eremaean elements in relation to the coastal region of the south west, deserves particular mention. We have already pointed out in describing the formation, what a large number of Eremaean elements extend along the coast or at least intrude far into the littoral area from the east and north. Many representatives of the families Santalaceae and Loranthaceae have thus penetrated into the coastal woodlands and occur further south in these formations, than anywhere else in the true south western flora.

Callitris robusta (Pinac.) an important almost Pan-Australian species is absent from the whole of the South Western Province with the exception of the littoral zone where it occurs not uncommonly as a bush or tree. Similar conditions are presented in the south east part of the Province by *Callitris Drummondii.* In addition to these examples there is a whole series of species whose distribution is more or less the same in forms of the criteria adopted. They are amongst the most common features of the coastal formation of the south-west. I might mention *Gyrostemon* (Phytolacc.), *Fusanus acuminatus* (Solan.) [sic], *Pittosporum phylliraeoides* (Pittspor.), several acacias and some species of *Eucalyptus, Templetonia retusa* (Legum.), *Zygophyllum fruticulosum* (Zygophyll.), *Frankenia pauciflora* (Franken.), *Eremophila Brownii* (Myopor.) and *Olearia axillaris* (Comp.).

In the Angiantheae (Compos.) we can demonstrate as follows (Diels and Pritzel Fragm. Austr. occ., p.608): "As so commonly occurs in the Eremaean groups, the Littoral zone has its own species which extend along the coast from Shark Bay down below the Swan River - (eg. *Angianthus Cunninghamii, Calocephalus Brownii*)".

Several factors are involved in bringing about these close relations between the Littoral and Eremaean areas. The most important are the edaphic influences. These act directly through the ability of both types of floral elements to tolerate high concentrations of sodium chloride, and indirectly and perhaps most important still, through the exclusion of most of the south western plants from such areas. Another factor influencing the existence of many of the Eremaean plants may well be the lack of those trees whose absence results in the more open character of the plant associations. Such Eremaean plants appear to be unable to penetrate into the south western forest areas, but they can find their way to the Littoral zone by way of the north and east. The genus *Adriana* of the Euphorbiaceae which is certainly not an original type of the south west, is an example showing both modes of entry. *A. tomentosa* has its headquarters in the tropical north west of the continent from whence it has passed south beyond Shark Bay into the north western part of the south western Littoral. The second example is *A. quadripartita* which occurs commonly on the south coast and extends along the shore of the Great [Australian] Bight. It borders the Southwest Province over a wide range and extends north at least as far as the Swan River.

With the exception of the Pan-Australian elements treated earlier the polymorphic groups of the Eremaea stop at the boundary of the Southwest Province, or if they do penetrate they show no further development there. The contrasts in the character of the climate may well explain this.

There are, however, some exceptions from this normal condition. Thus in the case of the Verbenaceae there is an important further evolution on the south western margin of the Eremaea which is possibly due to the influence of the winter rain climate. *Lachnostachys*, which is a most progressive genus of the Lachnostachydinae attains a high degree of development there. The Chloanthinae are also "most richly developed on the western margin of the Eremaea and in the transition zones of the Southwest Province" (Diels and Pritzel Fragm. Austr. occ., p. 495).

Certain species of the genus *Dodonaea* are of great importance within the real Southwest Province[1]. However the greater part of this genus is undoubtedly Eremaean, moreover, on general plant geographical grounds, the genus appears in the Southwest Province only as a secondary development. It should be noted that the group, "Cornutae", (in which the wings of the fruit are reduced) originated in the south west. The other sections of the genus originated in the Eremaea.

1 See Diels and Pritzel, Fragm. Austr. occ. p. 344, 345.

CHAPTER 3 FLORISTIC RELATIONSHIPS OF EXTRA-TROPICAL WESTERN AUSTRALIA WITH OTHER REGIONS.

a. Relationships with other parts of the Earth, particularly the Cape region.

The flora which characterizes the extra-tropical parts of Western Australia is not restricted to the two provinces of this area, but extends far into other parts of the continent. It is specifically Australian. It shows therefore, the closest relationship to the flora of the east coast of the continent and presents also important links with that of the northern part of Australia. The above, however, includes all its affinities. In no other part of the earth does one find connecting links. While eastern Australia is in very close connection with the Malaysian-Papuan region, Western Australia shows no such connection with Malaysia to the north.

There is no evidence for even an indirect exchange since there is no inclusion of the Malaysian components of the east Australian flora in the extra-tropical west. This negative character is the most important difference between the east and west Australian floras. The only examples which might be considered as exceptions are certain liana-like plants of the northern Southwest Province (*Clematicissus*, *Dioscorea*), but they are of no great account.

One has often had occasion to refer to the floristic relations between south west Australia and Cape region [South Africa]. This is due in the first place to the geographical analogies between both regions, the general resemblance in structure, climatic differentiation, and in certain analogies which may be demonstrated in the types of soil on the western coastal plain. A similarity in the physiognomy of the vegetation has been brought about by these features - the dominance of the everlasting green sclerophyll formations with great diversity of species. Taking everything into consideration, however, there are still great differences between the vegetation of the Cape region and Western Australia. To fail to appreciate this despite the similarity of external conditions in both regions, would be a great error. In this the contrast between the actual and the expected provides a salutary lesson.

There are for instance no plants which grow to tree-size in the real Cape region. Some species in the gorges of the mountains do attain to arborecent stature, but there is a complete absence of anything that might be compared with the imposing eucalypts, casuarinas or even banksias of the Southwest Province. Even in the Eremaea of Western Australia in some regions which correspond climatically with the Karroo, stately trees and man-high shrubs are present.

Many succulent plants are present in the Cape region. Thus on the actual slopes of the mountains of Capetown itself one can find cactoid euphorbias and species of the succulent *Mesembrianthemum* growing quite strongly. On the sandhills of the north west, *Tetragonia* and *Zygophyllum* dominate. *Stapelia* and *Aloineae* occur on the Karroo-like plains while species of *Mesembrianthemum* of all shapes and sizes (but always with the typical fleshy leaves) are constant features of the scenery. Western Australia has nothing comparable to this. Only the coastal-formations and the desert-like interior possesses succulent forms and these are unimportant for they belong to almost cosmopolitan orders (Zygophyllaceae, Chenopodiaceae and Aizoaceae).

The Cape region of South Africa is famous on account of its richness in tuberous plants. The amazing number of Lilies, Amaryllids and Iridaceae is well known and the multitude of Orchids (ground forms), the diverse forms of *Oxalis* and the tuberous species of *Pelargonium, Cyphia, Euphorbia* and other genera unite in forming an entity which in all parts of the south western Cape region is of the greatest importance in determining the physiognomy of the landscape. In Western Australia the Southwest Province at least has also its beautiful lily flora, its rare species of Orchids and species of *Drosera* and *Trachymene* with bulbs and tubers. But even if they all bloomed at the same time their physiognomic effect would be infinitesimal as compared with the richness and beauty of the flowers covering the South African landscape when the bulbous plants are in blossom.

In the Cape region the annuals play a most important role. In particular on sandy soil the number of annuals which come and go with the rainy season is high and their diversity most surprising. In the dry regions the sandplains after the wet months are often exclusively covered with the gay and delicate flowers of the ephemeral flora. The loamy and clayey soils, however, also produce a large number of beautiful annuals, Composites in particular adorn the ground in crowded masses. In Western Australia it is only in the Eremaea and the country influenced by the Eremaea where the Composites here and there show a similar importance. In the south-west on the contrary, Composites are poorly represented, and other families do not occur to compensate for this. Furthermore a difference from South Africa lies in the fact that the sandy soils are poor in annuals. One never finds mass developments upon them as in South Africa, as for example on the Olifant River. The annuals in the Southwest Province are of as little importance as are the tuberous plants in terms of being part of the vegetation scene.

One has, however, to recognize certain bridges between the South African flora and that of Western Australia. J. D. Hooker dedicates a whole chapter in his “Introductory Essay on the Flora of Australia, its Origins, Relationships and Distribution” to the South African traits of the Australians vegetation, and refers more than once to the more concentrated nature of these relationships in south west Australia.

On page 92 of his work, Hooker gives a list of the families which are richer in species in South Africa and Australia than anywhere else on the earth. They are as follows:

Proteaceae	Restiaceae	Thymeleaceae
Compositae	Epacrideae, Ericaeae	Santalaceae
Irideae	Decandrous Papilionaceae,	Anthospermous Rubiaceae
Haemodoraceae	and tribes Podalyrieae	
Buettneriaceae	and Loteae	
Polygaleae	Rutaceae	

He also names *Encephalartos* as a common form, (*Macrozamia* was to be included in this) together with a series of other genera not repeated here as they are not of importance in south west Australia and are altogether very heterogenous in nature. What Hooker found surprising was the presence of genera which are common to Western Australia and South Africa, but absent from the rest of the world, e.g. *Encephalartos, Restio, Hypolaena* and *Angullaria.* Hooker also mentions as negative items of agreement the rareness of the Aracaceae, Lauracaceae, and the Rubiaceae, excluding Anthospermeae.

The advance in the study of relationships in the plant world and the deeper study of the flora of Australia puts the above list in another light from that of Hooker’s time. It has been shown that the Haemodoraceae, the Polygaleae, the Rutaceae, Thymeleae and Droseraceae of the Cape are not directly related with those groups in Australia. It is also doubtful whether the Leguminosae, many members of Compositae or the Anthospermeae of both regions present close affinity with each other or are only convergent types. The Epacridaceae have long been considered as a parallel evolution to the Ericaceae.

Thus there remains only the Proteaceae and the Restionaceae. These certainly present an undisputed analogy between South Africa and Australia. From the point of view of numbers they are far more numerous in south west Australia and it would appear therefore as if the centre of convergence with the Cape lay in that Province. This however, indicates no direct relationship between the two regions. It may be more suitably explained from the geographical conditions ; graded climatic differences occur in the two areas, there is a natural hindrance in both to the entrance of heterogeneous elements, and finally there is in the two areas a wide distribution of sandy soil.

Before a final conclusion is possible it must be demonstrated that there is a distinction between the two countries. This already has been done by J. D. Hooker. He has placed in two groups the families which are poorly represented or entirely absent from Australia or South Africa. Of the typical Cape families poorly represented or absent in Australia we have the Geraniaceae, Oxalidaceae, Aizoaceae, *Brunoniaceae, *Penaeaceae, Crassulaceae, Ericaceae, Campanulaceae, *Stilbaceae, *Selaginaceae. On the other hand amongst the typical Australian families the following are absent or poorly represented in the Cape: *Dilleniaceae, Sapindaceae, *Tremandraceae, Pittosporaceae, *Stackhousiaceae, Haloragaceae, Myrtaceae, *Goodeniaceae *Stylidiaceae, Brunoniaceae, *Epacridaceae, Loganiaceae, Myoporaceae and *Casuarinaceae.

This large list of floral differences and the striking differences between the types of vegetation of the Cape and of Australia leave no doubt how we must consider the floristic relations of the two regions. A direct influence between them is out of the question. The similarities are to be explained rather on two grounds, the one arising as a derivation from common sources, the other on convergent evolution.

That common source is an old southern hemisphere flora to which many of the present-day groups of plants belong. The further study of this will no doubt furnish important information concerning the history of the present plant geography and its relation to plant evolution. The Proteaceae, Droseraceae and Restionaceae belong without doubt to the common flora.

In contrast to this we must note the lack of boreal groups in both South Africa and in Australia - e.g the Abietineae, Betulaceae, Platanaceae, Juglandaceae, Berberidaceae and so on.

As convergences we have the rich development of certain branches under the climatically similar conditions of both continents - as shown by the Rutaceae, Sterculiaceae and annual composites. In the same way the poor development of hydrothermic elements may be explained.

b Relationships within Australia.

The study of the relations between the different floras of the districts of Australia has already received some attention from earlier authors. Hooker was the first to go into detail as regards this Later on Engler used the materials of the “Flora Australiensis” and the details in F. v. Müller’s Census in order to present statistically the most important peculiarities of Australian flora.

These two investigators have worked up the material available to the last detail and even given percentages in decimals. In spite, however, of this extraordinary exactness it gives no true picture of the real conditions, and can not do so for both used (as does Bentham in Flora Australiensis) the political divisions of Australia as the basis of their subdivisions. Engler was to a certain extent aware of the danger of this and stated that to give up the political boundaries “would have resulted in more natural and better characterized areas, and sharper and better results. However, this would have required as many years for the working out of the tables as it had taken months for the present table. We also know that the given results are supplemented from other sources[1]”. Engler’s opinion is also suggested by his statement that “the politcal subdivisions of Australia correspond much more with the natural than does the political divisions of other countries”. We know today, however, that the differences between the political and natural subdivisions of Australia were greatly under-estimated. Consequently for any detailed presentation of the floristic conditions within the continent a complete revision of the material available on the basis of a natural subdivision is necessary. This is the work which Engler recognized would take a considerable time. It has not yet been completed.

The incompleteness of records is also responsible for the fact that neither in Hooker nor in Engler does the most essential feature of the entire Australian flora become apparent, namely the presence of the Eremaean flora. This flora is lost or hidden in their lists and tables dealing with the flora of Queensland, New South Wales, Victoria, South Australia and Western Australia. It is combined everywhere with the heterogeneous flora of the coastal districts. It may thus be easily seen how the most interesting features of the floristics of the country may be lost sight of.

1 Versuch einer Entwickelungsgeschichte. II 14 (1882)

The floristic duality which exists in all five States was first understood and correctly evaluated by R. Tate for South Australia. He distinguished an "Eremean Region" in that State as separate from an "Euronotian Region", and at the same time gave an exact analysis of the whole South Australian flora which was required to demonstrate clearly the floral characteristics of the two regions.

In addition to the two above-mentioned districts of South Australia Tate recognized in Australia only the autochthonian flora which corresponds to that of our Southwest Province. The future will always have to reckon with these three categories of Tate, for only then will a clear picture of the constitution of the various areas be possible.

It follows from this that the position of the flora of Western Australia within Australia can only be correctly understood when one considers the Southwest Province separately from the Eremaean province.

a. Eremaean Province.

The Eremaean part of Western Australia was as good as unknown in Hooker's time. Drummond had only touched on its borders. Consequently Hooker's statistics refer almost solely to the Southwest Province and must be judged in relation to that.

Even today our knowledge of the Eremaean Region is still quite incomplete. As compared with the area concerned the material so far obtained is relatively small. One thing, however, is already certain, namely, that the Western Australian Eremaea is not a separate entity. In biogeographical terms it is not separate from the rest of the Eremaea. One can only speak of the Eremaea as a whole.

The position at the present time is that about 40% of the species of the Western Australian Eremaea is regarded as being endemic, but it would be a mistake to conclude that the Western Eremaea should be separated from the rest because of this. In the first place this figure will probably be reduced as a closer investigation of the whole Eremaea is made. In the second place, the percentage is made up of species which taxonomically are not particularly distinguished. Finally, the really important species have already been recorded from the whole Eremaea. How far the general vegetation agrees within the region may be seen when a description from eastern Australia is compared with ours from the West. W. Woolls published in 1867 some observations on the flora of Australia and in a section dealing with the "Plants of the Darling" he listed numerous character plants of the Darling District[1]. Almost all of these appear again and play an important part in the flora of the west: - eg. *Lavatera plebeia* (Malv.) *Clianthus Dampieri* (Legum.), *Eremophila* (Myopor.), *Cassia Sturtii* (Legum.), *Lotus australia* (Legum.), many everlastings, *Fugosia hakeifolia* (Malvac.), *Zygophyllum* (Zygophyll.), *Dodonaea* (Sapind.), Chenopodiaceae, *Exocarpos aphyllus* (Santal.), *Fusanus acuminatus* (Santal.), *Scaevola spinescens* (Gooden.), and *Stipa elegantissima* (Gramin.).

The "oneness" of the Eremaean flora has up to the present time not been recognised and in any case given insufficient weight by the plant geographers. This explains also why no adequate investigation has as yet been made into the relationships and origin of its flora.

Hooker does indicate here and there its near relationship to the flora of tropical Australia giving as evidence, however, a comparatively unimportant palaeotropic character. As a matter of fact the flora of the Eremaea still exhibits much of this palaeotropic foundation. The following important genera of the Eremaean flora are well known sub-cosmopolitan or palaeotropical types. They represent the "Exotic Elements" as Tate[2] expresses it, of the Eremaean flora:

1 W. Woolls, A Contribution to the Flora of Australia. Sydney 1867, 192-202.

2 R. Tate in "Australas. Assoc. Advanc. Science. Report I Meeting." Sydney 1888, 317.

Jonidium (Viol.)	*Brachychiton* (Sercul.)	*Crotalaria* (Legum.)
Zygophyllum (Zygophyll.)	*Atriplex* (Chenopod.)	*Indigofera* (Legum.)
Nitraria (Zygophyll.)	*Chenopodium* (Chenopod.)	*Cassia* (Legum.)
Tribulus (Zygophyll.)	*Kochia* (Chenopod.)	*Exocarpos* (Santal.)
Lavatera (Malvac.)	*Bassia* (Chenopod.)	*Solanum* (Solan.)
Sida (Malvac.)	*Salicornia* (Chenopod.)	*Heliotropium* (Borr.)
Hibiscus (Malvac.)	*Trianthema* (Aizoac.)	*Eragrostis* (Gramin.)
Abutilon (Malvac.)	*Boerhavia* (Nyctag.)	*Triodia* (Gramin.)

Most of these plants are either absent or rare outside the Eremaean parts of Australia.

Frequently, however, a more or less wider development has taken place. This is particularly the case with the Amaranthaceae, the Malvaceae and *Dodonaea.* Members of the Santalaceae and species of *Acacia* and *Eucalyptus* probably indicate northern influences. They are not restricted to the Eremaea.

Other elements of the Eremaea are not so easily understood genetically. In so far as the numerous plants of the Chenopodiaceae and Myoporaceae of the Eremaea are concerned one is probably closest to the truth if one assumes that they owe their origin to the continued development of originally littoral types. On the other hand the origin of the Gyrostemoneae (Phytolacc.), the peculiar Chloanthinae and Lachnostachydinae (Verben.) and also that of most of the everlastings (Compos.) is very problematic.

All things considered the Eremaean flora shows the strongest affinity with the flora of tropical north Australia. This affinity is so great that both flora gradually pass one into another and no sharp boundary occurs between them.

The relationship with the extra-tropical floras is much weaker. We have seen that in Western Australia the Eremaean flora and the south-west flora often pass over into one another's districts. Thus on sandy soils within the Eremaea one finds south-western genera while whole formations of Eremaean types invade the Southwest Province and in the littoral practically surround south-western formations. Despite this there seldom appears to be any really successful exchange between the two floras. The real south-western groups as a rule have attained but little further development in the Eremaea. Rarely have Eremaean types branched off from south-western stock, except perhaps here and there in the genera *Eucalyptus* and *Acacia.* More frequently the reverse has taken place and many acacias, eucalypts, composites, santalaceous plants and dodonaeas, etc. of the south west are seen to be derivatives of the Eremaean flora. Further details relating to this are given in the next section.

