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Contributions to West Australian Botany.

By

C. H. Ostenfeld.

Part I.

(Introduction. — The Sea-grasses of West Australia,
by C. H. Ostenfeld).

Introduction.

In June 1914 I visited Australia in response to an invitation from "the British Association for the Advancement of Science" to take part in the annual meeting to be held in the capitals of the different States of the Commonwealth of Australia. An accident during the voyage prevented me from fulfilling my original purpose. I was laid up in Perth, West Australia, during the period of the meeting, and it was not until later that I was able to utilise my sojourn in a country which from a botanical point of view is amongst the most interesting.

The Government of West Australia many years ago had the foresight to secure a forest area of about 1000 acres on Mount Eliza just outside the capital overlooking Perth Waters, and to make it into a nature reserve under the name of Kings Park. Except a small portion close to the main entrance where the ground has been changed into an artificial park with foreign plants, the whole area is left practically untouched though it is intersected by several drives and footpaths. The natural vegetation remains, especially the shrubs and herbaceous plants, and there is still a considerable number of forest trees¹, mostly Jarrah (*Eucalyptus marginata*) and Red Gum (*E. calophylla*). The park is under the control of a board which wisely has prohibited any

¹ The best timber trees were removed before the park was reserved.

collecting of flowers there, and thanks to this there is a profusion of flowers covering the ground in the spring.

The study of this natural reserve gave me a splendid introduction to the rich and peculiar flora of West Australia, and the authorities greatly facilitated my studies by granting a special permit for collecting.

From Perth I made several trips by rail to more or less distant parts of the State: — to Armadale and Mundaring Weir to study the flora of the western slopes of the Darling Range, to Bayswater and Cannington for the plants of the alluvial plains, and to Cottesloe (near Fremantle) for the strand flora. I made an interesting excursion to the Cave District (Yallingup Cave) in the south-west corner of the state, and travelled by rail to Bridgetown and Big Brook State Mill to obtain some impression of the Karri forest (*Eucalyptus diversicolor*) the most luxuriant plant growth in the State. Later on I paid a flying visit to Albany on King George's Sound to see the "pitcher plant" (*Cephalotus follicularis*) in its native habitat along with the otherwise rich flora of this botanically classical place. In order to become acquainted with the flora of the arid interior I visited Tammin on the way to Kalgoorlie, and also the famous mining-town Kalgoorlie itself with its semi-desert surroundings.

These excursions were planned to obtain what I should call selected samples of the different kinds of vegetation occurring in the south-western part of the State.

As I was interested in obtaining some idea of the vegetation of the more tropical parts of West Australia, I decided to leave the State by means of a coasting steamer which runs from Fremantle to Java, calling at a good many places along the north-western and northern coast of West Australia. Thus I visited Geraldton, Carnarvon, Point Sampson, Port Hedland, Broome and Derby and had an opportunity of seeing the vegetation of these tracts and of making collections.

My stay in West Australia lasted from August to the end of October, the best time of the year as regards the plant world; and I brought home a fairly large collection (mostly herbarium plants), the study of which will occupy some time.

The flora of West Australia is fairly well known. The main sources are BENTHAM'S *Flora Australiensis* and the publications by

DIELS and PRITZEL¹ in which all the earlier literature has been quoted. A very useful list of the flora has been published in the State Yearbook for 1900—1901², and a periodical issued in Perth by a scientific society which goes under various names ("The Mueller Botanic Society", "The West Australian Natural History Society", "The Natural History and Science Society of W. A.") contains several papers on the flora (1902—1914).

Valuable contributions have also been made by SPENCER LE MARCHANT MOORE (Journ. Linnean Soc., Botany, XXXIV, 1899) as the result of travels in the interior of the state, and by K. DOMIN (ibid., XLI, 1912) who has worked out some recent collections from West Australia preserved in the Kew Herbarium. Isolated minor contributions to West Australian Botany are to be found in the Kew Bulletin and other British periodicals, in Fedde's *Repertor. novar. spec.*, in K. DOMIN's important work; *Beitr. zur Flora und Pflanzengeographie Australiens* (1915—), and in the journals of various Australian scientific societies.

As regards the phytogeography our main source is the monograph by L. DIELS (1906) dealing with the extra-tropical part of the State. Shorter sketches of the vegetation have been published by A. MORRISON (in the State Yearbook for 1900—1901) and by C. ANDREWS (in the Handbook of W. A., prepared for the members of the British Association for the Advancement of Science, 1914).

From this summary of the earlier studies on West Australian botany it is evident that any contributions of mine resulting from journeys mostly within areas previously visited by botanists, must be relatively unimportant. A longer stay in the tropical part of the State would have been a great opportunity, since the flora and vegetation of this part are very poorly investigated³. The future botanical exploration of the north-western and the tropical

¹ L. DIELS and E. PRITZEL: *Fragmenta Phytographiæ Australiæ occidentalis*. — Engler, *Botan. Jahrb.*, XXXV, 1904—05.

L. DIELS: *Die Pflanzenwelt von West-Australien südlich des Wendekreises*. — Engler u. Prude, *Die Vegetation der Erde*. VII. 1906.

² F. VON MUELLER: *List of Extra-tropic West Australian Plants*. Revised and augmented by A. MORRISON. — *Western Australian Year-Book for 1900—1901*, vol. I. Perth 1902.

³ After this was written I received a valuable contribution to the flora of the tropical W. A., viz.: E. CHEEL: *Plants*, in: *Results of Dr. E. Mjöberg's Swedish scientific Expeditions to Australia 1910—13*. K. Svenska Vetensk. Akad. *Handl.* Bd. 52, No. 10. Stockholm 1916.

parts of West Australia will certainly produce interesting results both floristic and phyto-geographic.

Yet the richness of the flora of the south-western part of the State is so great that my collections and observations contain some additions to our knowledge. These I propose to publish as a short series of contributions.

I should like to use this opportunity to acknowledge the extreme kindness extended to me by the Government of West Australia and by several persons, amongst whom I wish especially to mention the Hon. W. KINGSMILL, M. L. C.; Mr. CECIL ANDREWS, Director of Education; Mr. W. CATTON GRASBY, Editor of the Western Mail; Professor and Mrs. W. J. DAKIN; Mr. BERNARD H. WOODWARD, Director of the Perth Museum; Mr. W. B. ALEXANDER, Keeper of Biology, Perth Museum; Mr. O. H. SARGENT, Chemist at York; Mr. R. STRELITZ, then Royal Danish Consul; and Mr. FRED. A. HADLEY, my excellent doctor. I am also specially indebted to my good friend Mrs. MIRIAM DAVIS, proprietress of the St. Omer Hospital, who assisted me in collecting in every possible way, and from whom I have later received a valuable collection of herbarium specimens and seeds. My countryman Mr. ERIK DORPH-PETERSEN also contributed greatly by bringing me numerous specimens of plants from the neighbourhood of Perth.

The Sea-Grasses of West Australia.

By

C. H. Ostenfeld.

General Remarks.

The name "sea-grasses" is here used to designate the few Flowering Plants, which live in sea water and are unable to exist in fresh or nearly fresh water. Thus I exclude by this definition the brackish water genera, such as *Zannichellia*, *Ruppia*, *Althenia* and *Lepilaena* and limit the group to the following genera: *Halophila*, *Enhalus* and *Thalassia* of the *Hydrocharitaceæ*; *Cymodocea*, *Diplanthera* (*Halodule*), *Zostera*, *Phyllospadix* and *Posidonia* of the *Potamogetonaceæ*. The number of species of sea-grasses known does not much exceed 30. Some of them have very wide areas of distribution, others rather limited.

As to Australia, about 13 species belonging to all the above enumerated genera, *Phyllospadix* excepted, have been reported, most of them from the eastern coasts of the continent, a few only from the western side.

During my visit to West Australia in 1914 I succeeded in finding a couple of species new to the flora of that State, and in making observations as regards the distribution and biology of other species. An account of these observations forms the subject of the present paper, which also includes the earlier records of sea-grasses along the West Australian coast.

As early as in 1792 LABILLARDIÈRE found a sterile sea-grass on the West Australian coast near Cape Leeuwin and described it in 1806 under the name of *Ruppia antarctica*¹. The same species was later collected by GAUDICHAUD in 1818 at Sharks Bay and this time male flowers were found and figured under the name of *Amphibolis zosterifolius* Agardh².

¹ LABILLARDIÈRE, Nov. Holland. Plant. species, vol. II, p. 116, tab. 264, 1806.

² GAUDICHAUD, Voyage autour du Monde, Botanique, p. 35 et p. 161, pl. 40, fig. 2. 1826.

Later on (1854) W. H. HARVEY¹ during his investigations of the West Australian Marine Algæ met with sea-grasses, and in his reports on the algæ he mentions them incidentally. Thus when describing the algal vegetation of King George's Sound he states (1855, p. 527): "On the leaves of *Zostera* and on the stems of *Caulinia antarctica*, both of which form vast meadows in water from two to six feet deep, grows"; further he mentions the same two species when reporting on the Algæ off Rottnest Island and Fremantle (l. c. p. 528 and p. 529).

The two species are now known under the names *Cymodocea antarctica* Endl. (= *Ruppia a.* Labill, *Caulinia a.* R. Br.) and *Posidonia australis* Hook f. (Harvey's *Zostera*). It appears from these reports that they play an important rôle in the marine vegetation of the south-western coast of West-Australia from Albany in the south to Sharks Bay in the north.

Since the time of HARVEY's visit little has been added to our knowledge of the sea-grasses of West Australia. A few interesting notes are found in a report on sea-grasses from the Indian Ocean published by P. ASCHERSON². Dr. NAUMANN, the doctor of the German warship "Gazelle" then engaged in deep sea soundings etc. in the Indian Ocean, became interested in the study of sea-grasses, and from him P. ASCHERSON received several letters and specimens of sea-grasses. As regards West Australia Dr. NAUMANN says: "Die Gazelle besuchte Ende April [1875] Australien an zwei Orten, an der Westküste bei Cap Inscription, der Nordspitze von Dirk Hartog Island, und in Nordwesten, hier innerhalb des Dampier-Archipels beim Fastlande ankernd. An ersterem Orte wurde aus dem Ankergrunde (7 Faden tief) viel langhalmiges, zum Teil ziemlich frisch aussehendes Seegras mit dem Schleppnetz heraufgebracht [This species was not received by Ascherson, probably it was *Posidonia*]. Am Strande der Insel bemerkte ich, fast im Sande in der Brandung vergraben, einige Stückchen des beifolgenden kurzhalmigen Seegrases [*Cymodocea antarctica*], das jedenfalls dort, aber nur vereinzelt wuchs. Auch war hier ein wenig der vorhin genannten Art mit langen Halmen aufgespült. In der Nähe der Nordwestspitze Australiens, im N.W. der Montebello-Inseln brachte das Oberflächennetz abermals Seegras aus dem Meere, aber nur

¹ HARVEY, W. H. Some Account of the Marine Botany of the Colony of Western Australia. Transact. R. Irish Acad. vol. XXII, Part V, 1855.

² P. ASCHERSON: Ueber Meeresphanerogamen des indischen Ozeans und indischen Archipels. Botanische Zeitung 1875, pp. 761—765.

wenige Stückchen [*Cymod. rotundata*, determ. Ascherson]; das nächste Land war hier 20 Seemeilen entfernt. Weiterhin zwischen den Dampier-Inseln trieben sehr grosse Massen verschiedener Sargassum-Arten, aber von Seegrass keine Spur, auch nicht beim Fastlande”.