In south-eastern Australia the inter-mixing of the Eremaean elements and the types of the coastal flora is more intimate. This is favoured by the prevailing climatic conditions. The conditions are in general, however, much more complicated than in the west, because the hydrothermic Malaysian element and the Antarctic admixtures are present and result in a much more diverse flora.

b Southwest Province.

All authors who have discussed the floristics of Australia have recognized the independence of the south west and emphasized its difference from the rest of the continent. As we shall see presently, the earlier views were somewhat vague since the geographical boundaries of the western flora were uncertain. Nevertheless they were struck by the uncommonly rich development in the west. Later on, after Tate had traced its boundaries with greater exactitude, he denoted the south western flora by the term "autochthonian". I have intentionally avoided this name because it conveys definite genetic implications which I can not accept. Tate[1] assumed that the autochthonous element was the oldest constituent of the whole Australian flora. He believed that it originally covered the whole continent, and that in the Cretaceous period it became split up. As a result of this separation a moderate development took place in the south east, a major

1 R. Tate in Australas. Assoc. Advanc. Science. Report I. Meet. Sydney 1888.

modification took place in the Eremaea, while in the west little change occurred. The original flora maintained its position and then a further and richer development occurred. Other authors have gone even further and assumed that the autochthonous flora was originally only present in Western Australia and that it later spread from there over the rest of the continent.

In order to determine the correctness of this assumption one must first test the present day relationships of the south west flora. In relation to this, J. D. Hooker has already drawn certain conclusions from his data. "When one investigates the extra-tropical flora of Australia" he says (*loc. cit.* p. 50) "the first thing which attracts attention is the remarkable difference between the eastern and western parts of the continent. There is nothing analogous to this in the tropical portions of the continent. An experimental estimation will serve to show approximately how great this difference is, a difference which is all the more important because I believe it is without parallel in plant geography. These floras contain, according to my figures:

	South West	South East, including Tasmania
Families	90	125
Genera	600	700
Species	3600	3000

So far as I can determine about one-fifth of the south eastern species are distributed beyond that area but only one-tenth of them are to be found in south-western Australia".

Hooker then continues with the suggestion that the floristic peculiarities and contrasts of both these regions of Australia differ from normal expectations. Both areas are about the same parallels of latitude, their physical conditions are not appreciably different, or at least not as different as in the case of say Greece, Spain, and other countries, which present no such floristic contrasts. The regions are only 1700 (engl.) miles apart and are everywhere connected by land. From analogy with other countries one would expect the richer flora to occur in the south east. This is because its area is much greater, it has many large rivers, extensive mountain systems and moist forests. This, however, is not the case. "Despite the fact that the area is larger, that it has been more closely investigated, and is more diversely conditioned, despite the large number of families and genera there are, nevertheless, several hundred fewer species than in the south west."

To emphasize this important point further, J. W. Hooker (*loc cit.* p. 51), has compared the largest genera of the two areas in order to show how small is the number of species common to each area. In order to show the kind of result I append the second of his tables here (containing the south-western Australian genera). The only alteration is that the figures are brought up to date to correspond with our present knowledge of species and of plant geography.

	Species in W. Austral.	No. of these in SE. Austral.		Species in W. Austral.	No. of these in SE. Austral.
Acacia (Legum.)	144	11	*Lasiopetalum* (Stercul.)	23	1
Grevillea (Prot.)	112	5	*Calothamnos* (Myrt.)	22	-
Leucopogon (Epacrid.)	88	6	*Xerotes* (Lil.)	22	4
Melaleuca (Myrt.)	80	3	*Lepidosperma* (Cyper.)	21	4
Hakea (Prot.)	74	3	*Darwinia* (Myrt.)	21	-
Stylidium (Stylid.)	69	3	*Pultenaea* (Legum.)	21	2
Eremophila (Myopor.)	63	11	*Andersonia* (Epacr.)	20	-
Eucalyptus (Myrt.)	53	8 (0)	*Angianthus* (Comp.)	20	4
Hibbertia (Dillen.)	52	1	*Oxylobium* (Legum.)	20	-

**Dryandra* (Prot.)	48	0	*Hydrocotyle* (Umbell.)	19	5
Schoenus (Cyper.)	47	3	*Caladenia* (Orchid.)	19	3
Daviesia (Legum.)	46	2	*Olearia* (Compos.)	18	3
**Verticordia* (Myrt.)	46	-	*Gahnia* (Cyper.)	18	6
Scaevola (Gooden.)	39	5	*Adenanthos* (Prot.)	17	1
Boronia (Rut.)	38	1	*Astroloma* (Epacr.)	17	1
Banksia (Prot.)	37	-	*Stipa* (Gramin.)	17	8
Baeckea (Myrt.)	37	2	*Pityrodia* (Verben.)	17	-
Goodenia (Gooden.)	36	5	*Casuarina* (Casuar.)	17	3
Dampiera (Gooden.)	36	1	*Bossiaea* (Legum.)	17	1
Conostylis (Amaryll.)	34	-	*Helichrysum* (Compos.)	17	5
Petrophila (Prot.)	34	-	*Comesperma* (Polygal.)	16	5
Gastrolobium (Legum.)	33	1	*Microcorys* (Lab.)	16	-
Helipterum (Compos.)	33	12	*Restio* (Restion.)	16	-
Trichinium (Amaran.)	32	8 (1)	*Kochia* (Chenopod.)	16	7
Drosera (Dros.)	32	2	*Leschenaultia* (Gooden.)	16	-
Pimelea (Thymel.)	32	5	*Calandrinia* (Portulac.)	15	7
Calythrix (Myrt.)	30	1	*Thysanotus* (Lil.)	15	2
Jacksonia (Legum.)	29	-	*Beaufortia* (Myrt.)	15	-
Conospermum (Prot.)	28	-	*Gompholobium* (Legum.)	15	-
Haloragis (Halorag.)	27	5	*Xanthosia* (Umbell.)	14	1
Isopogon (Prot.)	27	-	*Solanum* (Solan.)	14	9
Hemigenia (Lab.)	26	-	*Atriplex* (Chenopod.)	14	10
Dodonaea (Sapind.)	26	6 (1)	*Cryptandra* (Rhamn.)	14	-
Persoonia (Prot.)	25	-	*Gnephosis* (Compos.)	13	2
Thomasia (Stercul.)	23	1	Logania (Logan.)	13	4
Thelymitra (Orchid.)	13	6	*Chamaelaucium* (Myrt.)	12	-
Patersonia (Irid.)	13	-	*Scholtzia* (Myrt.)	12	-
Hypocalymma (Myrt.)	13	-	*Trachymene* (Umbell.)	12	-
Spyridium (Rhamn.)	13	-	*Scirpus* (Cyper.)	12	9
Brachycome (Compos.)	12	3			

The results agree (notwithstanding all the alterations in the figures) in all essentials with Hooker's communication of 50 years ago. However, despite the similarity of our material we have today come to hold very different views from those of Hooker. The contrast does not lie between south-west and south-east, but between the south-west and the Eremaea. Our list could come out practically the same as the above if we compared the south-west and the Eremaea. The contrasting regions are thus not 1700 miles apart, but actually touch. Thus the speculations and objections of Hooker have for the greater part no point, or rather they must be re-applied in quite another direction. The question of the relationships of Western Australia falls into two questions - what relations exist between the Southwest Province and the Eremaea and what relations exist between between the Southwest Province and the south-east?

1. Floristic Relationships between the Southwest Province and the Eremaea.

The intermingling of south-western and Eremaean floras has been touched on in several places in our discussion. I will refrain from further repetition here except to remind the reader of the Eremaean character of the whole littoral flora; the invasion by the Eremaea of the loamy terrain, of the transition landscapes and the floristic mixture of both floras, particularly in the northern landscapes. Because of this the Irwin District receives much that is peculiar, but the first exploration of Drummond demonstrated strikingly that its vegetation was "still typical of the Swan River" as Hooker himself pointed out. (Introduct. Ess. Fl. of Aust. p. 38).

The great differences of the real Eremaean flora from the Southwest can be seen from the preceding lists and from the earlier discussions. It remains to be said that these differences were distinctly recognized by J. D. Hooker but not correctly interpreted since he compared the south east with the south west, and knew little of the flora of the intervening zone. In this way he confused two different problems, namely: (1) The floristic contrasts of the west and the Eremaea, and (2) the contrast of the "richer" flora of the west and the "poorer" flora of the naturally more diverse south-eastern environment.

We have for the present only to concern ourselves with the first of these points. All the facts regarding this have been given. We have only found a limited number of species which are equally widespread in the two regions. They were chiefly annuals of epigeal ephemeral growths. The characteristic genera of the Eremaea succeed in obtaining not only room for their species in the transition boundary regions of the Southwest Provicnce, but show further morphological development. The Verbenaceae provide an example. The genus *Trichinium* has also produced true south-western species such as the beautiful *Trichinium Manglesii.* The same holds good for the annual composites which undoubtedly have their headquarters in the Eremaea but have nevertheless produced endemics in the Southwest such as *Helipterum* and *Angianthus*

All this, however, scarcely affects the far-reaching contrasts which separate the two floras. It is not possible today to explain adequately the causes for this contrast. But important lines of evidence can be brought forward and these are naturally partly of a geographical and partly of a genetic nature.

Looked at geographically the Eremaean flora covers a very uniform area which because of its wide extent over the Australian continent is subjected to a succession of edaphically suitable conditions, while climatically it remains very uniform. There are no restrictions to migration. All the conditions are suitable, therefore for the extensive distribution of types which are constant in form. This feature is characteristic of the Eremaea. The climatic variability of the rainfall makes the immigration to any extent of types from the regions of regular rainfall exceedingly difficult. In particular migration from the winter rainfall regions is almost entirely precluded. It is only in the west in the boundary zone south of 30° where the winter rains occur (even although very weak) that certain suitable edaphic conditions, an invasion of the Eremaean flora by the south-western flora occurs. These are the plains with sandy surface layers. On this porous soil the period of adequate moisture is too transient for most of the Eremaean elements which are either ground water plants or ephemeral herbs. The psammophilous dwarf shrubs on the contrary, which originated in the more favourably situated parts of the south west and which by reason of a gradual restriction of their demands on water, have come to be able to exist on the minimal amount of moisture (so long as it can be safely reckoned on) find themselves more favourably situated than the Eremaean elements.

2. Floristic relationships between the Southwest Province and southeast Australia.

Study of the floristic elements of the Southwest Province shows numerous links with south eastern Australia, from which it is separated by the whole width of the Eremaea. These connections or relationships are of every possible graduation. It is true that only occasionally do we get the highest degree - a direct identity of species, but the number of generic groups which occur on both sides is considerable while the common genera with disjunctive areas are surprisingly numerous. Furthermore, the endemics of the south west show a variety of links with south eastern floral elements, partly as substitute representatives, partly as developments of eastern types.

As a matter of fact a purely floristic inspection of the two extra-tropical winter rainfall regions of Australia shows a considerable degree of agreement between the two areas as soon as one passed beyond purely species statistics and begins to pay regard to general relationships.

Hitherto there has always been the tendency to emphasize the differences and Hooker is particular stresses this. The limited nature of his material owing to the relative absence of Eremaean types is some excuse for this, as we have already mentioned.

In order to recognize the real differences between east and west in southern Australia the following must be emphasized.

The south eastern area possesses two floral elements which are lacking entirely in the west - the Malaysian and the Antarctic. The Malaysian element becomes more and more powerful as one travels northwards and culminates in north eastern Queensland. It must, however, be noted that it is still evident even on the southern extremity of Tasmania. The Antarctic element is restricted to the southern portion and disappears in southern New South Wales, although it is still important in the high mountain zones. Both elements are somewhat hydrophyllous. Consequently in the extra-tropical districts they are often competitors with the real Australian "autochthonian" elements of the flora which have similar tendencies. This is shown very well in the mountain flora of the south eastern ranges where the "autochthonian" element gains in vigour. At lower elevations it is often overwhelmed by the Malaysian. This double competition explains the fact, regarded as remarkable by Hooker, that the south-eastern flora despite the greater diversity of the environment is not as rich in species as that of the south west.

This brings us to evaluate this advantage in species which is a feature of the Southwest Province. Hooker emphasized this excess of species because according to him the number of species is incomparably greater, and the comparison very striking indeed. In contra-distinction from this, Engler (in Versuch einer Entwickelungsgeschichte II. 48-51) emphasizes the modern view that the advantage of Western Australia lies not in the variety of its flora, but in the possession of numerous species which in certain genera are new centres for development there. Thus there is a second difference between east and west due to the greater success of progressive endemism in the Southwest Province.

This advantage of the south west is dependent on the absence of the two competing elements previously mentioned. South-western Australia is climatically a better defined and closed region than perhaps any other non-insular area on the earth. Consequently its flora is fundamentally more of an entity than even that of the Cape. It covers an area rich in types of climate but they grade freely into one another. As a result we have an excellent exposition of how a flora, left to itself and unhindered by foreign elements adapts itself to the conditions of its home.

The climate in east Australia is certainly more favourable than in Western Australia, in so far as it provides a much greater diversity of environments and conditions of existence for plants. This diversity, however, brings as well a correspondingly greater diversity amongst the types developed. Although east Australia is twice as large as the south western corner of Australia, a great part is quite useless for distinctive development as will be seen below. As a consequence the development of new forms and thereby of an area of endemism, is weakened[1]. In east Australia there is no regular grading of rainfall zones so characteristic of the south-west. These act as a predisposing cause and result in an absence of that constancy which is necessary for any great success in floral development. From the long coast line of the Southwest Province the various plant species pass into the interior under conditions which modify quite gradually in thousands of different ways the function of their parts and result in the evolution of many new and different forms. In south eastern Australia this process which needs peace and constancy is seriously disturbed by the competition of the Malaysian and Antarctic elements. The Eremaean traits of the climate are not as clearly excluded from the coastal climate as in the west. They are often apparent right down to the strand line and as a consequence the Eremaean element is a more dangerous competitor. The consequence is that in south east Australia we have a very mixed flora where little room for calm evolution remains. As a result we get the "euronotic" flora. In the south-west we have an entity which allows freedom for continuous modification and leads to the so-called "autochthonian" flora.

The remaining question is in what respect the undoubted relationship between east and west is to be expressed. Many features overlooked when paying most attention to the differences, have been given above. It would appear that even amongst the western

1 Engler, Versuch einer Entwickelungsgeschichte. II. 48.

endemics there are still many which are related to eastern forms; some as substitutive types, some as genera which have undergone further evolution. This further development of types, which also occurs in eastern Australia, is a particularly interesting feature in the flora of the Southwest Province. It has already been discussed in a previous chapter and several examples given in detail. We found in morphological progressions (*Stawellia, Dampiera, Melaleuca, Nematolepis, Coleanthera, Oligarrhena,* etc) as well as in functionally specialised form (Prostantheroideae*, Hibbertia, Grevillea, Chamaelauceae* and involucres of the endemics) clear signs that these groups originated for the first time in Western Australia. At the same time we also obtained clear evidence of relationships which were genetically of great importance.

Thus from an intensive elementary analysis we find agreement in many essential features between the floras of the south west and south east. The physiognomic and floristic agreement which exists between whole formations is still more striking. We may here mention a few examples of this.

Climbing from the almost Eremaean coloured coastal landscape near Adelaide to the height of the plateau at Mount Lofty one finds a repetition of the scenery of the Darling Range. The trees grow closer together than on the coastal plain, the shrubby undergrowth covers the ground in more crowded fashion, fresh water is still present in sunken areas in January, and the grass trees (*Xanthorrhoea quadrangulata*) here and there dominate the undergrowth. *Grevillea, Hakea, Isopogon, Banksia, Leucopogon, Daviesia, Pultenaea* and other sclerophyllous genera of the west are to be found in the diverse shrub vegetation.

The heath formation as seen on the coast at Sandringham not far from Melbourne is also very similar in habit to that of those in the south west. I have only seen this vegetation at the height of the summer, it may therefore not be quite as like in detail as it appeared to me.

I was able, however, to study the slopes of the plateau more closely in New South Wales where I visited the region towards the end of April. It was north of the Hawkesbury River where I entered the region of the upper zone of the sandstone slopes at an elevation of about 200 m. The soil was sandy becoming gravelly and rocky at times and carried a light *Eucalyptus* wood mixed with *Xylomelum pyriforme* (Prot.). With increase in elevation the undergrowth gradually increased in an extraordinary manner until finally it became quite dense. A bipinnate *Acacia* (*A. discolor* Willd.) and a phyllodinous species, (*A. suaveolens* Willd.) were in flower with pale yellow blossoms. Numerous members of the family Proteaceae were present taking the form of well developed bushes. One species of *Isopogon* (*I. anemonifolius* Knight) reminded one of *I. formosus* R. Br. in Western Australia. The beautiful *Lambertia formosa* Sm. takes up the role of the Western *L. multiflora.* Two species of *Grevillea* are present: - *G. sericea* R. Br. with a glabrous perianth and *G. buxifolia* R. Br. with a hairy perianth. Beautiful low Banksias brighten the whole area with reddish yellow flower cones, *Xanthorrhoea* species, (*X. hastilis* R. Br. and *X. arborea* R. Br.) also occur. *Persoonia* is present, showing a variety of leaf forms from broad to ericoid leaves. In the undergrowth one sees a *Pimelea* (like *P. sylvestris* of the west), *Xanthosia pilosa* Rudge*, Trachymene linearifolia* (Cav.)*, Patersonia, Haemodorum planifolium* R. Br. and *Tetratheca ericifolia* Sm.*,* covering the soil. A species of *Hibbertia* and several almost ericoid members of the Leguminosae are also present. The whole is so like what occurs in Western Australia that one could almost believe one had been deposited at some point in the real Southwest Province. The resemblance is greatest to the Jarrah zone, in particular to the light woodland type north of King George Sound.

This picture was doubly distinct to me as I investigated the closer differentiation of the formation in New South Wales. In the middle of the bush I found a heath-like area which indicated a somewhat moister sub-soil. There one found small scattered but numerous *Banksia* shrubs. The basic vegetation consisted, however, of very closely growing low dwarf shrubs. Several epacrids could be recognized, e.g. *Sprengelia incarnata* Sm. and others - also *Epacris purpurascens* R. Br.*,* which resembles *Cosmelia*, was present. Altogether the whole habitat was strikingly like the famous heaths on King George Sound.

The same dominance of the family Epacridaceae, the same type of interlacing stalks, of the often flowerless restionaceous plants; the small white flowered bushes (*Baeckea*) together with large numbers of the delicate *Tetratheca ericifolia* Sm.. These together with an abundance of plants with smooth finely divided leaves were present exactly as in the south-west.

Far away in the tropical region about 2000 km north of the heartland of the "authocthonian" flora in New South Wales, a granite mountain known as Walsh's Pyramid occurs not far from the Russell River in the north-eastern corner of Queensland. It rises from flat alluvium to a height of 900 m. Here again - and rather unexpectedly - I gained the impression of unrestricted Australian vegetation and a lively remembrance of the far south west. The whole mountain carried light *Eucalyptus* woodland mixed with *Casuarina.* At a height of about 500 m *Banksia integrifolia* appears and out of a grassy undergrowth rises species of *Acacia, Xanthorrhoea, Xerotes, Haemodorum, Dianella,* etc.. The undergrowth, which higher up includes *Banksia collina* and *Hibbertia velutina* thickens up gradually into fresh green masses. Here and there where the granite out crops one can collect tiny herbs *(Mitrasacme, Utricularia* and *Byblis liniflora*) together with species of *Drosera.* On the stone itself compact clumps of *Borya septentrionalis* occur. This is the only relation of the south western granite character plants. It looks surprisingly like its sister species. Altogether the whole ecological character of this granite flora corresponds so closely to the pictures of the south-west that one forgets how far apart the two places are. It thus appears almost unnatural to see down below in the valleys and on the near mountains of Bellenden-Ker the dark masses of the thick foliaged rain forest.

Such experiences lead the observer to an understanding of the fact that the flora of Australia possesses a common and very uniform foundation. This is freely exposed in the west, but often disappears in the south east when in competition with other vegetation elements, but which still becomes manifest here and there in the far north. In other words it is present everywhere, throughout the whole.

CHAPTER 4. THE EVOLUTION OF THE FLORA OF EXTRA-TROPICAL WESTERN AUSTRALIA

The conclusion reached at the close of the previous section on the uniform base of the Australian flora, provides the basis for our views on the evolution of the vegetation of the extra-tropical parts of the west.

In its entire geological structure the Southwest Province appears as a country with a relatively undisturbed past. The vegetation also bears the marks of a calm development. It is of similar value and age to one of the elements of the east Australian flora, from which it is now separated by the extensive region of the Eremaea. In spite of this separation the taxonomic relations and the resemblance of the components of formation demonstrate the entity of the two disjunct floras.

While the further evolution of this primitive element in east Australia has been hindered by the intrusion of other kinds of elements, it proceeded in the Southwest Province along peaceful lines. Several very peculiar endemic types exist there, (e.g. *Cephalotus, Kingia, Franklandia* and various others). Whether these always belong only to the west or whether they once also existed in the east and gradually died out there, may never be known. At the same time the second alternative must still be considered. One must remember how many of the genera now so strongly developed in the west are so poorly represented in eastern Australia today, or are only found in limited areas, e.g. *Borya, Petrophila, Isopogon, Lambertia, Chorizema* and *Darwinia.*

The conservatism of these genera, however, together with the peaceful development of Western Australia provided particularly favourable conditions for progressive endemism since it permitted the fullest use of the topography of the country. Adaptation in many genera have produced very diverse structural development, many in morphological or functional respects have made important progress - progress which the less favoured eastern groups never made. The result is the high degree of differentiation which characterizes the flora of the Southwest Province.

How the earlier ancestral flora of Australia (which has now attained its most complete further evolution in the south west) obtained its constitution can no longer be determined. It would appear that both southern and northern hemisphere groups were concerned. There must have been a many-sided exchange between the east and west, particularly by way of the south, and only partly in the north.

Many authors, particularly Wallace (in Island Life, p. 465 on) have assumed that Western Australia alone had originally the real Australian flora and the progenitors of the marsupial fauna. From there they are supposed to have passed east from about the middle Tertiary period. This unfortunately very wide-spread view, I consider, with Hedley[1] to be an error. Western Australia itself possesses many derived types particularly in families whose origin on general grounds may be looked for in the north (e.g. Myrtaceae and Rutaceae). Furthermore the abundant occurrence of typical Australian groups in New Caledonia makes a late invasion from the west most unlikely. That part of the present Australian flora, so richly developed in Western Australia, must be regarded as an old Pan-Australian element.

The present day division of this original element is easily understood from the present climatic conditions in Australia. This stage, however, is only the result of geohistorical occurrences which has afflicted central Australia. According to geologists the eastern part of the Eremaea was covered by the sea in Cretaceous times so that the geography of Australia was very different then from what it is at present. In Pliocene times a period rich in rain is supposed to have been experienced. Lake Eyre is the remains of a giant inland sea which filled the eastern part of the State of South Australia. Since Pliocene times, according to Tate Australia has experienced a drying period. As a result the Eremaean region separating the east and west gradually became larger, thus gradually separating the two floras still further.

If this is correct the fate of the central part of Australia must have been rather momentous In particular a direct and broad exchange between west and east must have been always greatly hindered. This explanation would make clear why the Malaysian hydrothermic elements and the Antarctic types, which are found in south east Australia, either do not occur or are found rarely in south west Australia. Climatic conditions alone are inadequate to explain the rareness of Malaysian ferns and other similar plants in the south of the Southwest Province.

In recent times only a single narrow bridge seems to have been left between the west and the east. The old Tertiary beds which bound the Bight terminate over a range of 450 km in a steep cliff of about 50-80 m in height. This indicates that there was a greater extension of the land southwards in post-Miocene times. The floristic relations between Kangaroo Island and the Eyre Peninsula to the south east of the Western Australian Southwest Province supports this assumption. This, however, would only explain a minor episode in the history of the Western Australian flora.

The Eremaea, that part of the Australian continent which has originated as a result of the drying period, is dominated today by a climate which shows very little correspondence with the requirements of the old Australian flora. It is therefore, occupied by a vegetation which a localized stimulus has brought into being out of the original floral entity. This stimulus has continued to modify and further develop the flora which has also been enriched by additions from the tropical north. This evolution has resulted in the marked separation of the vegetation of the Eremaea from the adjoining regions which have a higher rainfall. Only a few genera remain equally important in both areas (e.g. *Eucalyptus* and *Acacia).* It appears that what is important in the one is usually unimportant in the other. It is true that the Eremaean flora passes over into the south eastern area in many places and in diverse ways. Taken as a whole, however, it stands today as something different and alien to the coastal flora. The duality of the two floras

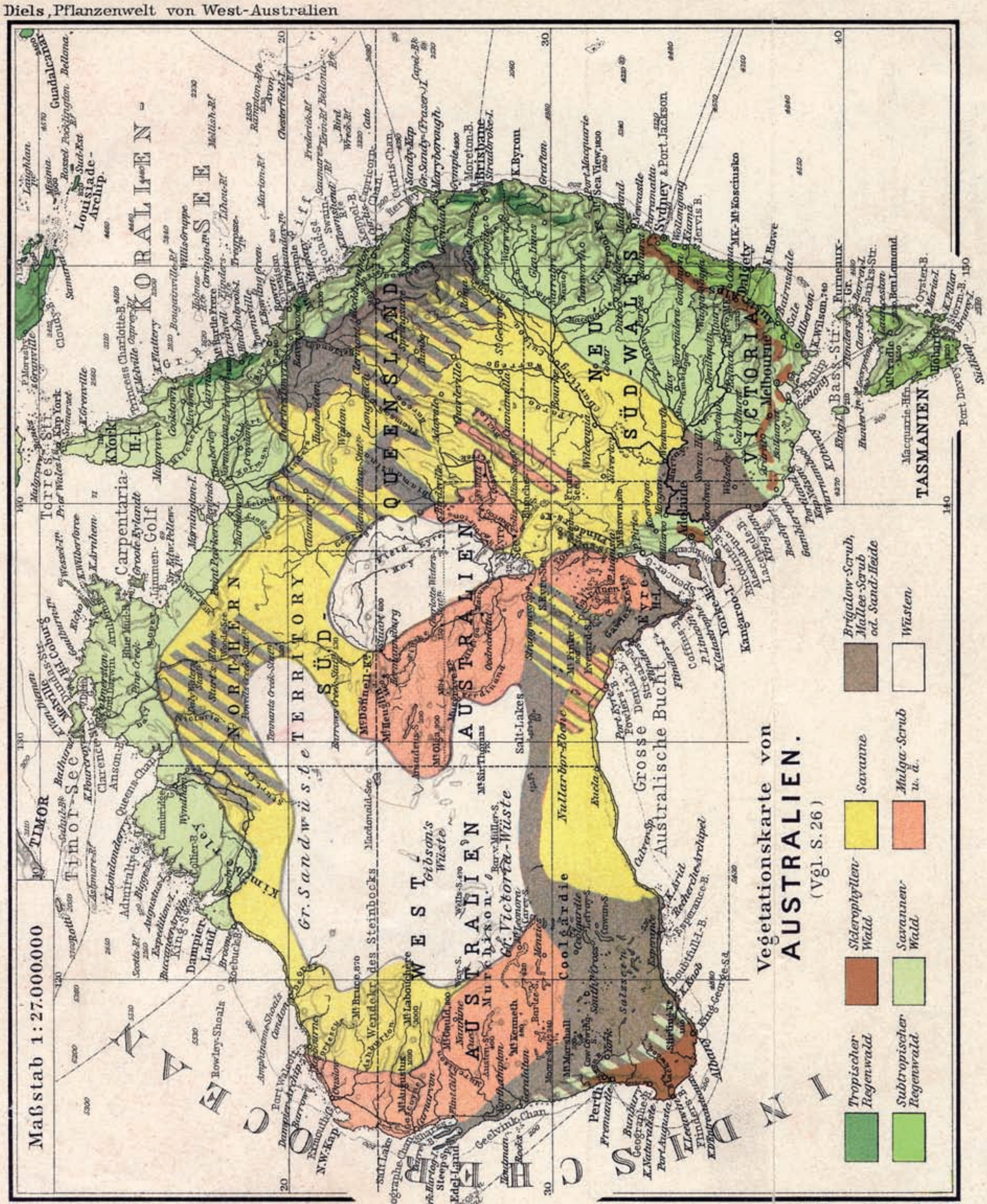
1 Hedley in Natural Science. III (1893). 187-191.

results in two completely independent provinces in extra-tropical Western Australia.

The last phase of the evolution of Western Australia is modified by the appearance of man. Man's appearance, which for so many floras of the earth has meant great changes and disturbances, has, however, left Western Australia with its old stability. It is true that the original inhabitants of Australia have on occasion set fire to the bush, but this burning has never shifted the equilibrium of the vegetation for long. The Europeans who have now possessed the country for nearly 70 years have done more in the way of destruction. For them the fire was only the fore-runner for the axe. In the Avon valley in the fruitful river lowlands of the south, in the woody districts of the hilly plateau and lastly in the arid goldfields of the interior, the original woodland has been cleared. Here and there too, the coastal woodlands have been destroyed. Cattle and sheep run in the bush. Yet perhaps they do no more harm than the indigenous animals which earlier were more numerous. All in all that which man has done up to the present is but little when one thinks of the extent of the unexplored wilderness, the undisturbed woodlands, the endless sand heaths of this country. It is, however, certain that this condition will change and change to the disadvantage of the autochthonian world of organisms. To what extent no one can say. In any case, however, for a long time yet Western Australia will preserve the picture of its original nature more faithfully than all more richly endowed countries whose treasures attract people.

Even the weeds which man has carelessly brought with him into the country have never seriously influenced the natural vegetation. We saw that almost everywhere the invaders appeared as a weak competitor of the native vegetation, and that most of them soon disappeared when man and his culture again passed on. There is never a question of them pressing on the old vegetation and affecting its existence. In this again the beautiful flora of Western Australia exhibits its stability and harmony with the nature of the country in which it has originated and becomes what we see it to be today.

Diels, Pflanzenwelt von West-Australien



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Appendix A

Current Western Australian names (2002) for taxa mentioned in Diels' "*Die Pflanzenwelt von West-Australien südlich des Wendekreises*". EST = Eastern States taxa (some not current)

Diel's name	Current WA name	comments
Abutilon geranioides	Abutilon geranioides	
Acacia acuminata	Acacia acuminata	
Acacia aestivalis	Acacia aestivalis	
Acacia alata	Acacia alata	
Acacia alata var biglandulosa	Acacia alata var. biglandulosa	
Acacia aneura	Acacia aneura	
Acacia aureonitens	Acacia auronitens	
Acacia barbinervis	Acacia barbinervis	
Acacia bivenosa	Acacia bivenosa	
Acacia congesta	Acacia congesta	
Acacia craspedocarpa	Acacia craspedocarpa	
Acacia cuneata	Acacia truncata	
Acacia cyanophylla	Acacia saligna	
Acacia cyclopis	Acacia cyclops	
Acacia diptera	Acacia willdenowiana	
Acacia discolor		= Acacia terminalis EST
Acacia doratoxylon	Acacia dorsenna	
Acacia extensa	Acacia extensa	
Acacia genistoides	Acacia tetragonophylla	
Acacia harpophylla		= Brigalow EST
Acacia hastulata	Acacia hastulata	
Acacia Harveyi	Acacia harveyi	
Acacia Huegelii	Acacia huegelii	
Acacia idiornorpha	Acacia idiomorpha	
Acacia insolita	Acacia insolita	
Acacia laricina	Acacia laricina	
Acacia leptopetala	Acacia leptopetala	
Acacia latipes	Acacia latipes	
Acacia leucosperma	Acacia sclerosperma	
Acacia Meissneri	Acacia meisneri	
Acacia microbotrya	Acacia microbotrya	
Acacia myrtifolia	Acacia myrtifolia	
Acacia nervosa	Acacia nervosa	
Acacia nigricans	Acacia nigricans	
Acacia obovata	Acacia obovata	
Acacia oncinophylla	Acacia oncinophylla	
Acacia palustris	Acacia palustris	
Acacia pentadenia	Acacia pentadenia	
Acacia pulchella	Acacia pulchella	
Acacia pycnantha	Acacia pycnantha	
Acacia restiacea	Acacia restiacea	
Acacia retinodes		EST
Acacia Rossii	Acacia rossei	
Acacia rostellifera	Acacia rostellifera	
Acacia salicina		EST
Acacia scirpifolia	Acacia scirpifolia	
Acacia spinosissima	Acacia spinosissima	
Acacia squamata	Acacia squamata	
Acacia stenoptera	Acacia stenoptera	
Acacia stereophylla	Acacia stenophylla	
Acacia strigosa	Acacia browniana	
Acacia suaveolens		EST
Acacia sulcata	Acacia sulcata	
Acacia teretifolia	Acacia teretifolia	
Acacia urophylla	Acacia urophylla	
Aciphylla glacialis		EST
Acronychia		EST
Actinotus leucocephalus	Actinotus leucocephalus	
Actinotus Schwarzii		= Actinotus schwarzii EST
Adenanthos barbigerus	Adenanthos barbiger	
Adenanthos cuneata	Adenanthos cuneatus	
Adenanthos cygnorum	Adenanthos cygnorum	
Adenanthos filifolia	Adenanthos filifolius	
Adenanthos obovata	Adenanthos obovatus	
Adenanthos procumbens	Adenanthos apiculatus	
Adenanthos sericea	Adenanthos sericeus	
Adiantum aethiopicum	Adiantum aethiopicum	
Adriana quadripartita	Adriana quadripartita	
Adriana tomentosa	Adriana tomentosa	
Agathis Palmerstoni		= Agathis robusta EST

Agonis flexuosa	Agonis flexuosa	
Agonis floribunda	Agonis floribunda	
Agonis juniperina	Agonis juniperina	
Agonis marginata	Agonis marginata	
Agonis parviceps	Agonis parviceps	
Agrostocrinum stypandroides	Agrostocrinum stypandroides	
Albizzia lophantha	Paraserianthes lophantha	
Aleurites moluccana		EST
Alphitonia excelsa		EST
Alpinia coerulea		EST
Alsophila australis		= Cyathea australis EST
Alsophila Rebeccae		= Cyathea rebeccae EST
Alyxia brevifolia		probably refers to Alyxia buxifolia
Alyxia buxifolia	Alyxia buxifolia	
Alyxia ruscifolia		EST
Amphipogon cygnorum	Amphipogon laguroides	
Anagallis arvensis	Anagallis arvensis	
Anarthria scabra	Anarthria scabra	
Andersonia coerulea	Andersonia caerulea	
Andersonia colossea	Andersonia axilliflora	
Andersonia patricia		probably Andersonia echinocephala
Andropogon sericeus	Dichanthium sericeum	
Anemone crassifolia		EST
Angianthus Cunninghamii	Angianthus cunninghamii	
Angianthus humifusus	Siloxerus humifusus	
Angianthus pygmaeus	Angianthus pygmaeus	
Angianthus strictus	Pogonolepis stricta	
Anguillaria dioica	Wurmbea dioica	
Anigozanthos flavida	Anigozanthos flavidus	
Anigozanthos Manglesii	Anigozanthos manglesii	
Anigozanthos pulcherrima	Anigozanthos pulcherrimus	
Anigozanthos rufa	Anigozanthos rufus	
Anigozanthos viridis	Anigozanthos viridis	
Anthobolus foveolatus	Anthobolus foveolatus	
Anthocercis intricata	Anthocercis intricata	
Anthocercis viscosa	Anthocercis viscosa	
Aotus cordifolia	Aotus cordifolia	
Aphanopetalum occidentale	Aphanopetalum clematideum	
Aphelia cyperoides	Aphelia cyperoides	
Araucaria Bidwillii		= Araucaria bidwillii EST
Araucaria Cunninghamii		= Araucaria cunninghamii EST
Archontophoenix Alexandrae		= Archontophoenix alexandrae EST
Archontophoenix Cunninghamii		= Archontophoenix cunninghamiana EST
Arthrotaxis cupressoides		EST
Asplenium nidus		EST
Astartea fascicularis	Astartea fascicularis	
Astelia alpina		EST
Aster argophyllus		= Olearia argophylla EST
Astrebla pectinata	Astrebla pectinata	
Astroloma humifusum	Astroloma humifusum	
Atalaya hemiglauca	Atalaya hemiglauca	
Atherosperma moschatum		EST
Athrixia australis	Asteridea pulverulenta	
Atriplex Drummondii	Atriplex paludosa subsp. baudinii	
Atriplex halimoides	Atriplex lindleyi subsp. inflata	
Atriplex isatidea	Atriplex isatidea	
Atriplex paludosa	Atriplex paludosa	
Atriplex rhagodioides	Atriplex amnicola	
Atriplex semibaccata	Atriplex semibaccata	
Avellinia Michelii	Avellinia michelii	
Avicennia officinalis	Avicennia marina	
Babbagia dipterocarpa		= Osterocarpum dipterocarpum EST
Bacularia Palmeriana		= Bacularia palmeriana EST
Baeckea camphorosmae	Baeckea camphorosmae	
Baeckea pentandra	Baeckea pentagonantha	
Bambusa Moreheadiana		= Bambusa moreheadiana EST
Banksia attenuata	Banksia attenuata	
Banksia Brownii	Banksia brownii	
Banksia Caleyi	Banksia caleyi	
Banksia coccinea	Banksia coccinea	
Banksia colina		= Banksia spinulosa var. collina EST
Banksia Elderiana	Banksia elderiana	
Banksia grandis	Banksia grandis	
Banksia ilicifolia	Banksia ilicifolia	
Banksia integrifolia		EST
Banksia Lindleyana	Banksia lindleyana	