In F. v. MÜLLER'S and A. MORRISON'S list¹ of the flora of W. A. we find only the two first recorded species, *Posidonia* and *Cym. antarctica* (the *Cymodocea* is given here under the name of *C. zosterifolia* F. M.), but not *Cym. rotundata*. Later P. ASCHERSON² added one more species to the flora, viz. *Cymodocea isoëtifolia* from Champion Bay (i. e. off Geraldton), thus making four species. A fifth has recently been discovered, viz. *Halophila ovalis*, which C. ANDREWS³ in 1902 found in Freshwater Bay, Swan River Estuary, and still later it was collected at Rottnest Island, off Fremantle. We have thus recorded 5 species, if we regard the free-floating *C. rotundata* as growing on the West Australian coast. All these five⁴ species were also found by me with the addition of two more, viz. *Halophila spinulosa* and *Diplanthera uninervis*, both of which are known from the tropical eastern coast of Australia. The sea-grass flora of West Australia now extends to 7 species, nearly one fourth of the whole sea-grass flora of the Earth.

As to their distribution along the extensive coast-line of W. A. our knowledge is very scanty. But it is remarkable that the north coast from N. W. Cape to King Sound seems to harbour no sea-grasses at all. Dr. NAUMANN emphasises that he did not see any sea-grasses in Dampier's Archipelago (his *Cym. rotundata* was floating on the surface, not growing), nor at any of the places where I landed (Point Samson, Port Hedland, Broome, Derby) did I find any trace of them. Now it is a well known fact that the north coast of W. A. has a very strongly marked tide, rising in places from 10 to 15 metres. This may be the reason for the absence of sea-grasses, since they cannot endure being laid bare and daily exposed to the burning tropical sun during low tide,

¹ F. v. MÜLLER: List of Extra-tropic West Australian Plants. Revised and augmented by A. MORRISON. Western Australian Yearbook for 1900—1901, vol. I. Perth 1902.

² P. ASCHERSON: Die geographische Verbreitung der Seegrässer, in: G. von Neumayer: Anleit. z. wiss. Beobacht. auf Reisen. 3. ed. 1905.

³ C. ANDREWS: *Halophila ovalis* Hook. f., an Addition to the Flora of West Australia. Journ. of Proc. Mueller Botan. Soc., Perth, vol. I, No. 10, 1902.

⁴ As regard the correctness of the identification of *Cym. rotundata* see p. 11.

while further out they would be covered at high tide by more water than is usually the case where they grow. Other unfavourable factors may be, that the water falls and rises with great force, and that its movements stir up the fine mud particles and greatly reduce the transparency of the water. Of course these are only suppositions, but the fact remains that sea-grasses do not seem to grow along the north coast, and also that Algæ are very scarce there.

Along the west coast the case is quite different. As Mrs. C. M. G. DAKIN states (in the Handbook and Guide to W. A. 1914, p. 73), there is no strong tide here. "The average tide at Fremantle is only about one or two feet". Here we find a well-developed sea-grass vegetation in the more sheltered places, and in many cases it covers wide areas, as at Shark's Bay.

The following are notes from my diary on the occurrence of sea-grasses at different places of the west coast of W. A.

1. The coast of the Cave District off the Yallingup Cave (between Cape Naturaliste and Cape Leeuwin), Sept. 26th 1914. The coast is partly sandy, partly rocky. The rocks consist of a calcareous conglomerate of grains of sand bound together by lime. In this rock formation numerous pools and flats with shallow water are found; they are protected by the outer fringe of rocks from the enormous force of the ocean waves, and harbour a rich algal vegetation in which *Cystoseira* species and *Corallinaceæ* are dominant. The algæ grow fixed to the rocks bordering the pools, while the sandy bottoms are largely covered with *Cymodocea antarctica* and *Halophila ovalis*.

At the Cottesloe beach near Fremantle the conditions were much the same, but *Halophila* was not seen there, only *Cymod. antarctica*.

2. Geraldton, Octob. 28th and 29th 1914. Many sea-grasses were thrown ashore and formed a low wall on the open sandy coast. I noticed a few specimens of *Halophila ovalis* and *Cymodocea antarctica*, some specimens of *Cym. isoëtifolia* and great masses of *Posidonia australis*, leaves and fruits.

The sea bottom, seen from the jetty, is barren naked sand close to the shore, but outside this a dense covering is seen over wide areas, probably of *Posidonia*.

3. Sharks Bay at Carnarvon, Octob. 31st 1914. Sharks Bay is rather shallow, and in calm weather when steaming over the bay from Cape Inscription to Carnarvon the sea bottom was visible nearly the whole time. The bottom is plant-covered

with white naked patches between. So far as I could discover, the vegetation nearly always consists of sea-grasses, the detached leaves and shoots of which were common on the surface of the water near the jetty. Along the shore there was a fringe of washed-up material consisting almost entirely of sea-grasses, with very few pieces of algæ intermixed. The main bulk was leaves of *Posidonia*, of which some fruits and empty pericarps were seen; in addition there was abundance of *Cymodocea isoëtifolia*, *Cym. angustata* nov. sp., some *Cym. antarctica* and *Halophila spinulosa*, and a few pieces of *Halophila ovalis* and *Diplanthera uninervis*.

From this list of species of the shore fringe, it is probable that the sea-grass vegetation of the bottom consists mainly of *Posidonia* with the *Cymodoceæ*, *Halophilæ* and *Diplanthera* as subordinate elements.

Sharks Bay in particular must produce enormous quantities of sea-grasses, as such wide areas are suitable for their growth, and I was told that nearly the whole Bay had a green bottom.

Other places suitable for sea-grass vegetation are:

4. King George's Sound. During my short visit to Albany there was no time to investigate the sea-grass vegetation, but we have the earlier records by HARVEY, who tells about the occurrence of large meadows of *Cymod. antarctica* and *Posidonia*.
5. Flinders Bay.
6. Geographe Bay.
7. Rottnest Island, where HARVEY dredged and found sea-grasses.
8. The Abrolhos Island to the west of Geraldton (Champion Bay).

On the whole, all places where there is a little shelter will most probably be found to bear a sea-grass vegetation, while on the other hand the open and quite unprotected coast will be devoid of them, unless they find a refuge in shallow pools amongst rocks, as was the case on the coast off Yallingup (see above).

The depth to which the sea-grass vegetation of W. A. extends, is not known. We have only the records of 2 to 6 feet ($\frac{2}{3}$ —2 m) by HARVEY and of 7 fathoms (c. 13 m) by NAUMANN.

No doubt the limit lies somewhat deeper than the two records, and investigations on this point are highly desirable.

Special Part.

Fam. I. Potamogetonaceæ.

This family furnishes five West Australian species of sea-grasses, four of the tribe *Cymodoceæ* and one of the tribe *Posidoniæ*.

The *Cymodoceæ* are the following:

- Cymodocea angustata* n. sp. (subg. *Phycagrostis*)
 — *isoëtifolia* Aschers. (subg. *Phycoschoenus*)
 — *antarctica* (Labill.) Endl. (subg. *Amphibolis*).
Diplanthera uninervis (Forsk.) Aschers.

The tribe *Posidoniæ* has only one genus *Posidonia*, with two species, one of which is Australian, viz.:

Posidonia australis J. D. Hook.

The three species of *Cymodocea* and *Posidonia australis* are here dealt with at some length, while the *Diplanthera* material does not show any essential point of interest.

1. *Cymodocea angustata* nov. sp.

Subgen. Phycagrostis. Rhizoma repens, foliorum cicatricibus annulos apertos efformantibus. Vaginæ foliorum longe obconicæ, valde compressæ, 2—8 cm longæ, 4—5 (3—7) mm longæ, diametro pluries longiores, distincte biauriculatæ, pallide purpurascens (in sicco). Foliorum laminæ lineales, 9—13-nerviæ, 10—20, rarius usque ad 60 cm. longæ, 4—5 (3—6) mm latæ, superne sensim angustatæ et distincte serrulatæ, apice obtuso. Flos masculus ignotus. Flos femineus præter stigmatum apices inclusus; carpella bina ovoidea; stylus curtus teres; stigmata bina, longissima, filiformia. Fructus (immaturus) compressus, suborbicularis vel ovali-orbicularis, marginibus integerrimis.

Differt a C. rotundata et C. nodosa præcipue foliis latioribus distincte serrulatis; a C. serrulata præcipue foliis angustioribus, longioribus et vaginis longis, pallide purpurascens; ab omnibus præcipue foliis superne angustatis.

Hab. in mare ad Carnarvon Australiæ occidentalis.

At Carnarvon I found quite a number of specimens of a *Cymodocea* cast ashore, and from the freshness of the leaves and rhizomes it must be regarded as certain that the plant was growing at a short distance from the beach. The specimens collected (C. H. Ostenfeld, *Plantae ex Austr. occid.* No. 271) consisted of the younger parts of the rhizomes with leaves, roots and, in some specimens, the female reproductive organs.

At first I identified it as *C. rotundata* Aschers. et Schweinf., which, as quoted above, was found floating near the Montebello Islands by Dr. NAUMANN in 1875. But on closer examination it soon became evident that it differed considerably from this species and did not agree with any hitherto described species. Therefore I describe it as new, the fourth species of the subgenus *Phycagrostis*.

As no later record of *C. rotundata* from the coast of West Australia is available, I consider its occurrence as doubtful and am inclined to think that Dr. NAUMANN's specimens also belonged to my new species, not to *C. rotundata*.

C. angustata is related to *C. rotundata*, *C. nodosa*, and *C. serrulata*, as will be seen from the diagnosis and from the following description of the specimens collected (both herbarium and alcohol material):