Banksia litoralis	Banksia littoralis	
Banksia media	Banksia media	
Banksia Menziesii	Banksia menziesii	
Banksia occidentalis	Banksia occidentalis	
Banksia petiolaris	Banksia petiolaris	
Banksia prionotes	Banksia prionotes	
Banksia prostrata	Banksia gardneri	
Banksia repens	Banksia repens	
Banksia sceptrum	Banksia sceptrum	
Banksia Solandri	Banksia solandri	
Banksia speciosa	Banksia speciosa	
Banksia sphaerocarpa	Banksia sphaerocarpa	
Banksia verticillata	Banksia verticillata	
Banksia Victoriae	Banksia victoriae	
Beaufortia decussata	Beaufortia decussata	
Beaufortia sparsa	Beaufortia sparsa	
Bertya dimerostigma	Bertya dimerostigma	
Beyeria viscosa	Beyeria viscosa	
Blue Grass	Dichanthium sericeum	
Boerhavia repanda	Commicarpus australis	
Boronia crassifolia	Boronia crassifolia	
Boronia cymosa	Boronia cymosa	
Boronia inornata	Boronia inornata	
Boronia juncea	Boronia juncea	
Boronia lanuginosa	Boronia lanuginosa	
Boronia megastigma	Boronia megastigma	
Boronia ovata	Boronia ovata	
Boronia Purdieana	Boronia purdieana	
Boronia ramosa	Boronia ramosa	
Boronia spinescens	Boronia coerulescens subsp. spinescens	
Boronia tetrandra	Boronia tetrandra	
Boronia xerophila	Boronia inornata subsp. inornata	
Borya nitida	Borya nitida	
Borya septentrionalis		EST
Bossiaea eriocarpa	Bossiaea eriocarpa	
Bossiaea rufa	Bossiaea rufa	
Brachychiton Gregorii	Brachychiton gregorii	
Brachychiton rupestris		EST
Brachycome latisquamea	Brachyscome latisquamea	
Brachysema daviesioides	Leptosema daviesioides	
Brachysema undulatum	Brachysema sericeum	
Briza maxima	Briza maxima	
Briza minor	Briza minor	
Brizula Drummondii	Aphelia drummondii	
Brizula Muelleri	Aphelia brizula	
Brunonia australis	Brunonia australis	
Bulbine semibarbata	Bulbine semibarbata	
Burchardia umbellata	Burchardia congesta	
Bursaria spinosa	Bursaria occidentalis	refers to WA taxa
Burtonia viscida	Gompholobium gompholobioides	
Byblis gigantea	Byblis gigantea	
Byblis liniflora	Byblis liniflora	
Caesia parviflora	Caesia micrantha	
Cakile maritima	Cakile maritima	
Caladenia deformis	Cyanicula deformis	
Caladenia gemmata	Cyanicula gemmata	
Caladenia hirta	Caladenia hirta	
Caladenia latifolia	Caladenia latifolia	
Caladenia Menziesii	Leptoceras menziesii	
Caladenia Patersoni	Caladenia longicauda	
Caladenia serrata	Lyperanthus serratus	
Calamus australis		EST
Calamus moti		EST
Calandrinia Lehmanni	Calandrinia lehmannii	
Calandrinia polyandra	Calandrinia polyandra	
Calandrinia primuliflora	Calandrinia primuliflora	
Calectasia cyanea	Calectasia cyanea	
Callistemon speciosus	Callistemon glaucus	
Callitris Drummondii	Callitris drummondii	
Callitris robusta	Callitris preissii	
Calocephalus Brownii	Leucophyta brownii	
Calocephalus phlegmatocarpus	Blennospora phlegmatocarpa	
Calothamnus robustus	Calothamnus robustus	
Caltha introloba		EST
Calyptrocalyx australasicus		EST
Calythrix	Calytrix	

Calythrix aurea	Calytrix aurea	
Calythrix Birdii	Calytrix birdii	
Calythrix brachyphylla	Calytrix leschenaultii	
Calythrix brevifolia	Calytrix brevifolia	
Calythrix flavescens	Calytrix flavescens	
Campylopus bicolor		lichen
Campylopus inflexus		lichen
Cananga odorata		EST
Carex Preissii	Carex preissii	
Carissa ovata	Carissa ovata	
Cassia artemisioides	Senna artemisioides subsp. x artemisioides	
Cassia Chatelainiana	Senna charlesiana	
Cassia eremophila	Senna artemisioides subsp. filifolia	
Cassia Sturtii	Senna artemisioides subsp. x sturtii	
Cassytha melantha	Cassytha melantha	
Cassytha pomiformis	Cassytha pomiformis	
Cassytha racemosa	Cassytha racemosa	
Casuarina campestris	Allocasuarina campestris	
Casuarina Cunninghamiana	Casuarina cunninghamiana	
Casuarina distyla		EST
Casuarina Drummondiana	Allocasuarina drummondiana	
Casuarina Fraseriana	Allocasuarina fraseriana	
Casuarina glauca	Casuarina obesa	
Casuarina humilis	Allocasuarina humilis	
Casuarina Huegeliana	Allocasuarina huegeliana	
Casuarina microstachya	Allocasuarina microstachya	
Casuarina stricta		= Allocasuarina verticellata EST
Casuarina trichodon		= Allocasuarina trichodon EST
Celmisia longifolia		EST
Centella asiatica	Centella asiatica	
Centipeda Cunninghamii	Centipeda cunninghamii	
Centrolepis aristata	Centrolepis aristata	
Centrolepis Drummondii	Centrolepis drummondiana	
Centrolepis mutica	Centrolepis mutica	
Centrolepis tenuior	Centrolepis strigosa	
Cephalipterum Drummondii	Cephalipterum drummondii	
Cephalotus follicularis	Cephalotus follicularis	
Ceratodon purpureus		moss
Chamaelaucium uncinatum	Chamelaucium uncinatum	
Cheiranthera filifolia	Cheiranthera filifolia	
Cheiranthera linearis		EST
Chenolea eurotioides	Sclerolaena eurotioides	
Chenopodium Preissii	Cheiranthera preissiana	
Choretrum glomeratum	Choretrum glomeratum	
Chorilaena quercirolia	Chorilaena quercifolia	
Chorizema Henchmanni	Chorizema aciculare subsp. aciculare	
Chorizema ilicifolium	Chorizema ilicifolium	
Chorizema parviflorum		EST
Christmas Tree	Nuytsia floribunda	
Cissus Baudiniana		= Cissus antarctica EST
Cladium arthrophyllum	Baumea arthrophylla	
Cladonia verticillata		lichen
Clematicissus angustissima	Clematicissus angustissima	
Clematis aristata	Clematis aristata	
Clematis glycinoides		EST
Clematis microphylla	Clematis linearifolia	
Clematis pubescens	Clematis pubescens	
Clianthus Dampieri	Swainsona formosa	
Codonocarpus cotinifolius	Codonocarpus cotinifolius	
Comesperma calymega	Comesperma calymega	
Comesperma ciliatum	Comesperma ciliatum	
Comesperma flavum	Comesperma flavum	
Comesperma nudiusculum	Comesperma nudiusculum	
Comesperma paucifolium		? Turczaninow name, blue flowered sp.
Comesperma scoparium	Comesperma scoparium	
Comesperma volubile	Comesperma volubile	
Commersonia echinata		EST
Conospermum densiflorum	Conospermum densiflorum	
Conospermum Eatoniae	Conospermum eatoniae	
Conospermum flexuosum	Conospermum flexuosum	
Conospermum glumaceum	Conospermum glumaceum	
Conospermum petiolare	Conospermum petiolare	
Conostephium pendulum	Conostephium pendulum	
Conostylis candicans	Conostylis candicans	
Conostylis Dielsii	Conostylis dielsii	
Conostylis phatyrantha	Conostylis phathyrantha	

Conostylis prolifera	Conostylis prolifera	
Corynotheca lateriflora		EST, probably refers to C. micrantha
Cotula coronopifolia	Cotula coronopifolia	
Cryptandra arbutiflora	Cryptandra arbutiflora	
Cryptandra leucopogon	Cryptandra leucopogon	
Cryptandra parvifolia	Cryptandra minutifolia	
Cryptandra petraea	Granitites intangendus	
Cryptandra polyclada	Cryptandra polyclada	
Cryptostemma calendulaceum	Arctotheca calendula	
Currajong	Brachychiton gregorii	
Cyanostegia microphylla	Cyanostegia microphylla	
Cycas - Palm		refers to Macrozamia fraseri & M. riedlei
Cynodon dactylon	Cynodon dactylon	
Cyperus tenenus	Cyperus tenellus	
Cyrtostylis reniformis	Cyrtostylis robusta	
Dampiera altissima	Dampiera altissima	
Dampiera eriocephala	Dampiera eriocephala	
Dampiera hederacea	Dampiera hederacea	
Dampiera incana	Dampiera incana	
Dampiera	Dampiera lavandulacea	
Dandelion	Hypochaeris glabra	
Danthonia	Austrodanthonia	
Darwinia diosmoides	Darwinia diosmoides	
Darwinia Hookeriana	Darwinia hypericifolia	
Darwinia macrostegia	Darwinia macrostegia	
Darwinia Meissneri	Darwinia lejostyla	
Dasypogon bromeliifolius	Dasypogon bromeliifolius	
Dasypogon Hookeri	Dasypogon hookeri	
Daviesia cordata	Daviesia cordata	
Daviesia crenulata	Daviesia crenulata	
Daviesia Croniniana	Daviesia croniniana	
Daviesia flexuosa	Daviesia flexuosa	
Daviesia hakeoides	Daviesia hakeoides	
Daviesia incrassata	Daviesia incrassata	
Daviesia pachyphylla	Daviesia pachyphylla	
Daviesia pectinata		EST, probably Daviesia decipiens
Daviesia quadrilatera	Daviesia quadrilatera	
Daviesia reversifolia	Daviesia incrassata subsp. reversifolia	
Daviesia trigonophylla	Daviesia trigonophylla	
Dendrobium speciosum		EST
Dendrobium Hillii		= Sarcochilus hillii EST
Delabechea rupestris		= Brachychiton rupestris EST
Dianella revoluta	Dianella revoluta	
Diaspasis filifolia	Diaspasis filifolia	
Dicksonia antarctica		EST
Dicrastyles fulva	Dicrastylis fulva	
Dicrastyles stoecbas	Dicrastylis corymbosa	
Didiscus pilosus	Trachymene pilosa	
Didymanthus Roei	Didymanthus roei	
Dioscorea hastifolia	Dioscorea hastifolia	
Dioscorea transversa	Dioscorea transversa	
Diplolaena Darwinii		?, shown in Fig.48
Diplolaena grandiflora	Diplolaena grandiflora	
Diuris setacea	Diuris setacea	
Dodonaea amblyophylla	Dodonaea amblyophylla	
Dodonaea attenuata	Dodonaea viscosa	
Dodonaea concinna	Dodonaea concinna	
Dodonaea filifolia	Dodonaea rigida	
Dodonaea inaequifolia	Dodonaea inaequifolia	
Dodonaea pinifolia	Dodonaea pinifolia	
Dodonaea ptarmicifolia	Dodonaea ptarmicaefolia	
Doryanthes excelsa		EST
Dracophyllum Sayeri		= Dracophyllum sayeri EST
Drosera Arcturii		= Drosera arcturii EST
Drosera buibosa	Drosera bulbosa	
Drosera gigantea	Drosera gigantea	
Drosera glanduligera	Drosera glanduligera	
Drosera heterophylla	Drosera heterophylla	
Drosera Huegelii	Drosera huegelii	
Drosera macrantha	Drosera macrantha	
Drosera macrophylla	Drosera macrophylla	
Drosera microphylla	Drosera microphylla	
Drosera nitidula	Drosera nitidula	
Drosera paleacea	Drosera paleacea	
Drosera pycnoblasta	Drosera pycnoblasta	
Drosera rosulata	Drosera rosulata	

Drosera squamosa	Drosera erythrorhiza subsp. squamosa	
Drosera Whittakerii		= Drosera whittakerii EST
Dryandra Baxteri	Dryandra baxteri	
Dryandra calophylla	Dryandra calophylla	
Dryandra carduacea	Dryandra squarrosa subsp. squarrosa	
Dryandra cuneata	Dryandra cuneata	
Dryandra falcata	Dryandra falcata	
Dryandra floribunda	Dryandra sessilis	
Dryandra formosa	Dryandra formosa	
Dryandra Fraseri	Dryandra fraseri	
Dryandra horrida	Dryandra horrida	
Dryandra Kippistiana	Dryandra kippistiana	
Dryandra mucronulata	Dryandra mucronulata	
Dryandra nivea		usually refering to Dryandra lindleyana
Dryandra plumosa	Dryandra plumosa	
Dryandra polycephala	Dryandra polycephala	
Dryandra praemorsa	Dryandra praemorsa	
Dryandra pteridifolia	Dryandra pteridifolia	
Dryandra repens		appears to be refering to D. lindleyana
Dryandra senecionifolia	Dryandra seneciifolia	
Dryandra serra	Dryandra serra	
Dryandra serratuloides	Dryandra serratuloides	
Dryandra speciosa	Dryandra speciosa	
Drynaria quercifolia	Drynaria quercifolia	
Ecdeiocolea monostachya	Ecdeiocolea monostachya	
Ehretia saligna	Ehretia saligna	
Elaeagnus latifolia		EST
Elaeocarpus cyaneus		= Elaeocarpus reticulatus EST
Elaeocarpus grandis		= Elaeocarpus angustifolia EST
Elettaria Scottiana		= Hornstedtia scottiana EST
Emblingia calceoliflora	Emblingia calceoliflora	
Emex australis	Emex australis	
Epacris purpurascens		EST
Epiblema grandiflorum	Epiblema grandiflorum	
Epilobium confertifoium		? from Mount Kosciusko, EST
Epilobium junceum	Epilobium hirtigerum	
Epipremnum mirabile		EST
Eremophila alternifolia	Eremophila alternifolia	
Eremophila Brownii	Eremophila glabra	
Eremophila calorhabdos	Eremophila calorhabdos	
Eremophila dichroantha	Eremophila dichroantha	
Eremophila Drummondii	Eremophila drummondii	
Eremophila elachantha	Eremophila elachantha	
Eremophila Fraseri	Eremophila fraseri	
Eremophila Georgei	Eremophila georgei	
Eremophila granitica	Eremophila granitica	
Eremophila interstans	Eremophila interstans	
Eremophila ionantha	Eremophila ionantha	
Eremophila leucophylla	Eremophila forrestii	
Eremophila longifolia	Eremophila longifolia	
Eremophila maculata	Eremophila maculata	
Eremophila Mitchellii		= Eremophila mitchellii EST
Eremophila Paisleyi	Eremophila paisleyi	
Eremophila platythamnos	Eremophila platythamnos	
Eremophila Youngii	Eremophila youngii	
Eriochilus dilatatus	Eriochilus dilatatus	
Erodium cygnorum	Erodium cygnorum	
Eucalyptus alpina		EST
Eucalyptus amygdalina		EST
Eucalyptus bicolor		= Erodium larifloreus EST
Eucalyptus buprestium	Eucalyptus buprestium	
Eucalyptus calophylla	Eucalyptus calophylla	
Eucalyptus calycogona	Eucalyptus calycogona	
Eucalyptus celastroides	Eucalyptus celastroides	
Eucalyptus coriacea		= Eucalyptus pauciflora EST
Eucalyptus cornuta	Eucalyptus cornuta	
Eucalyptus crebra	Eucalyptus creta	
Eucalyptus decurva	Eucalyptus decurva	
Eucalyptus diversicolor	Eucalyptus diversicolor	
Eucalyptus dumosa		EST, E. incrassata or E. angulosa
Eucalyptus erythrocorys	Eucalyptus erythrocorys	
Eucalyptus erythronema	Eucalyptus erythronema	
Eucalyptus eudesmioides	Eucalyptus eudesmioides	
Eucalyptus ficifolia	Eucalyptus ficifolia	
Eucalyptus Forrestiana	Eucalyptus forrestiana	
Eucalyptus globulus	Eucalyptus globulus	

Eucalyptus gomphocephala	Eucalyptus gomphocephala	
Eucalyptus gracilis	Eucalyptus gracilis	
Eucalyptus Gunnii		= Eucalyptus gunnii EST
Eucalyptus incrassata	Eucalyptus incrassata	
Eucalyptus Lehmanniana	Eucalyptus lehmannii	
Eucalyptus longicornis	Eucalyptus longicornis	
Eucalyptus loxophleba	Eucalyptus loxophleba	
Eucalyptus macrocarpa	Eucalyptus macrocarpa	
Eucalyptus marginata	Eucalyptus marginata	
Eucalyptus megacarpa	Eucalyptus megacarpa	
Eucalyptus melliodora		EST
Eucalyptus microtheca	Eucalyptus microtheca	
Eucalyptus occidentalis	Eucalyptus occidentalis	
Eucalyptus odorata	Eucalyptus odontocarpa	
Eucalyptus Oldfiedii	Eucalyptus oldfieldii	
Eucalyptus oleosa	Eucalyptus oleosa	
Eucalyptus paniculata		EST
Eucalyptus patens	Eucalyptus patens	
Eucalyptus platyphylla		EST
Eucalyptus Preissiana	Eucalyptus preissiana	
Eucalyptus pyriformis	Eucalyptus pyriformis	
Eucalyptus redunca		includes all E. wandoo-redunca complex
Eucalyptus rostrata	Eucalyptus camaldulensis var. obtusa	
Eucalyptus rudis	Eucalyptus rudis	
Eucalyptus salmonophloia	Eucalyptus salmonophloia	
Eucalyptus salubris	Eucalyptus salubris	
Eucalyptus spathulata	Eucalyptus spathulata	
Eucalyptus tetragona	Eucalyptus tetragona	
Eucalyptus tetraptera	Eucalyptus tetraptera	
Eucalyptus Todtiana	Eucalyptus todtiana	
Eucalyptus uncinata	Eucalyptus uncinata	
Eucalyptus viminalis		EST
Eucalyptus virgata		EST, ? E. luehmanniana X E. obtusiflora
Eugenia Smithii		= Acema smithii EST
Euphrasia Brownii		= Euphrasia alpina EST
Eutaxia empetrifolia		EST
Eutaxia myrtifolia	Eutaxia obovata	
Evandra aristata	Evandra aristata	
Exocarpus aphyla	Exocarpos aphyllus	
Fabronia Hampeana		liverwort
Festuca bromoides		?, annual grass SW, considered native
Festuca rigida		?, taxon of sandy beaches
Fieldia australis		EST
Flannel Flowers		Conospermum spp.
Flannel Plant	Lachnostachys verbascifolia	
Flat-topped Yate	Eucalyptus occidentalis	
Flindersia maculosa		EST
Flooded Gum	Eucalyptus rudis	
Frankenia pauciflora	Frankenia pauciflora	
Frankenia tetrapetala	Frankenia tetrapetala	
Frenela	= Callitris	
Frenela calcarata		= Callitris endlicheri EST
Frenela verrucosa	Callitris tuberculata	
Fugosia hakeifolia	Alyogyne hakeifolia	
Funaria gracilis		moss
Fusanus	Santalum	
Fusanus acuminatus	Santalum acuminatum	
Fusanus spicatus	Santalum spicatum	
Gaimardia australis		EST
Gastrolobium grandiflorum	Gastrolobium grandiflorum	
Gastrolobium obovatum	Nemcia obovata	
Gastrolobium spathulatum	Nemcia spathulata	
Gastrolobium spinosum	Gastrolobium spinosum	
Geleznovia	Geleznowia	
Geleznovia verrucosa	Geleznowia verrucosa	
Gleichenia alpina		EST
Glossostigma elatinoides		EST, probably Glossostigma diandrum
Gnaphalium japonicum		EST, possibly Pseudognaphalium luteoalbum
Gnephosis gynotricha	Gnephosis gynotricha	
Gnephosis rotundifolia	Stuartina muelleri	
Gompholobium calycinum		probably Gompholobium capitatum
Gompholobium marginatum	Gompholobium marginatum	
Gompholobium polymorphum	Gompholobium polymorphum	
Goodenia filiformis	Goodenia filiformis	
Goodenia geniculata		EST
Goodenia hederacea		EST

Goodenia phylicoides	Coopernookia polygalacea	
Goodenia tenella	Goodenia pusilla	
Gratiola peruviana	Gratiola pubescens	
Grevillea acerosa	Grevillea umbellulata	
Grevillea amplexans	Grevillea amplexans	
Grevillea argyrophylla	Grevillea argyrophylla	
Grevillea bipinnatifida	Grevillea bipinnatifida	
Grevillea brachystachya	Grevillea brachystachya	
Grevillea bracteosa	Grevillea bracteosa	
Grevillea Brownii	Grevillea depauperata	
Grevillea buxifolia		EST
Grevillea Candoleana	Grevillea candolleana	
Grevillea concinna	Grevillea concinna	
Grevillea crithmifolia	Grevillea crithmifolia	
Grevillea dimorpha		EST
Grevillea didymobotrya	Grevillea didymobotrya	
Grevillea diversifolia	Grevillea diversifolia	
Grevillea Drummondii	Grevillea drummondii	
Grevillea Endlicheriana	Grevillea endlicheriana	
Grevillea eriostachya	Grevillea eriostachya	
Grevillea excelsa	Grevillea excelsior	
Grevillea glabrata	Grevillea manglesii subsp. manglesii	
Grevillea Huegelii	Grevillea huegelii	
Grevillea ilicifolia		EST
Grevillea leucopteris	Grevillea leucopteris	
Grevillea nematophyla	Grevillea nematophylla	
Grevillea oxystigma	Grevillea pilulifera	
Grevillea patentiloba	Grevillea patentiloba	
Grevillea pinaster	Grevillea pinaster	
Grevillea polybotrya	Grevillea polybotrya	
Grevillea quercifolia	Grevillea quercifolia	
Grevillea sericea		EST
Grevillea striata	Grevillea striata	
Grevillea synapheae	Grevillea synapheae	
Grevillea tridentifera		WA sp., type missing application uncertain
Grevillea Wilsoni	Grevillea wilsonii	
Guichenotia micrantha	Guichenotia micrantha	
Gyrostemon ramulosus	Gyrostemon ramulosus	
Gyrostemon subnudus	Gyrostemon subnudus	
Haemodorum planifolium		EST
Haemodorum simplex	Haemodorum simplex	
Hakea adnata	Hakea adnata	
Hakea amplexicaulis	Hakea amplexicaulis	
Hakea Baxteri	Hakea baxteri	
Hakea Brookeana	Hakea obliqua subsp. obliqua	
Hakea Brownii	Hakea brownii	
Hakea cinerea	Hakea cinerea	
Hakea clavata	Hakea clavata	
Hakea corymbosa	Hakea corymbosa	
Hakea costata	Hakea costata	
Hakea crassifolia	Hakea pandanicarpa subsp. crassifolia	
Hakea cristata	Hakea cristata	
Hakea cucullata	Hakea cucullata	
Hakea dolichostyla	Hakea lasiocarpha	
Hakea erinacea	Hakea erinacea	
Hakea florida	Hakea florida	
Hakea glabella	Hakea prostrata	
Hakea laurina	Hakea laurina	
Hakea linearis	Hakea linearis	
Hakea lissocarpha	Hakea lissocarpha	
Hakea marginata	Hakea marginata	
Hakea multilineata	Hakea multilineata	
Hakea myrtoides	Hakea myrtoides	
Hakea oleifolia	Hakea oleifolia	
Hakea platysperma	Hakea platysperma	
Hakea Preissii	Hakea preissii	
Hakea pycnophylla		probably H. pycnoneura
Hakea recurva	Hakea recurva	
Hakea ruscifolia	Hakea ruscifolia	
Hakea suaveolens	Hakea drupacea	
Hakea suberea	Hakea lorea subsp. lorea	
Hakea trifurcata	Hakea trifurcata	
Hakea tripartita		probably H. trifurcata
Halgania holosericea		probably refers to Halgania tomentosa
Halgania lavandulacea	Halgania lavandulacea	
Haloragis nodulosa	Gonocarpus nodulosus	

Haloragis pithyoides	Gonocarpus pithyoides	
Haloragis rotundifolia	Gonocarpus benthamii	
Hardenbergia Comptoniana	Hardenbergia comptoniana	
Helichrysum cordatum	Ozothamnus cordatus	
Helichrysum roseum	Lawrencella rosea	
Helichrysum semipapposum	Chrysocephalum semipapposum	
Heliophila pumila	Heliophila pusilla	
Helipterum cotula	Hyalosperma cotula	
Helipterum Fitzgibbonii	Leucochrysum fitzgibbonii	
Helipterum gracile	Erymophyllum tenellum	
Helipterum hyalospermum	Hyalosperma glutinosum	
Helipterum involucratum	Erymophyllum ramosum subsp. involucratum	
Helipterum Lawrencella	Lawrencella rosea	
Helipterum Manglesii	Rhodanthe manglesii	
Helipterum splendidum	Rhodanthe chlorocephala subsp. splendida	
Helipterum teneum	Erymophyllum tenellum	
Heterodendron oleifolium	Alectryon oleifolius	
Hibbertia aurea	Hibbertia aurea	
Hibbertia amplexicaulis	Hibbertia amplexicaulis	
Hibbertia conspicua	Hibbertia conspicua	
Hibbertia cuneiformis	Hibbertia cuneiformis	
Hibbertia desmophya	Hibbertia desmophylla	
Hibbertia Huegelii	Hibbertia huegelii	
Hibbertia hypericoides	Hibbertia hypericoides	
Hibbertia microphya	Hibbertia microphylla	
Hibbertia montana	Hibbertia montana	
Hibbertia perfoliata	Hibbertia perfoliata	
Hibbertia potentilliflora	Hibbertia potentilliflora	
Hibbertia scandens		EST
Hibbertia velutina		EST
Hibbertia verrucosa	Hibbertia verrucosa	
Hibbertia virgata		EST
Hovea acanthoclada	Hovea acanthoclada	
Hovea elliptica	Hovea elliptica	
Hovea pungens	Hovea pungens	
Hovea trisperma	Hovea trisperma	
Hydrocotyle alata	Hydrocotyle alata	
Hydrocotyle callicarpa	Hydrocotyle callicarpa	
Hydrocotyle diantha	Hydrocotyle diantha	
Hydrocotyle hirta	Hydrocotyle hirta	
Hydrocotyle hispidula	Hydrocotyle hispidula	
Hydrocotyle homalocarpa	Homalosciadium homalocarpum	
Hydrocotyle pilifera	Hydrocotyle pilifera	
Hydrocotyle plebeia	Hydrocotyle plebeya	
Hydrocotyle rugulosa	Hydrocotyle rugulosa	
Hypocalymma cordifolium	Hypocalymma cordifolium	
Hypocalymma myrtifolium	Hypocalymma myrtifolium	
Hypolaena gracillima	Empodisma gracillimum	
Hypoxis glabella	Hypoxis glabella	
Inga moniliformis		= Cathormion umbellatum EST
Isopogon alcicornis	Isopogon alcicornis	
Isopogon anemonifolius		EST
Isopogon Baxteri	Isopogon baxteri	
Isopogon formosus	Isopogon formosus	
Isopogon latifolius	Isopogon latifolius	
Isopogon roseus	Isopogon dubius	
Isopogon scabriusculus	Isopogon scabriusculus	
Isopogon teretifolius	Isopogon teretifolius	
Isopogon trilobus	Isopogon trilobus	
Isotoma petraea	Isotoma petraea	
Isotropis atropurpurea	Isotropis atropurpurea	
Jacksonia densiflora	Jacksonia floribunda	
Jacksonia furcellata	Jacksonia furcellata	
Jacksonia furfuracea		probably Jacksonia furcellata
Jacksonia horrida	Jacksonia horrida	
Jacksonia sericea	Jacksonia sericea	
Jacksonia spinosa	Jacksonia spinosa	
Jacksonia Sternbergiana	Jacksonia sternbergiana	
Jam Tree	Acacia acuminata	
Jambosa eucalyptoides		= Syzygium eucalyptoides EST
Jasminum calcareum	Jasminum calcarium	
Jasminum Dallachii		= Jasminum dallachii EST
Jansonia formosa	Jansonia formosa	
Jarrah	Eucalyptus marginata	
Johnsonia lupulina	Johnsonia lupulina	
Juncus bufonius	Juncus bufonius	

Juncus caespiticius	Juncus caespiticius	
Kennedya	Kennedia	
Kennedya coccinea	Kennedia coccinea	
Kennedya microphylla	Kennedia microphylla	
Kennedya prostrata	Kennedia prostrata	
Kennedya rubicunda		EST
Keraudrenia integrifolia	Keraudrenia integrifolia	
Kingia australis	Kingia australis	
Kochia amoena	Maireana amoena	
Kochia polypterygia	Maireana polypterygia	
Kochia villosa	Maireana villosa	
Koeleria phleoides	Rostraria cristata	
Kunzea recurva	Kunzea recurva	
Kunzea sericea	Leptospermum sericeum	
Lachnostachys Cliftoni	Lachnostachys verbascifolia	
Lambertia ericifolia	Lambertia ericifolia	
Lambertia formosa		EST
Lambertia inermis	Lambertia inermis	
Lambertia multiflora	Lambertia multiflora	
Lambertia uniflora	Lambertia uniflora	
Lasiopetalum cordifolium	Lasiopetalum cordifolium	
Lasiopetalum discolor	Lasiopetalum discolor	
Lasiopetalum parviflorum	Lasiopetalum parvuliflorum	
Lasiopetalum Schulzenii		= Lasiopetalum schulzenii EST
Lavatera plebeia	Malva australiana	
Laxmannia ramosa	Laxmannia ramosa	
Lepidium linifolium	Lepidium linifolium	
Lepidosperma gladiatum	Lepidosperma gladiatum	
Lepidobolus deserti	Lepidobolus deserti	
Leptocarpus coangustatus	Meeboldina coangustata	
Leptocarpus scariosus	Meeboldina scariosa	
Leptocarpus tenax	Leptocarpus tenax	
Leptospermum crassipes	Pericalymma crassipes	
Leptospermum ellipticum	Pericalymma ellipticum	
Leptospermum firmum	Homalospermum firmum	
Leptospermum wooroonooran		EST
Lepyrodia glauca	Lepyrodia glauca	
Leschenaultia biloba	Lechenaultia biloba	
Leschenaultia expansa	Lechenaultia expansa	
Leschenaultia formosa	Lechenaultia formosa	
Leschenaultia linarioides	Lechenaultia linarioides	
Leucopogon australis	Leucopogon australis	
Leucopogon cinereus	Leucopogon cinereus	
Leucopogon conostephioides	Leucopogon conostephioides	
Leucopogon Dielsianus	Leucopogon dielsianus	
Leucopogon gibbosus	Leucopogon gibbosus	
Leucopogon gnaphalioides	Leucopogon gnaphalioides	
Leucopogon hamulosus	Leucopogon hamulosus	
Leucopogon hispidus	Leucopogon hispidus	
Leucopogon nutans	Leucopogon nutans	
Leucopogon psammophilus	Leucopogon psammophilus	
Leucopogon Richei		probably Leucopogon parviflorus
Leucopogon unilateralis	Leucopogon unilateralis	
Leucopogon verticillatus	Leucopogon verticillatus	
Leucopogon Woodsii	Leucopogon woodsii	
Levenhookia Preissii	Levenhookia preissii	
Levenhookia stipitata	Levenhookia stipitata	
Lindsaea triquetra		probably refers to Lindsaea linearis
Livistona Alfredi	Livistona alfredii	
Livistona australis		EST
Livistona Mariae	Livistona mariae	
Lobelia gibbosa	Lobelia gibbosa	
Lobelia rhytidosperma	Lobelia rhytidosperma	
Lobelia tenuior	Lobelia tenuior	
Logania buxifolia	Logania buxifolia	
Logania callosa	Logania callosa	
Logania campanuata	Logania campanulata	
Logania fasciculata	Logania fasciculata	
Logania flaviflora	Logania flaviflora	
Logania latifolia	Logania vaginalis	
Logania longifolia	Logania vaginalis	
Logania micrantha	Logania micrantha	
Logania nuda	Logania nuda	
Logania pusilla		EST
Logania serpylifolia	Logania serpyllifolia	
Logania spermacocea	Logania spermacocea	

Logania stenophylla	Logania stenophylla	
Logania vaginalis	Logania vaginalis	
Logania vaginalis var laxior	Logania vaginalis	
Loranthus linifolius		probably refers to Lysiana preissii
Loranthus quandang		probably refers to Amyema nestor
Lotus australis	Lotus australis	
Loxocarya densa	Loxocarya cinerea	
Loxocarya pubescens	Hypolaena pubescens	
Lupinus angustifolius	Lupinus angustifolius	
Lyginia barbata	Lyginia barbata	
Lysinema conspicuum	Lysinema conspicuum	
Macrozamia Dyeri	Macrozamia dyeri	
Macrozamia Macdonellii		EST
Macrozamia Perowskiana		= Macrozamia peroffskyana EST
Macrozamia Fraseri		refers to both M. fraseri & M. riedlei
Macrozamia spiralis		EST
Mallophora globiflora	Mallophora globiflora	
Marianthus caeruleopunctatus	Marianthus coeruleo-punctatus	
Marianthus candidus	Marianthus candidus	
Marianthus ringens	Marianthus ringens	
Marsdenia flavescens		EST
Marsdenia Leichhardtiana	Marsdenia australis	
Marsilia Drummondii	Marsilea drummondii	
Medicago denticulata	Medicago polymorpha	
Melaleuca acerosa	Melaleuca systena	
Melaleuca cardiophylla	Melaleuca cardiophylla	
Melaleuca exarata	Melaleuca suberosa	
Melaleuca glaberrima	Melaleuca glaberrima	
Melaleuca Huegelii	Melaleuca huegelii	
Melaleuca icana	Melaleuca incana	
Melaleuca lateritia	Melaleuca lateritia	
Melaleuca leucadendron	Melaleuca leucadendra	
Melaleuca megacephala	Melaleuca megacephala	
Melaleuca pauperiflora	Melaleuca pauperiflora	
Melaleuca Preissiana	Melaleuca preissiana	
Melaleuca radula	Melaleuca radula	
Melaleuca rhaphiophylla	Melaleuca rhaphiophylla	
Melaleuca seriata	Melaleuca seriata	
Melaleuca thyoides	Melaleuca thyoides	
Melaleuca uncinata	Melaleuca uncinata	
Melaleuca violacea	Melaleuca uncinata	
Melilotus parviflora	Melilotus indicus	
Mesembrianthemum aequilaterale	Carpobrotus aequilaterus	
Microtis alba	Microtis alba	
Millotia tenuifolia	Millotia tenuifolia	
Mirbelia microphylloides	Mirbelia microphylla	
Mirbelia spinosa	Mirbelia spinosa	
Mitchell Grass	Astrebla pectinata	
Mitrasacme paradoxa	Phyllangium paradoxum	
Monotoca tamariscina	Monotoca tamariscina	
Morinda Leichhardtii		invalid name, ref. a riparian Rub. - Qld.
Mulga	Acacia aneura	
Musa Banksii		moss
Musa Hillii		moss
Myoporum acuminatum	Myoporum acuminatum	
Myoporum oppositifolium	Myoporum oppositifolium	
Myriocephaus gracilis	Gilberta tenuifolia	
Myriocephaus Guerinae	Myriocephalus guerinae	
Myriocephaus Morrisonianus	Helipterum craspedioides	
Myriophyllum tillaeoides	Myriophyllum tillaeoides	
Myrtus metrosideros		= Uromyrtus metrosideros EST
Nelumbium speciosum		= Nelumbo speciosa EST
Newcastlia bracteosa	Newcastelia bracteosa	
Newcastlia cephalantha	Newcastelia cephalantha	
Newcastlia insignis	Newcastelia insignis	
Newcastlia viscida	Physopsis viscida	
Nicotiana suaveolens		probably refers to Nicotiana rotundifolia
Nothochlaena distans	Cheilanthes distans	
Nothofagus Cunninghamii		= Nothofagus cunninghamii EST
Nothofagus Moorei		= Nothofagus moorei EST
Nuytsia floribunda	Nuytsia floribunda	
Nymphaea gigantea	Nymphaea gigantea	
Oberonia palmicola		= Oberonia titania EST
Olearia axlllaris	Olearia axillaris	
Olearia candidissima	Olearia axillaris	
Olearia Muelleri	Olearia muelleri	