The creeping rhizome has elongated internodes; at each node

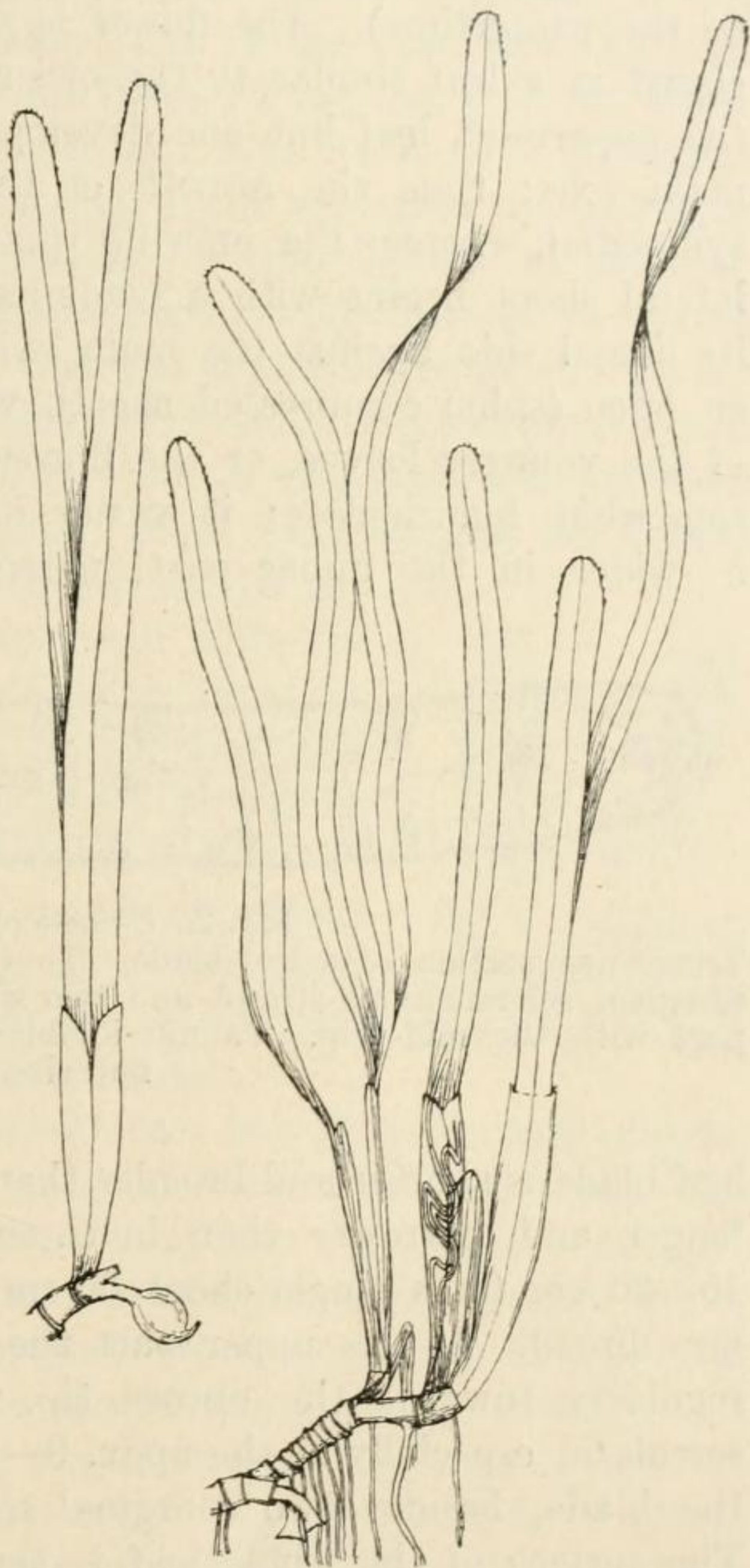


Fig. 1. *Cymodocea angustata* n. sp.
To the left a specimen with an unripe fruit, to the right another with a female flower enclosed in the sheath. ($\frac{2}{3}$ nat. size.)

one leaf and one root appear. The rhizome branches freely, especially where flowers are found, and here, sometimes elsewhere, parts of the rhizomes have short internodes (in *C. nodosa*, which is best known, each zone of short internodes is said to correspond to the wintertime). The flower is solitary and terminal; it is inclosed in a leaf similar to the others, while a bud in the axil of the uppermost leaf but one develops into the prolongation of the main axis; thus the growth of the flowering rhizome becomes sympodial, whereas the infertile rhizome is a monopodium. Each lateral shoot begins with a blade-less sheathing leaf, placed with its dorsal side against the main axis. The ordinary leaves have an open (split) compressed sheath which incloses the basal parts of the younger leaves, or the flower. At the apex the sheath is somewhat biauriculate; it varies in width from 3 to 7 mm and is wider in the upper part, narrower towards the base. The

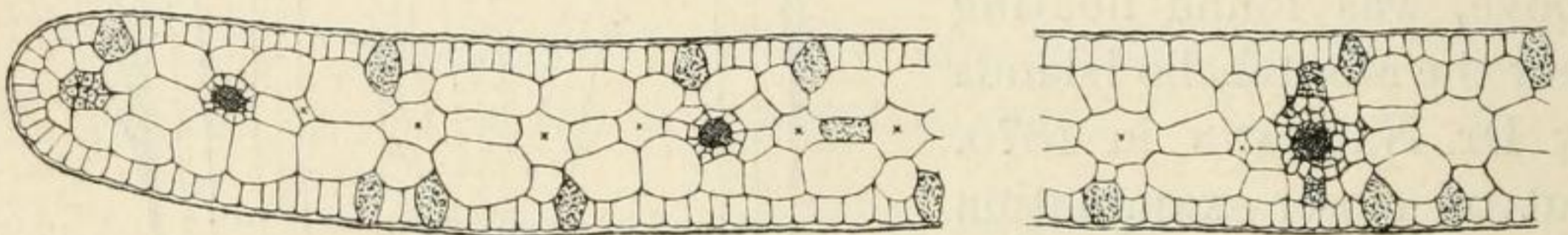


Fig. 2. *Cymodocea angustata*.

Transverse section of a leaf-blade. To the left the marginal part with a marginal sclerenchyma-strand and two side-veins; to the right the central part with the mid-vein. Tannin idioblasts dotted; x lacunæ. (About $\frac{125}{1}$ nat. size.)

leaf blade is shorter and broader than in *C. rotundata* and *C. nodosa*, longer and narrower than in *C. serrulata*, the proportions being 15—20 cm (in a single shoot 60 cm) long and 3—6 (mostly 4—5) mm broad. In its upper part the width of the blade decreases regularly towards the obtuse tip, the margins being distinctly serrulate, especially at the apex. 9—13 parallel nerves run through the blade, besides two marginal sclerenchyma-strands (Fig. 3 a). The surface of the whole leaf is very finely spotted by cells of a red-brown colour containing some tannic compound (“cellules sécrétrices”, SAUVAGEAU).

The place where the blade and sheath meet is distinctly marked and the blade breaks off easily, leaving the sheath persistent for some time.

As to the anatomy of the leaves, there is great resemblance between *C. nodosa*, *C. rotundata* and *C. serrulata* as shown by P. MAGNUS¹ and C. SAUVAGEAU¹; *C. angustata* does not differ in any essential

¹ P. MAGNUS, in Sitz. ber. d. Ges. naturf. Freunde, Berlin f. 1870, p. 85.

point. Nevertheless, in several minor points a transverse section of a leaf-blade of *C. angustata* is characteristic and makes it possible to distinguish this species from the three others. Fig. 2 shows that the lacunae (air chambers) of the leaves (marked x) are small and narrow, much smaller than in the other species; this is correlated with the lesser thickness of the leaf and the fewer layers of cells inside the epidermis. The tannin (?) idioblasts (dotted in the fig.) of the epidermal layer are numerous, and cells of the same kind occur sometimes in the interior of the leaf. The veins do not show any difference from those of the other species, but it is noteworthy that the sclerenchyma is very poorly developed: just inside the leaf-margins a small sclerenchyma-strand is found, and on both sides of the central vein small subepidermal sclerenchyma-strands are present, while such strands are absent beside the other veins. A comparison of my figures with those of SAUVAGEAU will make the differences clear better than a long explanation.

I have not succeeded in finding the male flowers; but judging from the near relationship to the other species it is probable that the male flowers are much alike. Thus we should expect the male flower of *C. angustata* to be a terminal one, consisting of a long filament and an 8-locular anther, i. e. really two connate stamens.

The female flower consists of two free short-stalked carpels, each surmounted by a short style and two very long thread-like stigmas (Fig. 3 *b*). The upper parts of the stigmas protrude out of the leaf-sheath while the rest of the flower is inclosed by it. As seen in fig. 1 the long stigmas have sometimes difficulty in finding their way out of the sheath and become much bent or coiled. After fertilisation the carpels begin to grow out and the upper part of the stigma dies away. In one specimen I found one carpel half-grown and the other broken off (Fig. 1). The young fruit was compressed and nearly round in circumference, with a curved beak, not oblique as in the fruits of *C. nodosa* and *C. rotundata*. In another specimen (that with the flower) a pair of fruit-stalks were present while the fruits themselves had disappeared. The fruits have a thin fleshy layer outside the hard endocarp. I have not seen the ripe fruits.

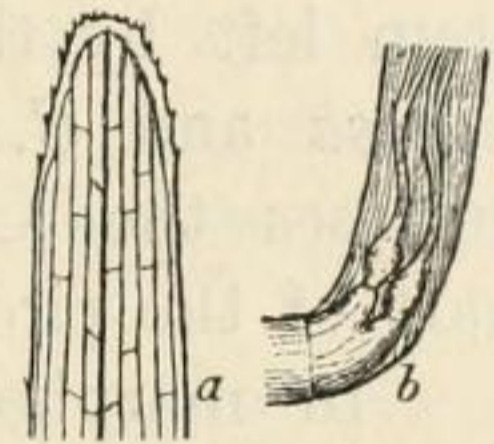


Fig. 3. *Cymodocea angustata*. *a* Apex of a leaf. *b* Female flower ($\frac{4}{3}$ nat. size).

¹ C. SAUVAGEAU, Observations sur la structure des feuilles aquatiques. — Journ. de Botanique, t. IV (1890).

Idem: Sur les feuilles de quelques monocotylédones aquatiques. — Ann. sc. nat. VII sér. Bot. t. 13 (1891), 103—296.

The new species has a somewhat intermediate position between *C. nodosa* and *C. rotundata* on one side, and *C. serrulata* on the other. It differs from *C. nodosa* and *C. rotundata* in the well-developed marginal teeth, the broader leaves and the open rings (scars) on the stem, left by the leaf-sheaths; besides the shape of the drupelet is different. From *C. serrulata*, on the other hand, it differs in the longer and narrower leaves and leaf-sheaths, the lighter (pale purplish) colour of the sheaths, and the smaller number (9—13) of nerves. The main difference from both lies in the regularly tapering uppermost part of the blade and the shape of the drupelet.

It has in common with *C. nodosa* and *C. rotundata* the light purplish colour of the sheaths, the number of nerves and the slightly obconical shape of the sheaths; in common with *C. serrulata* the well-developed marginal teeth and the open rings on the stem left by the sheaths; these scars are closed (annular) in *C. nodosa* and *C. rotundata*, which means that the sheath wholly encloses the axis, while in *C. serrulata* and *C. angustata* a small part of the circumference is free from the sheath.

In morphology it does not differ in any important feature from what we know about the morphology of *C. nodosa*, which is well known through the investigations of E. BORNET¹, CH. FLAHAULT² and others.

As to the geographical distribution, the new species is only known from Carnarvon, but I think it probable that Dr. NAUMANN's plant was also *C. angustata*, and not *C. rotundata*.

I have seen *C. rotundata* from the Red Sea, Madagascar, Andamans and Nicobar Islands, Java, the Philippines and Queensland (Port Denison, leg. Fitzalan, in the National Herb. of Victoria) and P. ASCHERSON (Geogr. Verbreit. Seegräser (1905) 398) gives further: Timor, Anachorete Isls., New-Hannover and New-Mecklenburg. Perhaps some of the Melanesian records should be placed under the new species. The same uncertainty rules with regard to *C. serrulata*, specimens of which I have seen from the Red Sea, the East coast area of Africa, Ceylon Strait, the Philippines, New Guinea and from Queensland, and ASCHERSON (l. c.) has the further records: Singapore and New Caledonia. It will be necessary to re-examine each of these records in comparison with *C. angustata*.

¹ E. BORNET, Recherches sur le Phucagrostis major Cavol. — Ann. sc. nat. Botanique, V ser., t. 1, 1864.

² CH. FLAHAULT, Cymodocea, in Kirchner, Loew u. Schroeter: Lebensgeschichte der Blütenpflanzen Mitteleuropas, Bd. 1, Abt. 1 (1908) 529.

2. *Cymodocea isoëtifolia* Ascherson,

in Sitzber. Ges. Naturforsch. Freunde Berlin (1867) 3; in Das Pflanzenreich IV 11 (1907) 149; Bentham, Fl. Austr. VII (1878) 178; F. v. Müller, Sec. Census Austr. Pl. (1889) 204.

Both male and female plants were cast ashore at Carnarvon (No. 262); they had a dark green colour. Sterile shoots were found at the beach of Geraldton (No. 263). But in none of the collections were creeping rhizomes present.