Olearia paucidentata	Olearia paucidentata	
Olearia stellulata		EST
Opercularia apicifiora	Opercularia apiciflora	
Oreobolus pumilio		EST
Orites fragrans		= O. excelsa EST
Oxalis cognata	Oxalis perennans	
Oxylobium alpestre		EST
Oxylobium Callistachys	Callistachys lanceolata	
Oxylobium graniticum	Gastrolobium graniticum	
Oxylobium lineare	Oxylobium lineare	
Oxylobium melinocaule	Nemcia retusa	
Oxylobium parviflorum	Gastrolobium parviflorum	
Oxylobium reticulatum	Nemcia carinata	
Oxylobium retusum	Nemcia reticulata	
Oxylobium tetragonophyllum	Gastrolobium tetragonophyllum	
Panax cephalobotrys		= Cephalaralia cephalobotrys EST
Parentucellia latifolia	Parentucellia latifolia	
Parietaria debilis	Parietaria debilis	
Parmelia conspersa		lichen
Pelargonium australe	Pelargonium australe	
Pelargonium Rodneyanum		probably refers to Geranium retrorsum
Pentaptilon Careyi	Pentaptilon careyi	
Persoonia longifolia	Persoonia longifolia	
Persoonia teretifolia	Persoonia teretifolia	
Petrophila divaricata	Petrophile divaricata	
Petrophila diversifolia	Petrophile diversifolia	
Petrophila ericifolia	Petrophile ericifolia	
Petrophila fastigiata	Petrophile fastigiata	
Petrophila linearis	Petrophile linearis	
Petrophila longifolia	Petrophile longifolia	
Petrophila media	Petrophile media	
Petrophila plumosa	Petrophile plumosa	
Petrophila scabriuscula	Petrophile scabriuscula	
Petrophila serruriae	Petrophile serruriae	
Petrophila squamata	Petrophile squamata	
Phebalium ovatifolium		= Nematolepis ovatifolia EST
Phebalium rude	Rhadinothamnus rudis	
Philotheca calida		= Drummondita calida EST
Philotheca ericoides	Drummondita ericoides	
Phylloglossum Drummondii	Phylloglossum drummondii	
Phyllota lycopodioides	Urodon dasyphyllus	
Phymatocarpus porphyrocephalus	Phymatocarpus porphyrocephalus	
Physcia chrysophthalma		lichen
Physopsis spicata	Physopsis spicata	
Pimelea argentea	Pimelea argentea	
Pimelea clavata	Pimelea clavata	
Pimelea Gilgiana	Pimelea gilgiana	
Pimelea glauca		EST
Pimelea hispida	Pimelea hispida	
Pimelea longiflora	Pimelea longiflora	
Pimelea microcephala	Pimelea microcephala	
Pimelea physodes	Pimelea physodes	
Pimelea sylvestris	Pimelea sylvestris	
Pittosporum bicolor		EST
Pittosporum phillyreifolium	Pittosporum ligustrifolium	
Pittosporum phillyreoides	Pittosporum ligustrifolium	
Pityrodia cuneata	Pityrodia cuneata	
Platytheca galioides	Platytheca galioides	
Pleurosorus rutifolius	Pleurosorus rutifolius	
Podocarpus amara		= Prumnopitys amara EST
Podocarpus Drouyniana	Podocarpus drouynianus	
Podolepis aristata	Podolepis canescens	
Podolepis Lessoni	Podolepis lessonii	
Podolepis nutans	Podolepis nutans	
Podolepis pallida	Podolepis auriculata	
Polinia fulva	Eulalia aurea	
Polygonum Cunninghamii	Muehlenbeckia florulenta	
Polypompolyx multifida	Utricularia multifida	
Poranthera ericoides	Poranthera ericoides	
Poranthera glauca	Poranthera ericoides	
Poranthera microphyla	Poranthera microphylla	
Pothos longipes		EST
Prasophylum parvifolium	Prasophyllum parvifolium	
Pride of the Desert		Erempohila spp.
Pritzelia	Philydrella	
Pritzelia pygmaea	Philydrella pygmaea	

Pronaya elegans	Pronaya fraseri	
Prostanthera Baxteri	Prostanthera baxteri	
Prostanthera Gryloana	Prostanthera grylloana	
Prostanthera microphylla	Prostanthera serpyllifolia subsp. microphylla	
Psammomoya choretroides	Psammomoya choretroides	
Psammomoya ephedroides	Psammomoya ephedroides	
Pseudanthus virgata	Pseudanthus virgatus	
Psoralea eriantha	Cullen patens	
Psoralea pinnata	Psoralea pinnata	
Pteridium aquilinum	Pteridium esculentum	
Pterostylis pyramidalis	Pterostylis pyramidalis	
Pultenaea obcordata	Pultenaea obcordata	
Pultenaea rosea		= Burtonia subalpina EST
Pultenaea tenuifolia	Pultenaea tenuifolia	
Pultenaea vestita	Pultenaea vestita	
Ranunculus anemoneus		EST
Ranunculus Gunnianus		= Ranunculus gunnianus EST
Ranunculus lappaceus		refers to Ranunculus colonorum
Ranunculus parviflorus		refers to Ranunculus pumilio
Raoulia catipes		= Ewartia catipes EST
Reedia	Reedia spathacea	
Rhagodia Billardieri	Rhagodia baccata	
Rhagodia Gaudichaudiana	Chenopodium gaudichaudianum	
Rhaphidostegium homomallum		moss
Rhododendron Lochae		= Rhododendron lochiae EST
Romulea rosea	Romulea rosea	
Rubus fruticosus		EST weed
Ruelingia coacta	Ruelingia craurophylla	
Ruelingia cuneata	Rulingia cuneata	
Ruelingia	Rulingia	
Salicornia arbuscula	Sclerostegia arbuscula	
Salicornia australis	Sarcocornia quinqueflora	
Salicornia leiostachya	Halosarcia indica subsp. leiostachya	
Salmon Gum	Eucalyptus salmonophloia	
Samolus Junceus	Samolus junceus	
Samolus repens	Samolus repens	
Sarcochilus parviflorus		EST
Scaevola crassifolia	Scaevola crassifolia	
Scaevola fasciculata	Goodenia fasciculata	
Scaevola humifusa	Scaevola humifusa	
Scaevola nitida	Scaevola nitida	
Scaevola paludosa	Scaevola paludosa	
Scaevola porocarya	Scaevola porocarya	
Scaevola restiacea	Scaevola restiacea	
Scaevola spinescens	Scaevola spinescens	
Scaevola striata	Scaevola striata	
Schizaea fistulosa	Schizaea fistulosa	
Schoenia Cassiniana	Schoenia cassiniana	
Schoenolaena juncoide	Schoenolaena juncea	
Schoenus apogon		an annual, possibly S. odontocarpus
Scholtzia capitata	Scholtzia capitata	
Scholtzia obovata		?, possibly Scholtzia involucrata
Scholtzia uberiflora	Scholtzia uberiflora	
Scirpus cartilagineus		?, annual of granite rocks
Scirpus nodosus	Isolepis nodosa	
Sclerolaena litoralis		possibly refers to Sclerolaena diacantha
Selaginella Preissiana		probably refers to Selaginella gracillima
Senecio centropappus		= Senecio brunonis EST
Senecio Gregorii	Othonna gregorii	
Silene acaulis		non Australian taxa
Sida brachystachys		?, type from near Gascoyne R
Silene gallica	Silene gallica	
Smilax australis	Smilax australis	
Solanum lasiophyllum	Solanum lasiophyllum	
Solanum orbiculatum	Solanum orbiculatum	
Sollya heterophylla	Sollya heterophylla	
Sphenotoma Drummondii	Sphaerolobium drummondii	
Sphenotoma gracile	Sphaerolobium gracile	
Spinifex hirsutus	Spinifex hirsutus	
Spinifex longifolius	Spinifex longifolius	
Sprengelia incarnata		EST
Spyridium globulosum	Spyridium globulosum	
Stackhousia megaloptera	Stackhousia megaloptera	
Stackhousia pulvinaris		EST
Statice salicornioides	Muellerolimon salicorniaceum	
Stenanthemum gracilipes	Stenanthemum gracilipes	

Stenopetaum pedicelare	Stenopetalum pedicellare	
Sterculia Gregorii	Brachychiton gregorii	
Sticta Billardieri		lichen
Stipa	Austrostipa	
Stipa elegantissima	Austrostipa elegantissima	
Stipa pycnostachya	Austrostipa pycnostachya	
Stirlingia latifolia	Stirlingia latifolia	
Stirlingia polymorpha		id uncertain, winter flowering Stirlingia
Stylidium breviscapum	Stylidium breviscapum	
Stylidium cacaratum	Stylidium calcaratum	
Stylidium canaliculatum	Stylidium canaliculatum	
Stylidium Dielsianum	Stylidium dielsianum	
Stylidium diversifoium	Stylidium diversifolium	
Stylidium junceum	Stylidium junceum	
Stylidium limbatum	Stylidium limbatum	
Stylidium Merrallii	Stylidium merrallii	
Stylidium repens	Stylidium repens	
Stylidium scandens	Stylidium scandens	
Stylidium striatum	Stylidium striatum	
Stylidium yilgarnense	Stylidium yilgarnense	
Styphelia melaleucoides	Styphelia melaleucoides	
Styphelia pusilliflora		= Styphelia exarrhena EST
Styphelia tenuiflora	Styphelia tenuiflora	
Suaeda maritima	Suaeda australis	
Synoum glandulosum		EST
Tarrietia argyrodendron		= Heritiera trifoliolata EST
Tecoma australis		= Pandorea pandorana EST
Templetonia egena	Templetonia egena	
Templetonia retusa	Templetonia retusa	
Terminalia chuncoa		= Terminalia canescens EST
Tetratheca ericifolia		EST
Thelymitra antennifera	Thelymitra antennifera	
Thelymitra crinita	Thelymitra crinita	
Thelymitra longifolia		?, probably refers to T. antennifera
Thomasia pauciflora	Thomasia pauciflora	
Thomasia solanacea	Thomasia solanacea	
Thryptomene australis	Thryptomene australis	
Thysanotus Patersoni	Thysanotus patersonii	
Thysanotus pauciflorus	Thysanotus pauciflorus	
Todea africana		= Todea barbara EST
Trachymene juncoide	Trachymene cyanopetala	
Trachymene compressa	Platysace compressa	
Trachymene effusa	Platysace effusa	
Trachymene heterophylla		EST
Trachymene linearifolia		EST
Tremandra diffusa	Tremandra diffusa	
Trichinium	Ptilotus	
Trichinium Drummondii	Ptilotus drummondii	
Trichinium exaltatum	Ptilotus exaltatus	
Trichinium Manglesii	Ptilotus manglesii	
Trichinium obovatum	Ptilotus obovatus	
Trichinium siphonandrum		?, flower shown in fig 71
Trichodesma zeylanicum	Trichodesma zeylanicum	
Trifolium tomentosum	Trifolium tomentosum	
Triglochin calcitrapa	Triglochin calcitrapa	
Triglochin centrocarpa	Triglochin centrocarpa	
Triglochin mucronata	Triglochin mucronata	
Triglochin nana	Triglochin nana	
Triglochin procera	Triglochin linearis	
Triglochin striata	Triglochin striata	
Triraphis danthonioides	Triodia danthonioides	
Triraphis rigidissima	Triodia rigidissima	
Tristania conferta		= Lophostemon confertus EST
Tristania suaveolens		= Lophostemon suaveolens EST
Trochocarpa laurina		EST
Trymalium Billardieri	Trymalium floribundum	
Tuart	Eucalyptus gomphocephala	
Ulex europaeus	Ulex europaeus	
Usnea barbata		lichen
Utricularia Menziesii	Utricularia menziesii	
Velleia cycnopotamica	Velleia cycnopotamica	
Velleia Daviesii	Velleia daviesii	
Veronica densifolia	Verticordia densiflora	
Verreauxia Reinwardtii	Verreauxia reinwardtii	
Verticordia acerosa	Verticordia acerosa	
Verticordia Brownii	Verticordia brownii	

Verticordia Drummondii	Verticordia drummondii	
Verticordia Fontanesii	Verticordia plumosa	
Verticordia grandiflora	Verticordia grandiflora	
Verticordia grandis	Verticordia grandis	
Verticordia habrantha	Verticordia habrantha	
Verticordia helichrysantha	Verticordia helichrysantha	
Verticordia Muelleriana	Verticordia muelleriana	
Verticordia nitens	Verticordia nitens	
Verticordia oculata	Verticordia oculata	
Verticordia ovalifolia	Verticordia ovalifolia	
Verticordia Pritzelii	Verticordia pritzelii	
Verticordia spicata	Verticordia spicata	
Verticordia stelluligera	Verticordia densiflora var. stelluligera	
Viminaria denudata	Viminaria juncea	
Viola betonicifolia		EST
Viola hederacea		EST
Vittadinia australis	Vittadinia australasica	
Wahlenbergia gracilis		probably Wahlenbergia gracilenta
Waitzia acuminata	Waitzia acuminata	
Waitzia aurea	Waitzia nitida	
Waitzia corymbosa	Waitzia corymbosa	
Waitzia nivea	Waitzia suaveolens	
Wandoo		refers to Euc. wandoo-redunca complex
Wehlia tryptomenoides	Homalocalyx thryptomenoides	
Westringia rigida	Westringia rigida	
Wormia alata		= Dillenia alata EST
Xanthium spinosum	Xanthium spinosum	
Xanthorrhoea arborea		EST
Xanthorrhoea gracilis	Xanthorrhoea gracilis	
Xanthorrhoea hastilis		= Xanthorrhoea resinosa EST
Xanthorrhoea Preissii	Xanthorrhoea preissii	
Xanthorrhoea quadrangulata		EST
Xanthosia candida	Xanthosia candida	
Xanthosia peltigera	Pentapeltis peltigera	
Xanthosia pilosa		EST
Xanthosia rotundifolia	Xanthosia rotundifolia	
Xanthosia tenuior	Schoenolaena juncea	
Xantorrhoea	Xanthorrhoea	
Xerotes	Lomandra	
Xerotes effusa	Lomandra effusa	
Xerotes longifolia		= L. longifolia EST
Xerotes rigida	Lomandra rigida	
Xylomelum angustifolium	Xylomelum angustifolium	
Xylomelum occidentale	Xylomelum occidentale	
Xylomelum pyriforme		EST
York Gum	Eucalyptus loxophleba	
Zygophyllum fruticulosum	Zygophyllum fruticulosum	

Appendix B

Translation of Figure captions.

Fig. 1. The state of floristic studies in South-western Australia in 1905. The four degrees of shading indicate the intensity of investigation in the different areas.

Fig. 2. Distribution of rainfall in south-west Australia. Average yearly rainfall in centimetres. The heavily dotted lines show the boundary between the Southwest Province and the Eremaea.

Fig. 3. *Eucalyptus marginata* Donn ex Sm.
A. Flowering twig; B. Fruits; C. Seeds
(Original)

Fig. 4. *Eucalyptus diversicolor* F. v. M.
A. Flowering twig; B. L.S. of flower-bud; C. Operculum; D. Fruit stalk; E., F. Seeds
(Original)

Fig. 5. *Eucalyptus gomphocephala* DC.
A. Flowering twig; B. Fruit as seen from the side; C. Fruit as seen from above
(Original)

Fig. 6. *Eucalyptus redunca* Schau.
A. Twig with flower buds; B. Leaf; C. Flowering twig; D. Fruits on stalk; E. Fruit
(Original)

Fig. 7.
A.-B. *Casuarina glauca* Mig.
A, Cone (fruit); B, Achene
C.-E. *C. Huegeliana* Miq.
C, Male catkin D, Cone (fruit) E, Achene
F. *C. Fraseriana* Miq., Stalk with cones
(After Diels and Pritzel)

Fig. 8. *Banksia grandis* R. Br.
A. Flowering twig; B. Flower; C. Perianth member with stamen;
D. Style and stigma
(Original)

Fig. 9. *Nuytsia floribunda* R. Br.
A. Flowering twig; B. Part of the inflorescence; C. cymose inflorescence; D. Basic unit of gynoecium with bracts which imitate an external calyx; E. Part of a fruiting branch
(Original)

Fig. 10.
A.-E. *Xantorrhoea Preissii* Endl.
A. Flower; B. Outer perianth segment; C. Inner perianth segment;
D. Stamen; E. Gynoecium;
F.-H. *Kingia australia* R. Br.
F. Flower; G. Stamen;
H.-I. Gynoecium
J.-M. *Dasypogon bromeliaefolius* R. Br.
J. Flower; K. Outer perianth segment; L. Inner perianth segment; M. Anther
(Original)

Fig. 11. *Petrophila ericifolia* R. Br.
A. Front view of a flowering branch; B. L.S. of flower; C. Stamen;
D. Style-end; E. Cone; F. Young fruit
G.-K . *Petrophila scabriuscula* Meissn.
G. Flowering branch; H. L.S. of flower; J. Anther; K. Style-end. (After Diels and Pritzel)

Fig. 12. *Hakea dolichostyla* Diels
A. Flowering branch; B. Flower head; C. Bud; D. E. Scales; F. Flower;
G. Perianth member; H. Torus, gland and ovary; Upper part of the style-end (After Diels and Pritzel)

Fig. 13. *Melaleuca Preissiana* Schau. in flower
Darling District, Bayswater (Photograph by E. Pritzel, Dec. 1900)

Fig. 14. Myrtaceae of the Southwest Province
A.-C. *Calythrix flavescens* A. Cunn.
A . Habit: flowering branches; B. Leaf; C. Floral leaf (bracteole);
D.-G. *Melaleuca seriata*, Lindl.
D. Flowering branch; E. Leaf; F. Flower; G. Fruit cluster
(Original)

Fig. 15. *Verticordia Pritzelii*, Diels
A. Habit; B. Flower; C. Calyx tube; D. Primary calyx lobe;
E. Accessory calyx lobe; F. Floral leaf; G. Stamen and staminodes; H. Stamen; J.-K. Style (After Diels and Pritzel)

Fig. 16. Podalyrieae of the Southwest Province
A. Twig of *Brachysema undulatum* Ker.; B. Corolla;
C. L.S. flower showing ovary and stamens; D. T.S. seed
E. Twig of *Oxylobium retusum* R, Br.
F. Calyx; G. Corolla; H. L.S. through ovary
(After Taubert)

Fig. 17.
A.-C. *Oxylobium parviflorum*, Benth.
A. Habit; B. Calyx; C. L.S. Gynoecium;
D. *Oxylobium melinocaule*, E. Pritzel. Habit
E. *Oxylobium tetragonophyllum* Pritzel Habit
(After Diels and Pritzel))

Fig. 18. *Acacia* species of the Southwest Province
A. *Acacia hastulata*, Sm.; B. *Acacia alata*, R. Br. C. *Acacia myrtifolia* Willd. var. *angustifolia* Willd.;
D. *Acacia pentadenia*, Lindl.

Fig. 19. *Leucopogon* spp. of the Southwest Province
A.-D. *L. cinereus* E. Pritzel
A. Branch; B. Leaf; C. Flower opened out; D. Stamen
E.-G. *L. psammophilus* E. Pritzel
E. Twig; F. Leaf; G. Flower opened out
H.-K. *L. Dielsianus*, E. Pritzel
H. Twig; J. Leaf; K. Flower opened out
L.-M. *L. nutans*, E. Pritzel
L. Twig; M. Flower opened out
N.-P. *L. hispidus*, E. Pritzel
N. Twig; 0. Leaves; P. Flower opened out
Q.-S. *L. hamulosus*, E. Pritzel
Q. Twig; R. Leaf; Flower opened out
(After Diels and Pritzel)

Fig. 20. Goodeniaceae of the Southwest Province
A. *Goodenia tenella* R. Br.; B. *Lechenaultia formosa* R. Br.; C. *Scaevola striata*, R. Br.
(Original)

Fig . 21. *Borya nitida*, Labill.
A. Habit; B. Flower (Original)

Fig. 22. *Stylidium* spp. of the Southwest Province
A.-D. *Stylidium scandens*, R. Br.
A. Habit; B. Flower; C. Joined anthers; D. Section through ovary;
E.-G. *Stylidium junceum*, R. Br.
E. Habit; F. Flower; G. Fruit.
(After Mildbraed in 'Pflanzenreich')

Fig. 23. Orchidaceae of the Southwest Province
A. *Microtis alba* R. Br.
B. *Pterostylis pyramidalis* R. Br.
C. *Caladenia gemmata*Lindl.
D. *Caladenia Patersoni* R. Br.
E. *Prasophyllium parvifolium* Lindl.
F. *Diuris setacea* R. Br.
(Original)

Fig. 24. Sterculiaceae of the Southwest Province
A.-B. *Thomasia solanacea* J. Gay.
A. Habit; B. Gynoecium and Androecium;
C.-D. *Cuichenotia micrantha* (Steetz.)Bth.
C. Habit; D. Androecium and Gynoecium
(Original)

Fig. 25. Restionaceae of the Southwest Province
A.-C. *Leptocarpus tenax* R. Br.
A. Habit of the male plant; B. Branch of male inflorescence;
C. Branch of female inflorescence;
D.-F. *Loxocarya pubescens* (R. Br.) Benth.
D. Habit; E.-F. Part of the inflorescence
(Original)

Fig. 26
A. *Boronia megastigma* Nees. Androecium and Gynoecium
B.-C. *Boronia Purdieana,* Diels
B. Habit; C. Androecium and Gynoecium
D.-G. *Boronia tetrandra.* Lab.
D. Androecium and Gynoecium; E. Stamen; F. Staminode;
G. Gynoecium
(After Diels and Pritzel)

Fig. 27. Umbelliferae of the Southwest Province
A. *Xanthosia rotundifolia* DC.
B. *Trachymene compressa* (Lab.) Spreng.
C.-D. *Actinotus leucocephalus* Benth.
(Original)

Fig. 28. A.-C. *Conostylis Dielsii* W. V. Fitzgerald.
A. Habit; B. L.S. Flower; C. Perianth segment;
D.-G. *Conostylis phathyrantha,* Diels
D. Habit; E. L.S. Flower; F.-G Stamen, front and back views
(After Diels and Pritzel)

Fig. 29. *Hibbertia hypericoides* (DC.) Benth.
A. Habit; B. Flower; C. Calyx segment; D. Corolla segment;
E. Androecium and Gynoecium (Original)

Fig. 30. Droseraceae of the Southwest Province
A.-D. *Drosera macrantha* Endl.
A. Habit; B. Leaves; C. Calyx; D. Calyx-segment;
E.-F. *Drosera microphylla* Endl.
E. Habit; F. Flower;
G. H. *Drosera heterophylla* Lindl.
G. Habit; H. Gynoecium
(After Diels in 'Pflanzenreich')

Fig. 31.
A. Habit of growth of *Centrolepis tenuior* (R. Br.) Röm et Schult. (nat. size.),
B. Flower of the above plant surrounded by bracts
C. Median section through the seed: e embryo
D. Seedling plant (cotyledons still bearing the seed coat)
E. Habit of growth of *Centrolepis aristata* (R. Br.) Röm et Schult. (nat size)
F. Ovary of *Centrolepis Drummondii* (N. Ab Esenb.) Hieron.
For comparison G.-J. *Gaimardia australis* Gaudich.
G. Habit of growth of a fruiting stalk
H. Flower; *a* empty anther
J. L.S. of ovary
The figures shown in the above are drawn at about natural size.
(After Hieronymus)

Fig 32.
A-B *Drosera nitidula* Planch
A. Habit, B. Gynoecium
C-F *Drosera paleacea* DC.
C. Habit, D. Stipule
E. Leaf without stipule, F. Gynoecium
G-K *Drosera pycnoblasta* Diels
G. Habit H, Stipule
J. Leaf without stipule, K. Ovary
(After Diels and Pritzel)

Fig. 33. *Calandrinia primuliflora* Diels
A-F A. Habit, B. Bracts or scale leaves
C. Sepals, D. Petal
E. Stamen, F. Ovary with free styles
G-L *Calandrinia Lehmannii* Endl.
G. Upper part of the stalk with the inflorescence
H. Bracts or scale leaves, J. Sepals
K. Petal, L. Ovary with partly-joined styles.
(After Diels and Pritzel)

Fig. 34 Bulbous plants : *Drosera* Sect. Erythrorhiza
A-D *Drosera rosulata* Lehm..
A. Habit,
B. Petal,
C. Stamen
D. Gynoecium (Ovary with styles)
E *Drosera squamosa* Benth. Habit
F. *Drosera macrophylla* Lindl. Habit
G. *Drosera bulbosa* Hook. Habit
(After Diels)

Fig. 35 Annuals. *Myriophyllum tillaeoides* Diels
A. Habit; B. Flowering stalk; C. Male flower; D. Hermaphrodite flower; E. Female flower
(After Diels and Pritzel)

Fig. 36 Hygrophilous annual Composites
A-D *Myriocephalus isoetes* Diels
A. Habit
B-C. Involucral bracts
D. Flower
E-J *Myriocephalus rhizocephalus* (DC) Benth.
E-F.Involucral bracts
G. Partial head.
H. Flower.
J. Habit
(After Diels and Pritzel)

Fig. 37 Branching patterns
A. *Petrophila linearis* R.Br.
B. *Isopogon scabriusculus* Meissn.
C. *Leucopogon gibbosus* Stschegl.
(Original)

Fig. 38 *Grevillea* - with long and short branches
A. *Grevillea acerosa* F. v. M.
B. *Grevillea oxystigma* var. *acerosa* Meissn.
C. *Grevillea uncinulata* Diels
(Original)

Fig 39. Cushion form of *Scaevola humifusa* De Vr. var. *pulvinaris* E. Pritzel
(Original)

Fig. 40 Developmental stages of the terminal shoot of a twig of *Acacia barbinervis* Benth.
A. 27th December 1900 - in active growth
B. 6th February 1901 - growth complete
(Original)

Fig. 41
A. *Cryptandra leucopogon* Meissn. - Flower stalk
B – D *Cryptandra polyclada* Diels
B. Habit
C. Flower with bracts
D. Part of the flower spread out
E – H *Stenanthemum gracilipes* Diels
E. Flower stalk
F. Flower
G. Part of the flower spread out
H. Floral leaf

Fig. 42 *Hakea Brooksiana* F. v. M.
A. Flowering twig.
B. Flower
C. Perianth
D. Disc and ovary
E. Upper part of style and pollen-presenter
F. Fruit-bearing branch
G. Seed
(After Diels and Pritzel)

Fig. 43 Aphyllous species
A - H. *Psammomoya choertroides* (F. v. M.) Diels et Loes.
A. Habit
B. Flower
C. Floral leaf
D. Disc and gynoecium
E-F Sections through ovary
G-H Fruit
H. Seed
J - L. *Psammomoya ephedroides* Diels et Loes.
J. Habit
K. Flower
L. Disc and gynoecium
(After Diels and Pritzel)

Fig. 44 *Acacia insolita* E. Pritzel
A. Habit
B. Leaf
C. Phyllode
D. Young bud
E. Flower
F. 2 corolla segments
(After Diels and Pritzel)

Fig. 45 Schematic representation of the typical anatomical leaf structure in the Southwest Province.
A. *Acacia microbotrya* Benth.
B. *Melaleuca Preissiana* Schau.
(Original)

Fig. 46 Schematic representation of the leaf structure typical of xeromorphic plants in the Southwest Province.
B-C. *Hakea platysperma* Hook.
A. *Daviesia pachyphylla* F. v. M.
(Original)

Fig. 47 Bud scales of flowers in south-western Australia
A. *Acacia squamata* Lindl.
B-C. *Acacia restiacea* Bth. Unfolding in C.
D. *Daviesia hakeoides* Meissn
E. *Grevillea bracteosa* Meissn.
F-G. *Grevillea Endlicheriana* Meissn. (In G. the whole young shoot with its bract-enclosed bud is shown enlarged.)
H. *Conostephium pendulum* Benth.
(Original)

Fig. 48 Corolla-like bracts as involucres of the inflorescences in south-western Australia
A. *Johnsonia lupulina* R.Br.
B. *Andersonia patrica* F. v. M.
C. *Pimelea physodes* Hook.
D. *Diplolaena Darwinii* Desf.
E. *Darwinia Meissneri* Benth.
(Original)

Fig. 49. Adaptations in leaves of *Logania*. Sect. Eulogania:
A. *Logania vaginalis* Labill. var *laxior* Nees from Denmark River. (Diels n.2166)
B. *Logania vaginalis* Labill. var *longifolia* R.Br. from Fremantle (Diels n.3896)
C. *Logania vaginalis* Labill.var *vaginalis*. from Esperance (Diels n.5388)
D. *Logania latifolia* F. v. M. from Baldhead on King George Sound (Preiss n.1244)
E. *Logania buxifolia* F. v. M. (Drumm.n.248)
F. *Logania fasciculata* R.Br. from Esperance (Diels N.5362)
G. *Logania stenophylla* F. v. M. from Phillips R. (N.4879)
H. *Logania micrantha* Benth. from headwaters of Blackwood R. (Muir)
(Original)

Fig. 50 Adaptations in leaves of *Logania*. Sect. Stomandra:
A. *Logania serpyllifolia* R.Br. from King George Sound (Diels n.4359)
B. *Logania campanulata* R.Br. from Swan River (Diels n.1885)
C. *Logania callosa* F. v. M. from Esperance (Diels n.5068)
D. *Logania flaviflora* F. v. M. from Tamin (Diels n.4140)
E. *Logania spermacocea* F. v. M. from Geraldton (Diels n.4140)
F. *Logania spermacocea* F. v. M. from Watheroo (Pritzel n.987)
G. *Logania nuda* F. v. M. from Tammin (Diels n.5061)
(Original)

Fig. 51 Adaptive variations in the leaves of some species of *Dryandra* (Prot.) of south-west Australia
A. *D. praemorsa* Meissn.
B. *D. cuneata* R.Br.
C. *D. serra* R.Br.
D. *D. carduacea* Lindl
E. *D. plumosa* R.Br.
F. *D. serratuloides* Meissn
G. *D. senecionifolia* R.Br.
H. *D. horrida* Meissn
J. *D. speciosa* Meissn.
The number gives the average rainfall for the species distribution.
(Original)

Fig. 52 Adaptive convergence
A. *Hibbertia microphylla* R.Br.
B. *Leucopogon gibbosus* Steschegl.
(Original)

Fig. 53 Everlasting Composites of the Southwest Province.
A. *Helipterum Manglesii* (Lindl.) F. v. M.
B. *Helipterum cotula* DC.
C. *Watzia acuminata* Steetz
(Original)

Fig. 54 *Pentaptilon Careyi* (F. v. M.) E. Pritzel
A. Habit.
B. Flowers.
C. Style.
D. Fruiting bodies.
E. E. Single fruit.
(After Diels and Pritzel)

Fig. 55 *Stylidium repens* R.Br.
A. Habit
B. Flower stalk
C. Flower
D. Fruit
E. Section through ovary.
(After Mildbraed in 'Pflanzenreich')

Fig. 56 A - E. *Melaleuca Preissiana* Schau.
A. Tip of a flowering stalk
B. Flower.
C. Petal
D. Staminal bundle.
E. Fruit.

F - M. *Astartea fascicularis* DC.
F. Flowering stalk
G. Flowering lateral branch.
H. Leaf
J. Flower
K. Staminal bundle
L. Gynoecium in L.S.
M. Ovary in T.S.

Fig. 57 *Levenhookia*
A - C *L. stipitata* F. v. M.
A. Habit.
B. Opened flower.
C. Column with sheath.

D - G *L. Preissii* F. v. M.
D. Habit.
E. Flower.
F. Throat of perianth tube with sheath.
G. Throat of perianth tube without sheath.

(After Diels and Pritzel)

Fig. 58 Herbaceous annuals characteristic of the alluvial area, all natural size:
A. *Selaginella Preissiana* Spring.
B. *Triglochin calcitrapa* Hook.
C. *Schoenus apogon* R. et S.
D. *Brizula Muelleri* Hieron.
E. *Haloragis nodulosa* (Nees) Walp.
F. *Hydrocotyle alata* R. Br.
G. *Polypompholyx multifida* F. v. M.
H. *Stylidium calcaratum* R. Br.
J. *Rutidosis argyrolepis* Schlecht.
(Original)

Fig. 59 *Eucalyptus* of the Eremaea
A. *Eucalyptus oleosa* F. v. M.
B, C. *Eucalyptus occidentalis* Endl.:
B Flowering twig.
C. Fruits on stalk.
(Original.)

Fig. 60 *Acacia aestivalis* E. Pritzel
A. Habit of flowering branch
C. Flower
D. Small bract
E. Calyx lobe
F. Petal
G. Pod
H. Seed
(After Diels and Pritzel).

Fig. 61 *Callitris robusta* R. Br.
A. Small twig with male flowers
B. Twig with fruiting cones
(Original)

Fig. 62
A - E. *Angianthus pygmaeus* (A.Gray) Benth.
A. Habit.
B. Little head of flowers.
C. Flower
D. Outer bract.
E. Inner bract.
F – J *Gnephosis gynotricha* Diels
F. Flowering stalk.
G. Flower.
H. Outer bract.
J. Inner bract.
K – N *Gnephosis rotundifolia* Diels
K. Habit.
L. Small flower head.
M. Flower.
N. Leaf
O – U *Calocephalus phlegmatocarpus* Diels
O. Habit.
P. Small flower bead.
Q. Outer bract
R. Inner bract.
S. Flower.
T. Pappus.
U. Achene.
(After Diels and Pritzel)

Fig. 63 *Eremophila*
A.- B. *E. platythamnos* Diels
A. Habit.
B. Flower.
C.-D. *E. ionantha* Diels
C. Habit.
D. Flower after removal of calyx.
E.-F. *E. elachnantha* Diels
E. Habit.
F. Flower.
G.-H. *E. dichroantha* Diels
G. Habit.
H. Flower.
(After Diels and Pritzel.)

Fig. 64 *Triraphis rigidissima* Pilger
A. Habit.
B. Ear of grass 1/1.
C. Ear of grass 2/1
D. Flower with glume.
E. Lemma.
(After Diels and Pritzel).

Fig. 65. Verbenaceae of the Eremaea
A.-C. *Physopsis spicata* Turcz
A. Habit.
B. Flower.
C. Gynoecium
D. E. *Mallophora globiflora* Endl.
D. Habit.
E. Flower

F.-G. *Dicrastylis fulva* Drumm.
F. Habit.
G. Flower spread out after the removal of the calyx.
H. Calyx.
J. *Dicrastylis stoechas* Drumm.
J. Habit.
(After Diels and Pritzel)

Fig. 66 *Dodonaea*
A. *D. attenuata* A. Cunn. var. *linearis* Benth.
A. Habit
B. *Dodonaea filifolia* Hook.
B. Habit
C.-D. *Dodonaea amblyophylla* Diels
C. Habit
D. Fruit
E.Seed
(After Diels and Pritzel)

Fig. 67 Typical Santalaceous plants of the Eremaea
A - E.*Fusanus acuminatus* R. Br.
A. Habit
B. Flower
C. Stamen
D. Fruit
E. Endocarp
F - H. *Fusanus spicatus* R. Br.
F. Leafy stalk
G. Fruit
H. Endocarp
(Original)

Fig. 68 *Exocarpus aphyllus* R.Br.
A. Habit
B. Piece of stem with flower group
C. Flower from the outside
D. Flower from above with sepal removed
E. Flower cut through
F. Piece of stem with fruits
G. Fruit
(Original)

Fig. 69. Felt covered Verbenaceae of the Eremaea genus *Newcastelia.*
A – C *N. viscida* E. Pritzel
A. Habit
B. Flower
C. Corolla of flower opened out.
D. *N. bracteosa* F. v. M.
D. Habit.
E – G *N. insignis* E. Pritzel
E. Habit
F. Undersurface of leave.
G. Flower.
H – J *N. cephalantha* F. v. M.
H. Corolla of flower opened out
J. Flowering twig
(After Diels & Pritzel)

Fig. 70 *Eremophila*
A – E *E. granitica* Sp. Moore
A. Habit
B. Flower
C. Corolla
D. Middle part of the anterior lip.
E. Gynoecium
F – G *E. Georgei* Diels
F. Habit
G. Gnoecium
H – J *E. calorhabdos* Diels
H. Habit
J. Flower
(After Diels and Pritzel)

Fig. 71 Typical plants of the Eremaea
A - C *Trichinium exaltatum* (Nees) Benth.
A. Habit
B. Bracts
C. Flower opened out
D - E *Trichinium siphonandrum* Diels
D. Flower opened out.
E. Bract.
(After Diels and Pritzel)

Fig. 72 Floristic arrangement of extra-tropical Western Australia into eight districts.

Fig.73. *Dryandra Fraseri* R.Br. A species typical of the Irwin District.
A. Branch with flower
B. Bract.
C. Upper part of a sepal.
D. Perianth.
(After Diels and Pritzel)

Fig.74. *Sphenotoma Drummondii* Benth.
A. Habit
B. L.S. of flower
C. Disc and gynoecium
D. L.S. gynoecium
(After Diels and Pritzel)

Fig. 75. *Verticordia* DC.
A-C *V. spicata* F. v. M.
B. Calyx lobe
A. Calyx appendage
C. Petal
D-F *V. ovalifolia* Meissn.
E. Calyx lobe
D. Calyx appendage
F. Petal
G-J *V. oculata* Meissn.
H. Calyx lobe
G. Calyx appendage
J. Petal
K-M *V. grandis* Drumm.
L. Calyx lobe
K. Calyx appendage
M. Petal

N-S *V. Muelleriana* E. Pritz.
N. Habit of a flowering branch.
P. Calyx lobe
O. Calyx appendage
Q. Petal
R. Section of stamen tube.
S. Style.
(After Diels and Pritzel)

Fig. 76. Distribution of *Jacksonia.*

Fig. 77. Distribution of *Banksia*.