The species has been reported once before from West Australia (Champion Bay) by P. ASCHERSON (see e. g. his paper of 1905), but this record is not quoted by BENTHAM, nor by F. v. MÜLLER. In the herbarium of Lund, Sweden, and in the National Herbarium of Victoria I have seen specimens labelled "Champion Bay, West Australia, comm. F. v. MÜLLER" and dated "26/7 1879, Ascherson". But I am unable to state the name of the collector or to give any further communication throwing light upon this record, the correctness of which has been doubted. Nevertheless my discovery of the plant both at Geraldton (= Champion Bay) and at Carnarvon corroborates it.

As to the other parts of Australia, BENTHAM (l. c.) reports it as doubtful from Edgcombe Bay, Queensland (Fitzalan), and I have seen specimens from this locality in the Herbarium of Kew; they belong really to our species. I may add that fragmentary leaves of a sea-grass from Port Denison, Queensland (Fitzalan) in the National Herbarium of Victoria also belong to *C. isoëtifolia* for which we now have certain records from both the west and the east sides of tropical Australia.

The general distribution of the species extends from the Red Sea eastwards to Oceania. The West Australian localities are the most southerly and the only ones which lie south of the tropic of Capricorn.

C. isoëtifolia and its near relative *C. manatorum* Aschers. (Sitzber. Ges. Naturf. Freunde Berlin (1868) 19) form the well-defined subgenus *Phycoschoenus* Aschers. characterized by a cymose inflorescence and the terete and filiform leaf-blades. The two species are very closely allied. ASCHERSON (1868, p. 19) gives the following distinctive features for *C. manatorum*: "schon steril durch längere und dünnere, trocken kaum 1 mm breite, beim Trockenen schwarz werdende Blätter zu unterscheiden, während sie bei der *C. isoëtifolia* eine helle, graugrüne Farbe beibehalten. Die bisher allein vorliegenden weiblichen Blüten und Früchte weichen von denen der *C. isoëtifolia* durch viel beträchtlichere Grösse ab (letztere

8 mm lang, bei jenen nur 3), letztere zeigen auch eine gestrecktere Form, indem sie als halbelliptisch (jene halboval) zu bezeichnen sind". Later, the male flower has been found as may be seen from ASCHERSON (1907) in „Das Pflanzenreich" (IV, 11; 149) where the anthers of *C. isoëtifolia* are given as 2 mm long. Here the diagnosis of *C. manatorum* consists only of the following words: "A praecedente ♂: [*C. isoëtifolia*] differt: Folia longiora graciliora in sicco nigricantia. Flores quam in praecedente plus duplo majores, sed iis *C. nodosae* minores".

The flowering material of *C. isoëtifolia* from Carnarvon gave an opportunity for a more detailed study of the differences between the two species, as I had also ample material of *C. manatorum* from the Danish West-Indies, collected by E. WARMING and myself.

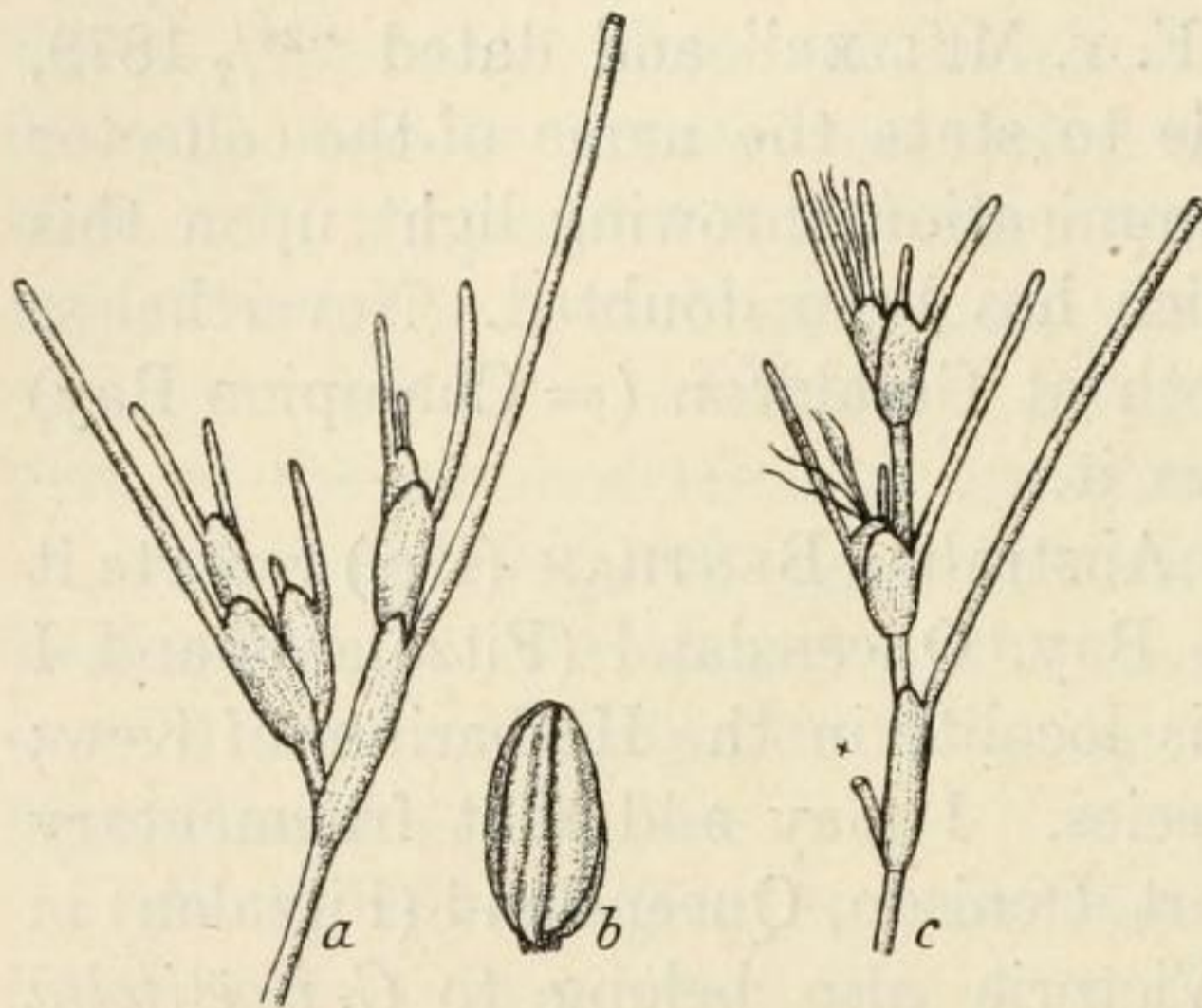


Fig. 4. *Cymodocea isoëtifolia* from Carnarvon. *a* A male inflorescence. *b* A male flower. *c* Part of a female inflorescence. (*a* and *c*, nat. size; *b*, 3:1 nat. size.)

As to the length of the leaves of *C. isoëtifolia*, the Geraldton specimens show that it varies from 20—30 cm (including the sheaths which are 3—4 cm); in the Carnarvon specimens the leaves are 12—15 cm long with sheaths 2—2,5 cm long. Specimens in the Botanical Museum of Copenhagen from the Red Sea and from Ceylon have the leaves nearly as long as those

from Geraldton, while, according to ASCHERSON (1907) the leaves reach only 15 cm, i. e. only the half of what I have actually measured. The leaves of numerous specimens of *C. manatorum* from the West Indies attain to 32 cm at the most, with sheaths 4—4,5 cm long. Therefore, as regards length of leaves there is no difference between the two species; the same is the case with their colour.

SAUVAGEAU (1890, pp. 188—191) has studied the anatomy of the leaves of the two species. On the whole they are much alike, but there is a well-marked difference in the number of veins. In *C. manatorum* there are only two "lateral" veins besides the central one, while in *C. isoëtifolia* the "lateral" veins, which are

arranged in a circle around the air-channels and the central vein, vary in number from 7 to 15. This difference between the species I have been able to verify by examining several specimens of both species, with this exception that the number of "lateral" veins

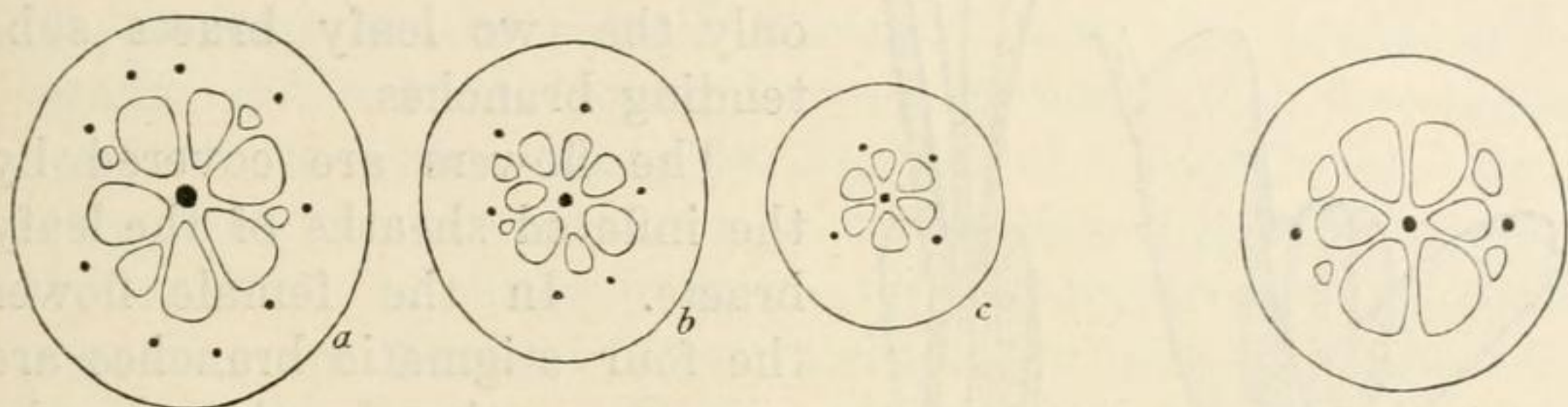


Fig. 5. *Cym. isoëtifolia*. Transverse sections of leaf-blades. *a*, of foliage leaf, from Ceylon; *b*, of foliage leaf from Carnarvon; *c*, of inflorescence leaf from Carnarvon. The black points represent the veins, the circles the lacunæ. (About $\frac{20}{1}$ nat. size.)

Fig. 6. *Cym. manatorum* Aschers., from St. Croix, Danish W. Indies. Transverse section of leaf-blade. (About $\frac{20}{1}$ nat. size.)

in *C. isoëtifolia* sometimes may be reduced to 4. The specimens from Carnarvon had 6—7 lateral veins in the foliage leaves, but only 4 in the short leaf-blades of the inflorescences, and specimens from Ceylon had 9—10 "lateral" veins (see Fig. 5). On the other hand in all the leaves of *C. manatorum* from the West Indies examined by me the number of lateral veins was only two (Fig. 6), as stated by SAUVAGEAU. We have thus in this character a distinctive mark of value, which is the more desirable because the other characters taken from the leaves do not stand on closer examination.

The inflorescence of the two species of the subgenus *Phycoschoenus* is very characteristic¹, and is the same in both species. The diagrammatic figures (Fig. 7) of young male and female inflorescences from Carnarvon show their cymose character better than

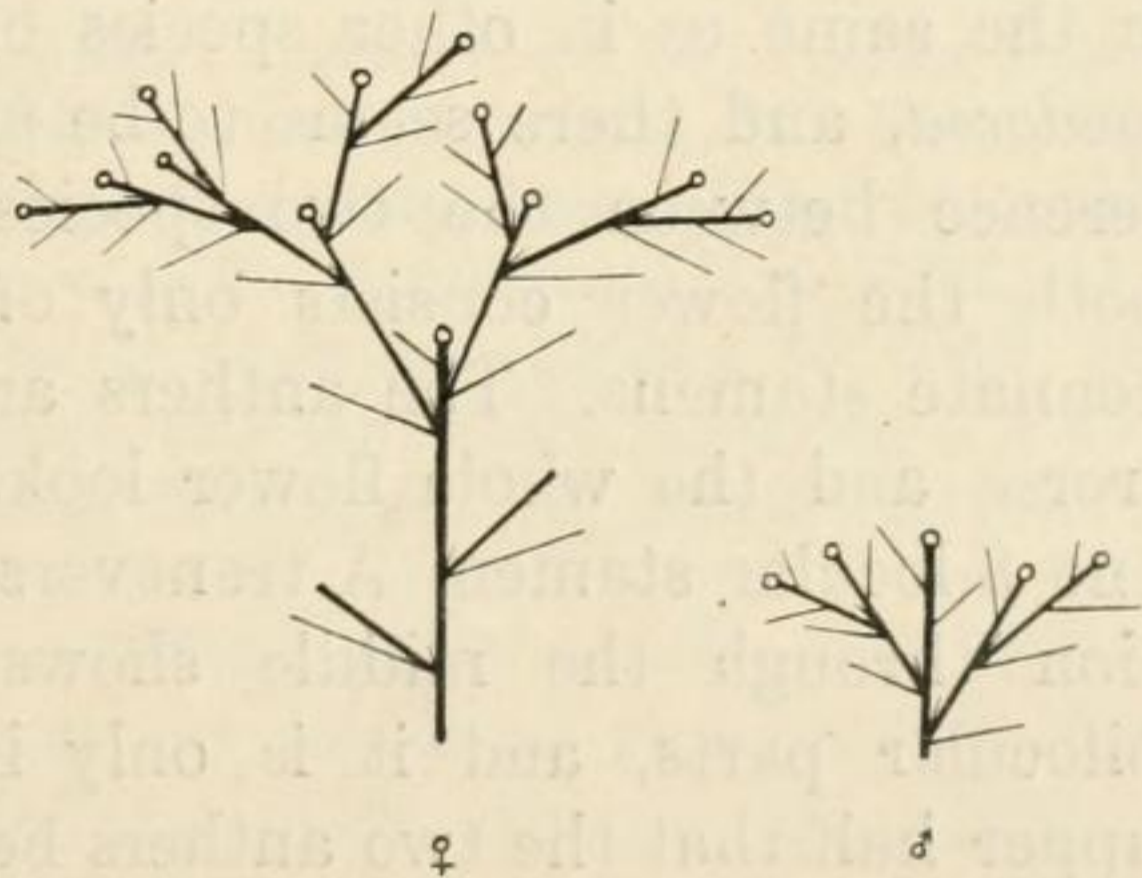


Fig. 7. *Cym. isoëtifolia*, from Carnarvon. Diagrams of female and male inflorescences, with flowers, leafy-bracts and prophylla.

drawings of the inflorescences themselves (Fig. 4). The cyme begins two-sided, but the younger parts are one-sided. The prim-

¹ P. MAGNUS has described the inflorescence of *C. manatorum* in Sitzber. Naturforsch. Freunde, Berlin, 19. März 1872.

ary axis usually has one or two leafy bracts inserted above those leafy bracts from the axils of which the secondary axes arise; this arrangement occurs again in the youngest one-sided parts of the inflorescence, whereas in its median part each axis has only the two leafy bracts subtending branches.

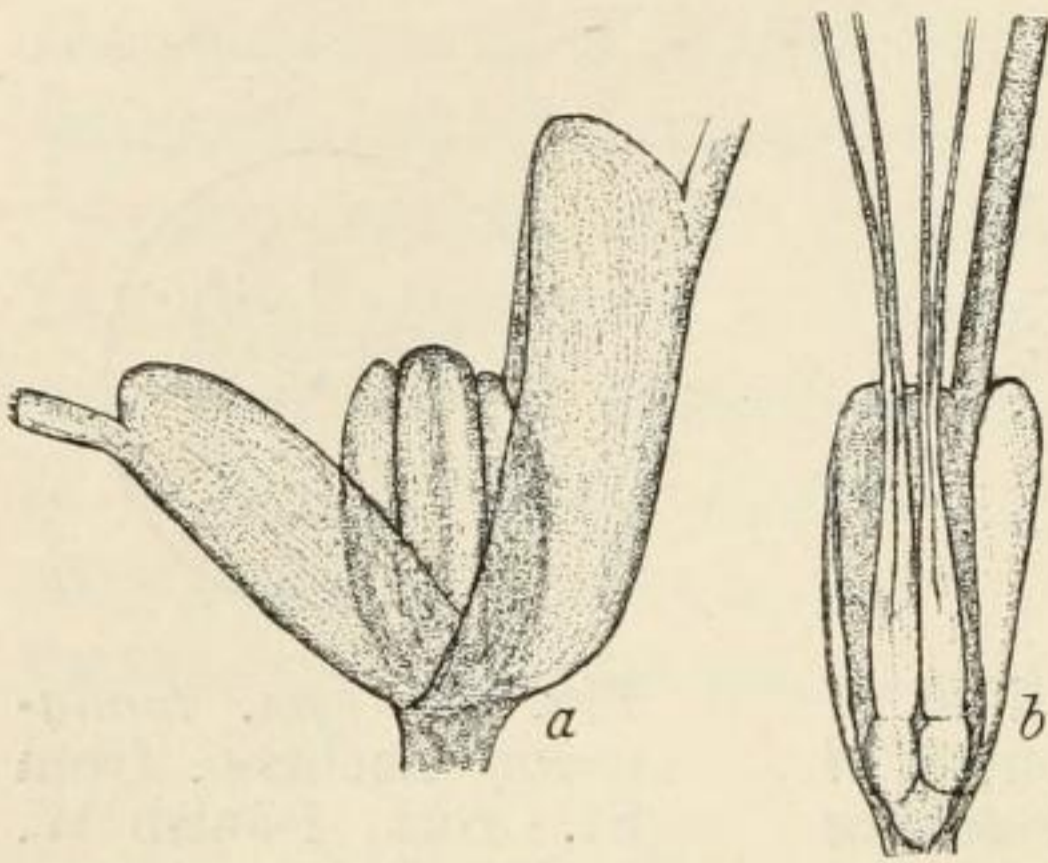


Fig. 8. *Cymodocea isoëtifolia*.
a, Male flower; b, Female flower.
($\frac{4}{1}$ nat. size.)

a sessile double stamen inclosed in the sheath or sheaths (Fig. 8 a); the filament is so short that the anther is almost sessile, but most probably it elongates suddenly thus enabling the anther to extend beyond the sheath, or perhaps the whole anther breaks off when ripe.

The structure of the male flower is the same as in other species of *Cymodocea*, and there seems to be no difference between the two species. In both the flower consists only of two connate stamens. The anthers are extrorse and the whole flower looks like one 8-locular stamen. A transverse section through the middle shows four bilocular parts, and it is only in the upper half that the two anthers become distinct from each other (Fig. 9). In *C. isoëtifolia* the anther is 3.5—4.2 mm long and 1.7—2.0 mm thick, and the pollen sacs are often somewhat twisted (see Fig. 4 b). In the two male flowers of *C. manatorum* which I have been able to examine, the anthers were a little shorter and broader: 3.1 and 3.6 mm

The flowers are covered by the inflated sheaths of the leafy bracts. In the female flower the four stigmatic branches are seen above the sheaths. In the male flower the anther must be supposed to appear when it is ripe, but I have not succeeded in finding this stage. All the male flowers examined by me had

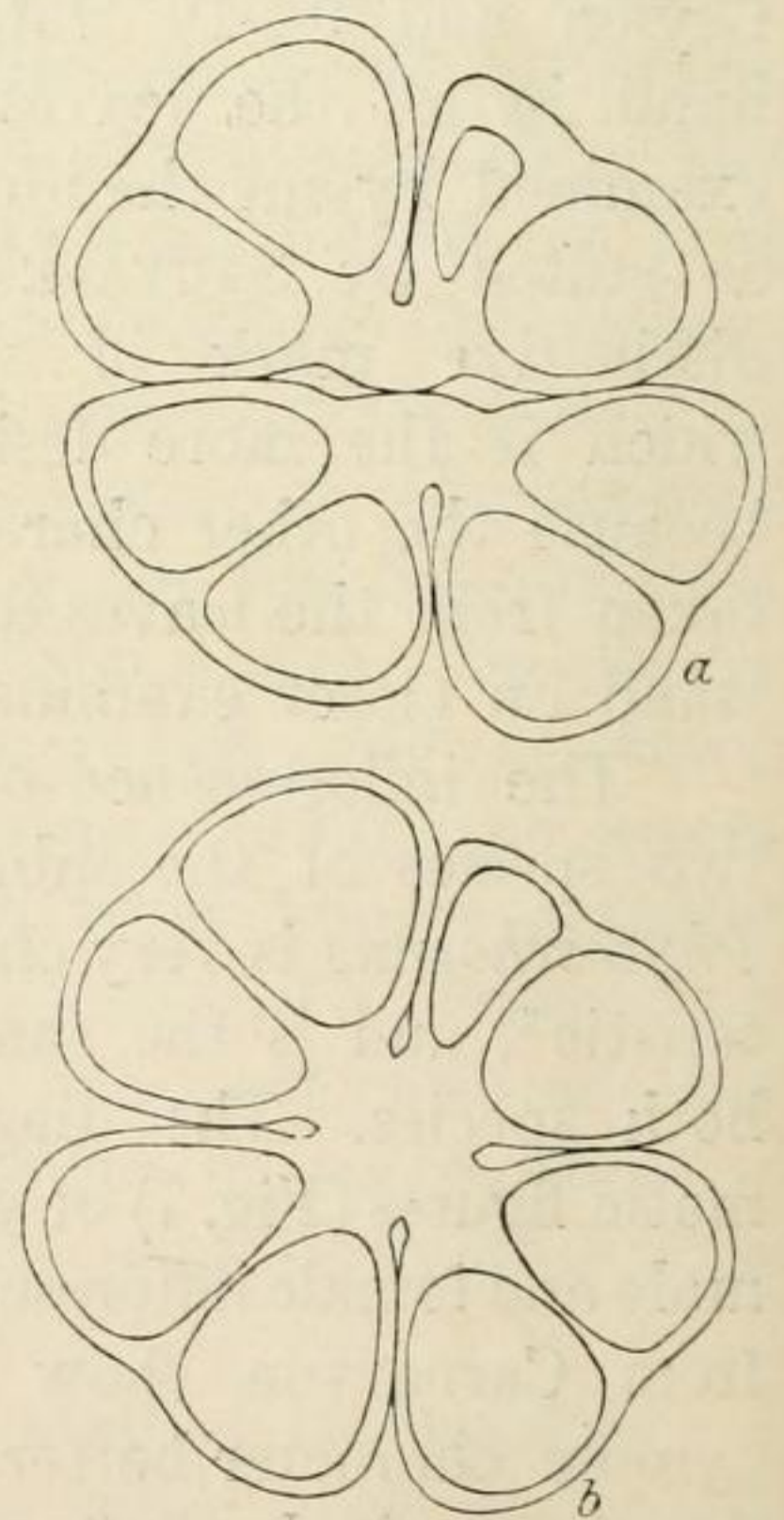


Fig. 9. *Cym. isoëtifolia*.
Transverse sections of the male flower. a, above the middle; b, through the middle. (About $\frac{20}{1}$ nat. size.)

long and 2.0—2.2 mm thick, and the pollen sacs were not at all twisted. There is thus a slight difference in shape between the male flowers of the two species, but nothing to justify the statement by ASCHERSON that the flowers of *C. manatorum* are twice as large as those of *C. isoëtifolia*¹.