Fig. 78. Distribution of *Drosera* Sect. Erythrorrhiza.

Fig. 79. *Eremosyne pectinata* Endl., monotypic, south-west Australian Saxifragaceae-genus.
A. Habit
B. Flower
C. Flower open out.
D. Young ovary in longitudinal section.
E. Developing ovary in longitudinal section.
(After Engler)

Fig. 80. *Cephalotus follicularis* Labill., a charasteristic, monotypic endemic of south-west Australia.
A. Habit (the flowering stalk is usually substantially longer in nature than represented here!)
B. Floral diagram.
C. Flower.
D. Carpel in longitudinal section.
E. Fruit in longitudinal section.
F. Seed in longitudinal section.
G-K. Different stages of leaf development.
(A-C after Baillon; D-F after Le Maout and Decaisne; G-K after Eichler.)

Fig. 81. *Diplolaena grandiflora* Desf.
A. Branch.
B. A single flower with small petals and long stamens.
C. Stamen.
D. Gynoecium.
E. Ovary.

Fig. 82. *Geleznovia verrucosa* Turcz.
A. Flowers with large sepals at time of fruit maturity.
B. The same flower after removal of a sepal.
C. Petal.
D. Stamen.
E. Foliage leaf below.
F. Foliage leaf above.
(After Engler)

Appendix C

Translation of Plate captions.

Plate I
Eucalyptus marginata Sm., Jarrah
In right foreground *Xantorrhoea Preissii* Endl.
Darling District, Darling Range near Mundaring
Photo E. Pritzel February 1901.

Plate II
Eucalyptus calophylla R. Br., Red Gum
In foreground numerous *Xantorrhoea Preissii* Endl.
Darling District, Bellevue east of Perth.
Photo E. Pritzel April 1901.

Plate III
Eucalyptus diversicolor F. v. M., Karri
The thick shrubby trees on the bank, *Melaleuca rhaphiophylla* Schau.
Warren District, Denmark River.
Photo E. Pritzel July 1901.

Plate IV
Eucalyptus gomphocephala DC., Tuart over *Callitris (Frenela) robusta* A. Cunn.
Darling District, Osborne Cliffs, littoral limestone on the lower Swan River.
Photo E. Pritzel November 1901.

Plate V
Banksia attenuata R. Br.
On left edge *Banksia ilicifolia* R. Br., behind in middle distance young *Eucalyptus marginata* Sm.
Photo E. Pritzel December 1901.

Plate VI
Nuytsia floribunda R. Br., Christmas Tree
The tree in the distance *Melaleuca Preissiana* Schau.
Darling District, Guildford.
Photo E. Pritzel December 1900.

Plate VII
Macrozamia Fraseri Miq., Cycas Palm
On left *Eucalyptus marginata* Sm., in the distance *Melaleuca Preissiana* Schau.
Darling District, Bayswater east of Perth.
Photo E. Pritzel December 1901.

Plate VIII
Tree-like Liliaceae Western Australia.
Xantorrhoea Preissii Endl. (left) and *Kingia australis* R. Br. (right). Along with *Xylomelum occidentale* R. Br., a poor stunted example (left edge), and *Banksia grandis* R. Br. (between the *Kingia*).
Darling District, Serpentine.
Photo E. Pritzel December 1900.

Plate IX
Dasypogon Hookeri Drumm., an unusual western Australian grass-tree.
In woodland with *Casuarina Fraseriana* Miq. (left), *Eucalyptus marginata* Sm. and *Banksia grandis* (right edge).
Warren District, south of the Vasse River.
Photo E. Pritzel December 1901.

Plate X
Mangrove and mudflats.
With *Avicenna officinalis L.* and *Sarcocornia australis* Sol. (in foreground).
Darling District near Bunbury.
Photo E. Pritzel November 1091 [sic].

Plate XI
Coastal Woodland in the Tuart Zone.
Eucalyptus gomphocephala DC. (trees on both sides); *Agonis flexuosa* DC. (Myrtac., small trees in the hollow in the background); *Olearia candidissima* (Compos., strongly defined white tomentose bushes); *Jacksonia furcellata* DC. (Legum., bushes in foreground on the left); *Hibbertia cuneiformis* (Lab.) Gilg. (Dilleniac., small bush in the foreground on the right).
Darling District, Bunbury.
Photo E. Pritzel November 1901.

Plate XII.
Forest belt in the Warren District.
Eucalyptus cornuta Lab. (on left); *Banksia verticillata* R.Br. (in centre); *Pteridium aquilinum* (L.) Kuhn (main undergrowth); *Macrozamia Fraseri* Miq. (foreground).
Warren District, Wilson's Inlet.
Photo E. Pritzel, March 1901.

Plate XIII.
Wandoo Woodland: *Eucalyptus redunca* Schau. (stand behind).
Eucalyptus occidentalis Endl. (individual in front).
Stirling District, Cranbrook.
Photo E. Pritzel, November 1901.

Plate XIV.
Mixed Woodland of sandy coastal plain.
Casuarina Fraseriana Miq. (left and right); *Eucalyptus marginata* Sm. (centre).
Darling District, Serpentine.
Photo E. Pritzel, December 1900.

Plate XV.
Mixed Woodland of sandy coastal plain.
Casuarina Fraseriana Miq. (tallest tree); *Banksia ilicifolia* R. Br. (narrow pyramidal shaped shrubby tree); *Adenanthos cygnorum* Diels (Proteac., grey left front); *Xantorrhoea Preissii* Endl. (right front).
Photo E. Pritzel, December 1900.

Plate XVI.
Very open Woodland of the sandy coastal plain
Eucalyptus marginata Sm.(centre) – *Banksia attenuata* R. Br. (low trees, mostly left).
Darling District, Bayswater east of Perth.
Photo E. Pritzel, November 1901.

Plate XVII
Shrublands
Numerous types represented.
The striking *Melaleuca megacephala* F. v. M. (Myrt.) is flowering in the foreground.
Irwin District, White Peak north of Champion Bay.
Photo E. Pritzel September 1901

Plate XVIII
Sclerophyll scrub in the western Stirling Range.
Eucalyptus tetragona F. v. M. (thin stemmed); *Eucalyptus Preissana* Schau. (large leaved, dwarf); *Xantorrhoea Preissii* Endl. (foreground); *Dryandra armata* (Proteac., very dark leaved).
Stirling District, Suckys Peak.
Photo E. Pritzel November 1901.

Plate XIX
Edge of sand heath.
Eucalyptus eudesmioides F. v. M., in the foreground *Ecdeiocolea monostachya* F. v. M. (Restionac.)
Irwin District, Greenough River crossing.
Photo E. Pritzel June 1901.

Plate XX
Scrub heath on sand
Eucalyptus macrocarpa Hook. (greyish-white shrubs in background); *Xanthorrhoea* (*Preissii* Endl. ?); *Petrophila scabriuscula* Meissn. (Proteac., flowering bush in foreground).
Avon District, Meenaar.
Photo. E. Pritzel December 1901.

Plate XXI
Edge of scrub heath on sand.
Actinostrobus pyramidalis Miq. (Pinac. extreme left); *Jacksonia eremodendron* E. Pritzel (Legum. - behind the *Actinostrobus*); *Grevillea eriostachya* Lindl. (Proteac., the apparently leafless shrub in middle background); *Conospermum stoechadis* Endl. (Proteac., smoky grey-white inflorescences).
Irwin District, Watheroo.
Photo E. Pritzel December 1901.

Plate XXII
Alluvial formation
Melaleuca Preissiana Schau. (background); *Xantorrhoea Preissii* Endl. (foreground).
Darling District, Bayswater east of Perth.
Photo E. Pritzel December 1901.

Plate XXIII
Vegetation of the granite rocks (in foreground).
The granite flats partially overlain with the dark green cushions of *Campylopus bicolor* (Musci). In the inter-spaces *Anthocersis viscosa* R. Br. (Scrophular., shrubby trees), *Agonis marginata* DC. (Myrtac., thick bushes left), *Anarthria scabra* R. Br. (Restionac., flowering sward in front), *Eucalyptus cornuta* Lab. (back right).
King George Sound, summit of Mt Elphinstone.
Photo E. Pritzel October 1901.

Plate XXIV
Eucalyptus loxophleba Benth., York Gum
In the background with *Acacia acuminata* Benth.
Harvested wheatfield in front.
Avon District, Newcastle [Toodyay].
Photo E. Pritzel February 1901.

Plate XXV
Eucalyptus occidentalis Endl., Flat-topped Yate (foreground)
A stand of *Eucalyptus redunca* Schan., Wandoo behind.
In front many annuals, particularly composites in flower.
Stirling District, Cranbrook.
Photo E. Pritzel November 1901.

Plate XXVI
Eucalyptus salmonophloia F. v. M., Salmon Gum
With under storey of *Melaleuca uncinata* R.Br.
Avon District, Meenaar.
Photo E. Pritzel November 1901.

Plate XXVII
Acacia acuminata Benth., Jam
With the top left crown occupied by a specimen of *Loranthus quandang* Lindl.
Iwin District, Mingenew.
Photo E. Pritzel June 1901.

Plate XXVIII
Eucalyptus Woodlands of the Eremaea
Eucalyptus celastroides Turcz. The two small trees in the left foreground are *Fusanus spicatus* R. Br. (Santal.); the rest of the bush consists of *Acacia* and *Melaleuca*.
Coolgardie District, Southern Cross.
Photo E. Pritzel May 1901

Plate XXIX
Eucalyptus stand of Eremaean Savanna type.
Eucalyptus loxophleba Benth. - In the centre is a fine example of *Cassytha racemosa* Nees.
In the foreground is good growth of *Triraphis mollis* R. Br. (Gramin.).
Irwin District, Watheroo.
Photo E. Pritzel December 1901.

Plate XXX
Savanna Woodland
With *Eucalyptus loxophleba* Benth. (left and middle) and *Acacia acuminata* Benth. (the smaller trees on the right and in the background).
Avon District, Meenaar.
Photo E. Pritzel November 1901.

Plate XXXI
Savanna type *Acacia* stand on loam in the dry period
Acacia acuminata Benth., mature and young specimens.
Avon District, Newcastle [Toodyay].
Photo. E. Pritzel Feburary 1901.

Plate XXXII
Creek vegetation in the transition zone between the Eremaea and the Southwest Province.
Casuarina glauca Sieb. (left); *Eucalyptus rostrata* Schlecht. (centre, with white stems); in the foreground, *Acacia acuminata* Benth., young specimen (left); *Melaleuca viminea* Lindl. (on right).
Irwin District, Mingenew.
Photo E. Pritzel June 1901.

Plate XXXIII
Mulga vegetation of the Eremaea
Chief vegetation consists of *Acacia* species, *Trichinium obovatum* Gaud. (Amarantac.). *Kochia* species (Chenpodiac.).
Austin District, Cue.
Photo E. Pritzel July 1901.

Plate XXXIV
Eremaean landscape with *Helipterum splendidum* Hemsl.
Acacias in the background.
Austin District, Murrin-Murrin.
Photo taken September or October 1900.

Appendix D

Diels' Photographic Sites - 82 years later
A study of Resilience in southwestern Australia

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In 1900-02, Drs L. Diels and E. Pritzel travelled extensively in southwestern Australia. The outcome was the classic work, Diels, L 1906. *Die Pflanzenwelt von West-Australien*. In the process of translating and updating this text, we have tried to relocate and rephotograph the sites of the 34 plates in this mammoth book. Below are paired photos from 12 selected sites in Diels, taken 82 years apart.

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June 1901

Sep. 1983

Eradu, 46km E of Geraldton

Little change. Same mallee (*Eucalyptus eusdesmoides*) present, 'grass' (*Ecdeiocolea monostachya*) thinned out, *Acacia rostellifera* (dead in foreground) established and died during that time.

Oct. 1901

Dec. 1982

Mt Elphin-stone, Albany

Site almost unchanged. Ground cover of *Lepidosperma* aff. *effusum* now almost completely replaced by *Stypandra imbricata* and annual grasses.

July 1901

Feb. 1984

Mouth of Denmark River

Original two karri trees blown over at a height of 39m by cyclone Alby, Jan. 1978; present stand up to 16m high, fringing vegetation now denser; *Watsonia* (South Africa) common along edge.

Feb. 1901

Sep. 1983

Newcastle (Toodyay)

Almost unchanged, except bare ground replaced by a wide range of annual weeds.

Nov. 1901

Dec. 1983

Leschenault Inlet, Bunbury

Only mangroves *Avicennia marina* left on S side of inlet are pictured in foreground; many mangroves on N side fallen over; in background, piles of woodchips, bauxite and harbour; retaining wall in foreground built about 1965.

Dec. 1900

Oct. 1983

Serpentine

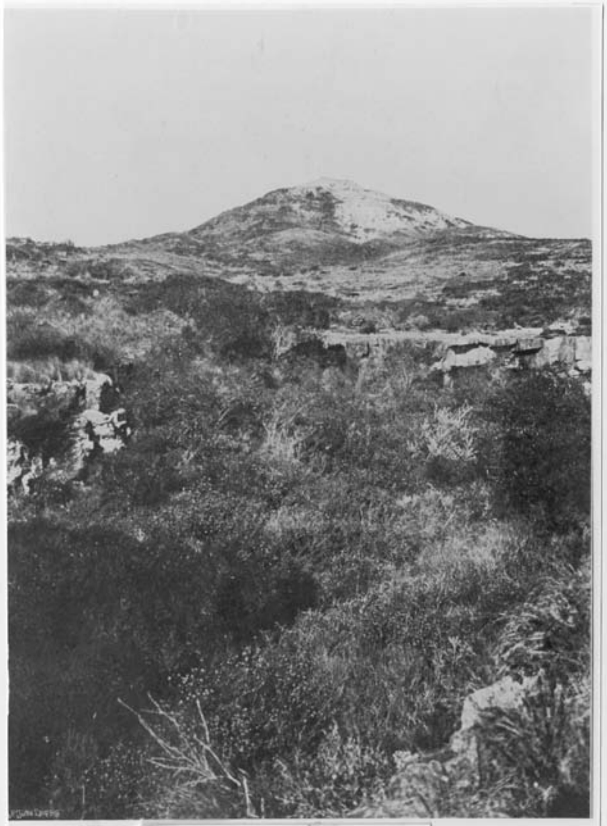
Grasstrees thinned considerably (human use); *Banksia grandis* replaced by *Eucalyptus calophylla*, new ground cover (*Leptocarpus, Hakea sulcata, Lepidospermum ellipticum*) suggests site now wetter.

Nov. 1901

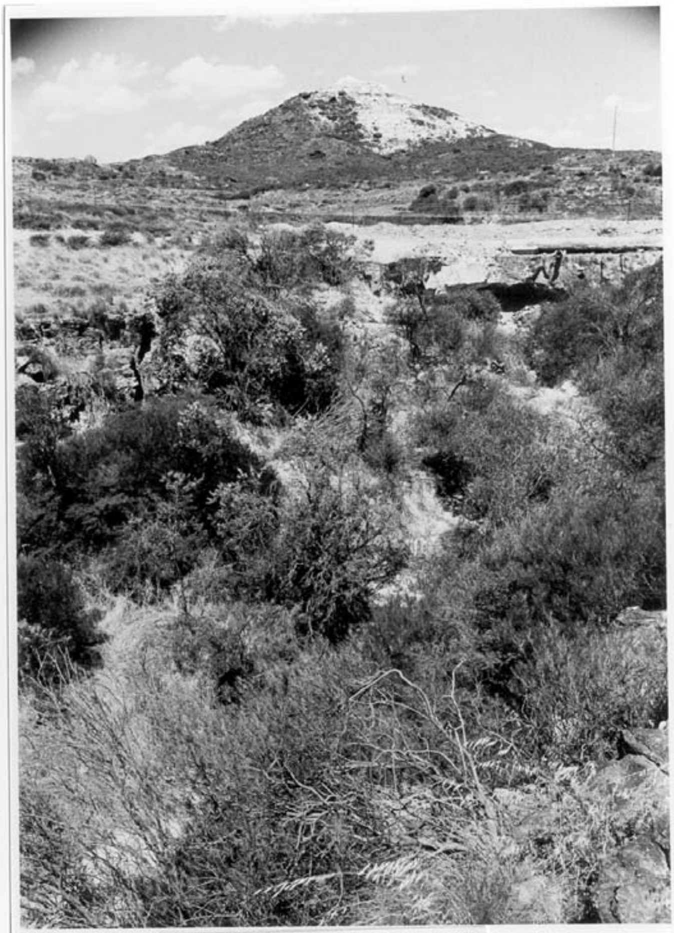
Dec. 1983

Sukey Hill, 5km E of Cranbrook

Little change except emergent mallee (*E. tetragona*) not found, *Dryandra armata* (erect dark branches in Diels) is very short, although no evidence of recent fire.



Sep. 1901



Nov. 1983

White Peak, 10km N Geraldton

Most of the surrounding area cleared for farming; vegetation now denser on peak; wild oats in valley; high species richness retained however *Melaleuca gomphocephala* replaced by more drought-tolerent species; peak fenced in October 1983, to protect rare species of *Drummondita*.

June 1901

Sep. 1983

Lockier River, Mingenew

Watercourses severely degraded as indirect result of widespread clearing for agriculture in 1950s; most trees and shrubs eliminated; slopes densely covered with annual weeds; a few native halophytes now present (increased salinity).

Dec. 1901

May 1984

Meenaar

Travelled 40km around Meenaar without finding a thicket of *Melaleuca uncinata* beneath salmon gums (*E. salmonophloia*) as this provides the best farmland; pictured is the closest remnant of salmon gum vegetation to Meenaar.

Dec. 1901

May 1984

Meenaar

Almost no change. Fallen York gum (*E. loxophleba*) may have been in original photo; minor annual weed invasion

May 1901

May 1984

Southern Cross

Little change. Individual plants seem to have denser foliage; salt bushes (*Atriplex, Maireana*) now widespread as a ground cover (saltier, less grazing?); some weeds.

CONCLUSIONS

Southwestern Australia has undergone massive human interference during the last 80 years. The level of *direct* interference has had greatest impact on *structure* of the vegetation and extent of invasion by annual *weeds*, while *indirect* interference (increased salinity, low or higher water availability) appears to have had most impact on *floristics* of the dominants. Some floristic changes suggest a reduction in effective rainfall may have occurred during that time. Unlike Diels, none of his revisited sites showed evidence of recent fire.