As regards the female flowers I have not found any discernible difference between the two species. They have the same size and the same shape (see Fig. 8 *b* of *C. isoëtifolia*). On the other hand there seems to be a distinctive character in the size of the fruits as already given by ASCHERSON (1868). I have measured ripe fruits of *C. manatorum* from Cuba which were 6 mm long (the beak not included), and unripe (?) fruits of *C. isoëtifolia* from India (the Australian specimens were in flower only) were 3.5 mm long; also their shape is somewhat different, viz.: oblique-obovate in *C. manatorum* and oblique-elliptic in *C. isoëtifolia*.

Summarising, we must admit: (1) that the Indo-pacific *C. isoëtifolia* and the Caribbean *C. manatorum* are very near in character; (2) that most of the distinctive marks hitherto given do not hold good; (3) that small differences in the anatomy of the leaves and in the size and shape of the anthers and fruits make it possible to retain them as distinct species.

3. *Cymodocea antarctica* (Labill.) Endl.,

Genera plant. (1836) 230; Ascherson, in Das Pflanzenreich IV, 11 (1907) 151; *C. zosterifolia* F. v. Müller, Census of Austr. Plants (1882) 121; *Ruppia antarct.* Labillardière, l. c. (1806) 116, tab. 264; *Caulinia antarct.* R. Br., Prodr. Nov. Holl. (1810) 339; *Amphibolis bicornis* C. A. Agardh, Spec. Algar. I, 2 (1822) 474; *A. zosteræfolia* C. A. Agardh, l. c. 475; Gaudichaud, l. c. (1826) 35 et 161, pl. 40, fig. 2; *A. antarct.* Sonder et Ascherson, Linnæa 35 (1867) 164; *Pectinella antarct.* I. M. Black, Transact. Roy. Soc. South Australia, XXXVII (1913) 1, pl. I et ibid. XXXIX (1915) 94; *P. Griffithii* I. M. Black, l. c. (1915) 94.

As already stated in the present paper (p. 6), this characteristic species is common along the southern part of the West Australian coast. I saw it in the Cave district (No. 267), at Cottesloe beach, at Geraldton (No. 264), and at Carnarvon, Sharks Bay (No. 265). LABILLARDIÈRE (l. c.) reports it from Cape Leeuwin, HARVEY (l. c.) from King George's Sound, Rottnest Island and Fremantle, GAUDICHAUD (l. c.) and NAUMANN (see ASCHERSON

¹ He says (Sitzber. Naturf. Freunde, 20. Oct. 1868) that *C. manatorum* "besitzt lineale, fast 0.01 m lange Antheren, welche sich von den ovalen kaum 0,003 m langen der *C. isoëtifolia* noch auffaldender unterscheiden als dies bei den weiblichen Blüten der Fall war".

(1875) 762) from Sharks Bay; in the herbaria at Kew and the British Museum I have seen specimens from King George's Sound and from Swan River, and in the U. S. National Herbarium specimens from Champion Bay, and I have got specimens from Bunburry, collected by Mr. CHAS. G. HAMILTON (No. 266). The distribution of these localities enables us to regard the species as growing all along the coast from Sharks Bay in the north to King George's Sound in the south.

Outside West Australia it is known from South Australia and Victoria; it is also said to occur at Tasmania (see e. g. ASCHERSON 1907), but I have not seen any specimens from there, neither does I. M. BLACK (1913) mention it from this State. The general distribution is, consequently, rather restricted, embracing only the southern and the temperate western coasts of Australia.

The species stands rather isolated within the genus. The synonyms cited above show how difficult it has been to find the right place for it, and still my citations are far from complete; it has further been referred to several other genera (*Kerneria* Willd., *Graumuellera* Rchb., *Thalassia* Soland). Quite recently I. M. BLACK (1913) has founded the new genus *Pectinella*¹ on it. It might be quite reasonable to segregate it as a genus, as it has many characters of its own, but I prefer to keep it in the genus *Cymodocea*, because its flowers, both female and male, do not in essential points differ from those of the other species of *Cymodocea*.

ASCHERSON (Sitzber. Naturforsch. Freunde Berlin (1870) 84) has shown that with regard to the vegetative parts of the plant our species has much in common with *C. ciliata* (Forsk.) Ehrb.², and he has adopted AGARDH's genus name *Amphibolis* as a subgenus name for these two species. They are characterized by their hard lignose rhizomes with branched and elongated upright shoots; their anatomy has also much in common, as shown by P. MAGNUS (Sitzber. Naturf. Freunde Berlin (1870) 89). Nevertheless these two species are much more distant from

¹ If it should be taken as a separate genus, AGARDH's old name, *Amphibolis*, ought to be used, instead of creating a new name.

² This species is distributed from the Red Sea along the eastern coast of Africa as far south as Luabo and Mauritius. It is further found on the shores of Queensland (e. g. Port Denison, leg. Fitzalan). In the National herbarium of Victoria (Melbourne) I have seen a specimen labelled "W. Australia, Geographe Bay, Herb. W. Sonder, Hamburg", but no doubt there is some mistake here.

each other than is the case with the species within the other subgenera of *Cymodocea*.

C. antarctica has some very striking features in its growth

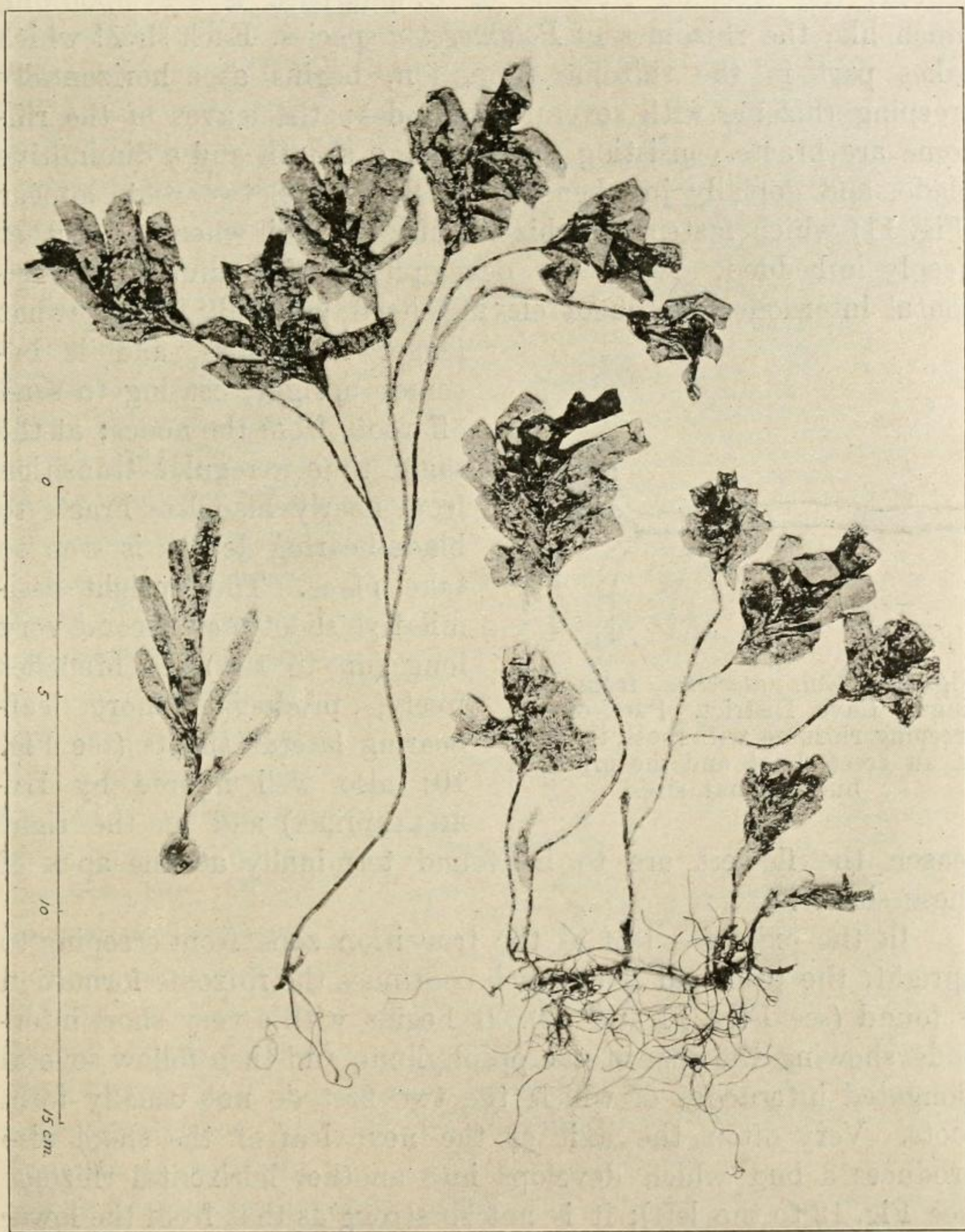


Fig. 10. *Cymodocea antarctica*, from Yallingup Cave District.
To the left a "seedling", in the middle a much branched assimilative shoot,
to the right the younger part of a rhizome with its assimilative shoots.
(Photo. of herbarium material.)

and biology, and these features have been interpreted in very different ways by different authors. Therefore I think it appropriate to give a description of the structure and biology so far

as they are known, besides a summarising review of the scattered papers in which the species is dealt with.

In contrast to the other *Cymodoceæ* (perhaps *C. ciliata* excepted) the creeping rhizome of *C. antarctica* is a sympodium, much like the rhizomes of *Potamogeton* species. Each shoot which takes part in the rhizome formation, begins as a horizontally creeping rhizome with several internodes; the leaves of the rhizome are bracts consisting of a clasping sheath and a diminutive blade, and dorsally just beneath the leaf-scars, two roots appear (Fig. 11) which fasten the rhizome into the soil where it is rather deeply imbedded. After the development of a number of horizontal internodes the shoot elevates itself, generally by somewhat

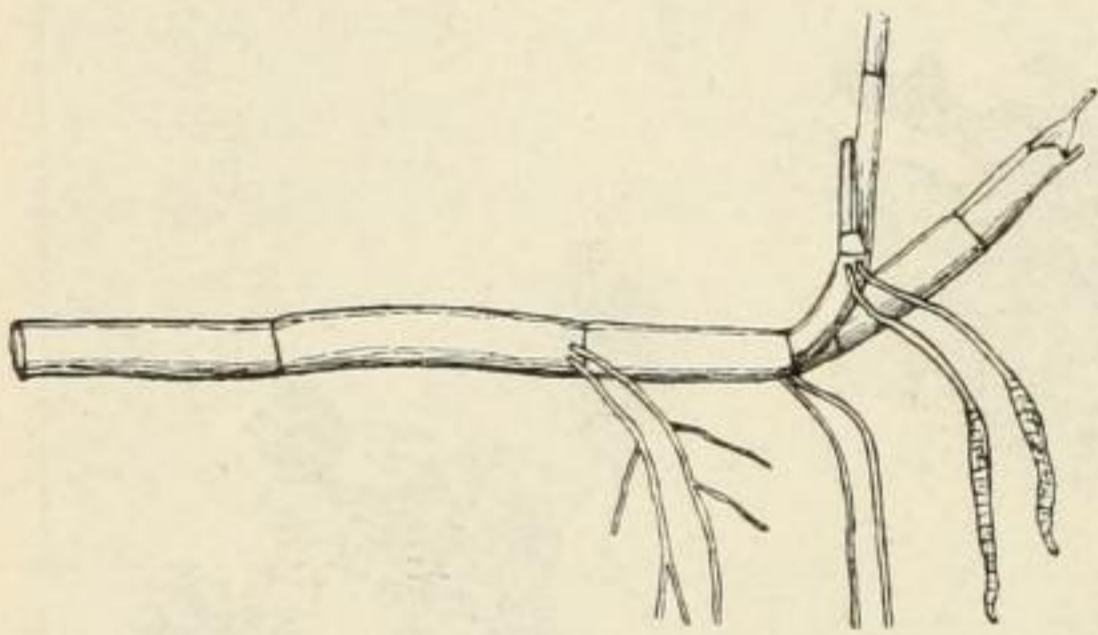


Fig. 11. *Cym. antarctica*, from Yallingup Cave District. Part of the creeping rhizome, with roots, the base of an erect shoot and the principal bud. ($\frac{3}{4}$ nat. size.)

longer internodes, and it becomes upright, ceasing to send off roots from the nodes; at the same time a regular transition from nearly bladeless bracts to blade-bearing leaves is seen to take place. The upright assimilative shoot may become very long (up to 1 m); it branches freely, producing short leaf-bearing lateral shoots (see Fig. 10; also well figured by LABILLARDIÈRE) and at the right

season the flowers are to be found terminally at the apex of these shoots.

In the axil of a leaf at the transition zone from creeping to upright, the principal bud which continues the rhizome formation is found (see Figs. 11 and 12). It begins with a very short internode showing the scar of the prophyllum, and then follow several elongated internodes of which the two first do not usually form roots. Very often the axil of the next leaf of the shoot also produces a bud which develops into another horizontal rhizome (see Fig. 12 to the left); it is not so strong as that from the lower axil, and sometimes it is checked in its growth remaining short and poorly developed (see Fig. 11). The scale-leaves of the rhizomes and the leaves of the lower parts of the upright shoots fall off very quickly leaving annular scars. At the top of each branch of an upright shoot there is a tuft of distichous leaves. The whole upright shoot is evidently of rather short duration, and it breaks off near the ground. According to TEPPER, quoted

by ASCHERSON (1882, 30)¹, the shoots break off in September and October, and are thrown up on the shore by the waves. When I collected *C. antarctica* in the pools on the coast of Yallingup on Sept. 26th, I did not get the impression that the season for their shedding had begun, but perhaps the time is not quite fixed. When examining the material I discovered remains of the short basal parts of the stems of the assimilative shoots shed last season; their dark, nearly black colour distinguished them clearly from the light-coloured stems of the present year-shoots. The rhizomes are very richly branched and, undoubtedly, they last for a longer time; they were rooted by many divaricate much-branched roots. (see Fig. 10). When ASCHERSON (1882) states that, according to TEPPER, the rhizomes do not propagate the plant from year to year ("Da ihre im Boden liegenden Teile, soweit Tepper beobachtete, niemals Knospen bilden, so würde die Pflanze nicht auf anderem als auf sexuellem Wege sich fortpflanzen können, wenn nicht" etc.), this observation is wrong. Evidently the rhizome sends up new upright shoots each growing season, just as the perennial rhizome-bearing pondweeds do.

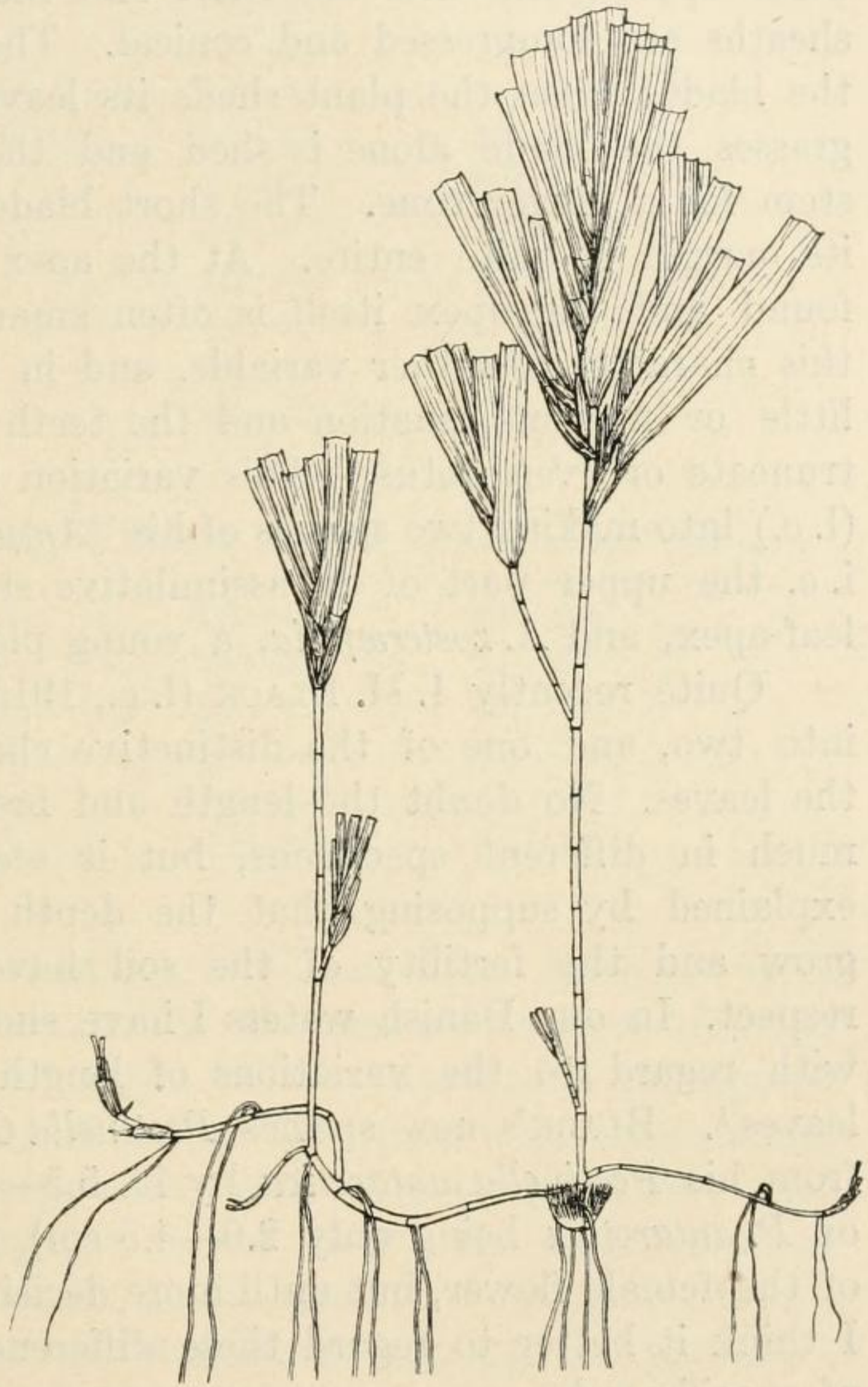


Fig. 12. *Cym. antarctica*, from Carnarvon. An old seedling grown from the "comb" and with creeping rhizome and erect assimilative shoots. (About $\frac{1}{2}$ nat. size.)

¹ P. ASCHERSON: Die vegetative Vermehrung einer australischen Seegrassart, der *Cymodocea antarctica* (Labill.) Endl. — Sitzber. Botan. Vereins Prov. Brandenburg XXIV (1882) 28—33.

The leaves of *C. antarctica* are short compared with those of the other *Cymodoceæ* etc. There seems to be a correlation between this fact and the elongated upright axes. The short leaves stream freely in the water owing to the long stems, while in the other species the axes are short and the leaves long. The leaf-sheaths are compressed and conical. They fall off together with the blades when the plant sheds its leaves, whereas in most sea-grasses the blade alone is shed and the sheath persists on the stem for a longer time. The short blade is flat and ribbon-like, its margin is quite entire. At the apex two marginal teeth are found and the apex itself is often emarginate (semilunate), but this character is rather variable, and in the lower leaves there is little or no emargination and the teeth are absent, the apex is truncate or even obtuse. This variation has misled C. A. AGARDH (l. c.) into making two species of his "*Amphibolis*", viz.: *A. bicornis*, i. e. the upper part of an assimilative shoot with its emarginate leaf-apex, and *A. zosteræfolia*, a young plant with truncate leaves.

Quite recently I. M. BLACK (l. c., 1915) has divided the species into two, and one of the distinctive characters is the length of the leaves. No doubt the length and breadth of the leaves differ much in different specimens, but it seems to me to be better explained by supposing that the depth at which the specimens grow and the fertility of the soil have some influence in this respect. In our Danish waters I have shown that such is the case with regard to the variations of length and breadth of *Zostera* leaves¹. BLACK's new species *Pectinella Griffithii* is said to differ from his *Pectinella antarctica* by its 5.5—9.0 cm long leaves (those of *P. antarctica* being only 2.0—4.5 cm), and by certain features of the female flower, but until more decisive distinctions are found I think it better to regard these differences as of individual, not of specific value.

I have made measurements of the leaves of specimens from different localities, also of specimens kindly sent me by Mr. BLACK and representing both his species. In comparing these it is necessary to keep the leaves of the branches of the upright assimilative shoot apart from those of the main shoot itself, as the latter are generally longer and sometimes narrower.

The table given here shows a variation range from 2.0 to 7.0 cm. in length, and from 3.0 to 10.0 mm in breadth, but it

¹ C. H. OSTENFELD: On the ecology and distribution of the Grass-wrack (*Zostera marina*) in Danish waters. — Report of the Danish Biological Station XVI, 1908.

does not give any confirmation to the view of the existence of two different species:

Leaves of the branches of the upright shoot.

	long (cm)	broad (mm)
Yallingup, W. A.....	2.0—2.5	5.0— 8.5
Port Philip Head, Vict. .	2.5—4.5	6.0—10.0
Henley Beach, S. A.	2.2—3.5	3.0— 4.5
— — —	2.0—2.5	3.0— 4.0
— — —	3.0—3.5	3.5— 4.0
— — — ...	4.0—5.5	3.0— 3.5
Victor Harbour, S. A....	2.0—2.5	4.0— 5.0
— — — ...	3.0—4.0	3.5— 4.5
— — — ...	5.0—7.0	3.0— 4.0

Leaves of the young upright shoot itself (* of young plants, "seedlings".)

Carnarvon, W. A.	3.0—4.5	3.0—5.5
Port Pirie, S. A.	3.0—3.3	3.0—3.5
*Yallingup, W. A.	3.0—4.5	5.0—7.0
*Carnarvon, W. A.	4.5—6.0	6.0—7.0
*Bunburry, W. A.	2.8—4.5	4.5—7.0
*Henley Beach, S. A.	3.0—4.5	3.5—4.0

Passing now to the flowers of *C. antarctica*. Both the male and female flowers are terminal at the apex of the short branches of the upright shoots. The male flower was found and figured by GAUDICHAUD who says (1826, 35): "J'ai trouvé quatre étamines biloculaires connées et supportées par un petit pédicule (voyez pl. 40, fig 2)". In reality the flower is like the male flower of the other species of *Cymodocea*, i. e. it consists of two short-stalked 4-locular stamens connected on the dorsal side, and GAUDICHAUD's figure is also better explained in this manner than by regarding the flower as consisting of four stamens. I. M. BLACK (1913, Figs. 10—12) has given good drawings of them. The apices of the anthers are adorned by branched appendages. GAUDICHAUD has drawn the appendages as unbranched, and if Mr. BLACK's claim for the existence of two separate species is right, it would be worth while to look here for a distinctive feature.

A transverse section of the double stamen does not differ in any point worth mentioning from the section of the male flower of *C. isoëtifolia* (see Fig. 13). I have not had specimens preserved in fluid for examination, but have soaked herbarium specimens sent by Mr. BLACK and then hardened them in spirit. The length

of the anthers is about 5—6 mm (the appendages excepted). The whole male flower is sheltered by the sheath of the uppermost leaf, and it seems as if it never extends itself out of the sheath, but opens while surrounded by the sheath. At least none of the flowers examined by me show any elongation of the filament, nor does Mr. BLACK mention anything of that kind.

The female flower was first described by ASCHERSON in 1876¹ from a flower received from F. v. MÜLLER. I quote the description, as the journal in which it was published is difficult to get:

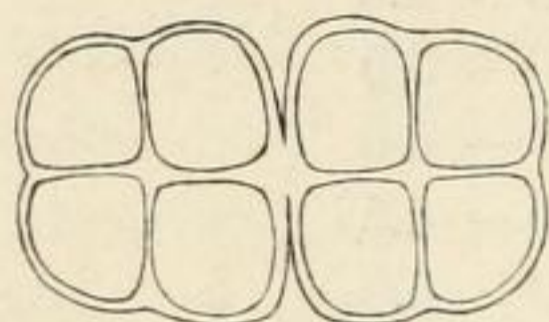


Fig. 13. *Cym. antarctica*, from Henley Beach, S. A. Transverse section of the male flower (about $\frac{10}{1}$ nat. size).

“Baron F. v. Müller sandte freundlichst ein Exemplar, von Mrs. Beal in Loutitt Bay westlich von Melbourne gesammelt, an dem er einen weiblichen Blütenstand bemerkt hatte. Unser berühmter Landsmann hatte bereits gesehen, dass sie, dem Charakter von *Cymodocea* entsprechend, aus zwei neben einander stehenden Carpellen bestehe, deren Griffellamelle sich, wie

an diesem Exemplar zu erkennen, nahe über der Basis in zwei Aeste theilt. Die Blüthe bildet, wie bei *C. ciliata* und den Arten der Section *Phycagrostis*, den terminalen Abschluss eines Laubzweiges, dessen äussere (an dem vorliegenden Exemplar beschädigte) Blätter von den gewöhnlichen Laubblättern nicht abzuweichen scheinen”.

This description is correct in the main points, but not exhaustive. The next time we hear about the female reproductive organs, a very interesting discovery was made. At the request of F. v. MÜLLER and ASCHERSON, Mr. I. G. O. TEPPER studied the plant at Ardrossan (York Peninsula, South Australia) and published some papers on it in the Royal Soc. of South Australia².

According to BLACK (1913), it seems as if TEPPER had not found the young female flower, but only what he considered to be the female propagative organ. From his observations he draws the conclusion “that the plant does not at all develop a fruit proper, nor does the seed ever become dissociated from its plant, but that the fertilized ovum at once germinates and develops

¹ In Sitzber. Ges. Naturforsch. Freunde Berlin (1876) 11.

² I. G. O. TEPPER: Some Observations on the Propagation of *Cymodocea antarctica* Endl. — Trans. Roy. Soc. South Australia, IV (1881) 1—4 and 47—49, pl. 1 and 5; and ibid. V, 37. — I have not access to the papers themselves, and am restricted to the abstracts given by P. ASCHERSON (1882) and I. M. BLACK (l. c., 1913).

into a new plant, which at maturity is detached and begins an independent cycle of existence”.

This peculiar behaviour was doubted by ASCHERSON, who in his paper of 1882 gave a quite different explanation of the matter. Nevertheless, as very convincingly shown by I. M. BLACK, Mr. TEPPER was right, and I may at once add that I can confirm Mr. BLACK's statements. We have in the propagation of *Cym. antarctica* a very interesting and unique kind of vivipary.

When C. A. AGARDH (1822) described his *Amphibolis zosteræfolia* he mentioned that at the base of the plant there were peculiar comb-shaped horny bracts (“Basis e tribus vel quatuor squamis pectinatis cuneatis, erectis, semiunguem altis, osseis, albis constituta”). They formed a kind of cup from the inner part of which the stem arose. The nature of this “comb-cup” remained unexplained for a long time. TEPPER evidently considered it as belonging to the female flower, as it makes up the basal part of what he took to be the “new plant”. But ASCHERSON (1882, l. c.) rejects this explanation completely. He gives a detailed description of the comb and its relation to the stem and the ordinary leaves. The comb consist of 4 lobes, 2 broader and 2 narrower, which he regards as leaves transformed into peculiar scales adapted to the vegetative propagation of the plant. This propagation takes place in the following way (as observed by TEPPER): The shoot breaks off beneath the comb and floats in the water until the comb acting as an anchor happens to hook on to some body on the sea-bottom, thus fastening the shoot which then takes root and grows into a new plant.

ASCHERSON's explanation of the vegetative nature of the comb was adopted universally, the more so as his description of the young female flower quoted above did not show any point which justifies a connection between the flower and the comb-shoot. It was not until I. M. BLACK found a series of successive stages of the development of the comb, that it became evident that ASCHERSON was quite wrong and that TEPPER's observation and conclusion — incomplete as they are — were right. The comb-lobes are in reality outgrowths on the outer side of the pericarp, and the shoot which arises from the comb is a seedling from an embryo which begins its growth at once. Not before the seedling has reached a considerable size (6—10 cm), does the “shoot” break off, still with the “comb”-pericarp girding its basal part and serving as an anchor. It floats in the water for a time, and in this way the species becomes dispersed by the currents.

Through the kindness of Mr. BLACK I have secured a considerable amount of herbarium material of *Cym. antarctica* from Henley Beach, S. A. and from it have been able to control his description of the female flower and fruit, and its behaviour.

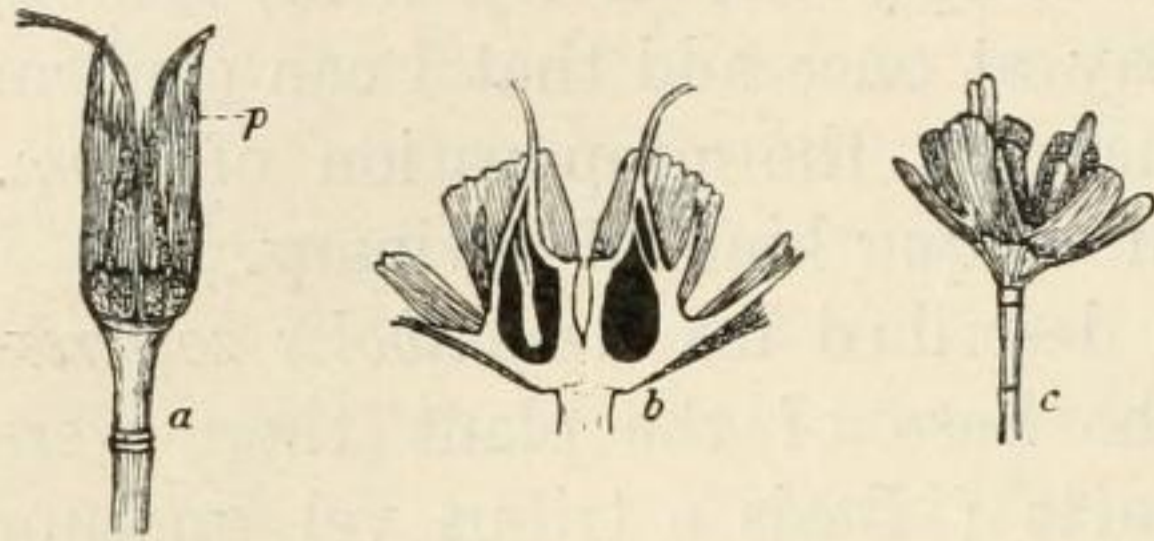


Fig. 14 *Cym. antarctica*, from Henley Beach, S. A. *a*, Female flower with involucre (*p*) (about $\frac{2}{1}$ nat. size). *b*, Longitudinal section through the fruit (about $\frac{3}{2}$ nat. size). *c*, Ripe fruit with "comb" and protruding plumula (about $\frac{3}{4}$ nat. size).

The detached seedlings I found myself on the West Australian coast, and also got some from Mr. HAMILTON from Bunbury; they seem to be commonly cast ashore during the spring. At Carnarvon I happened to find a seedling which was further developed and showed the manner in which the rhizome was formed (Fig. 12). By combining Mr. BLACK's exhaustive description and

my additional observations, we are able to give the following picture of the development of the propagation:

The female flower consists of two carpels, as in the other species of *Cymodocea*; it is terminal at the apex of the upright branches, and is sheltered by two nearly opposite normal foliage leaves. All this is typical and was seen by ASCHERSON (1876), but in two points the flower differs from the ordinary *Cymodocea* flower: the styles of the carpels divide into three stigmas (not as usually into two), and the flower is enclosed in a membranous involucre (Fig. 14 *a*); whether this cup is a kind of perianth or — more probably — bracteoles, I cannot say. According to Mr. BLACK this involucre is well developed in his *P. antarctica* and nearly absent in his *P. Griffithii*. The flowers and fruits examined by me all had a more or less well-developed involucre.

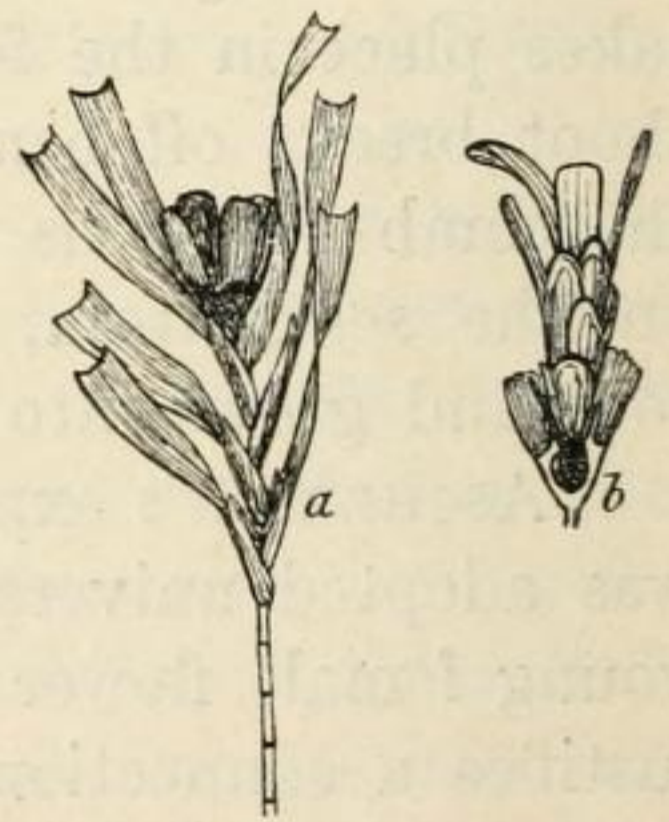


Fig. 15. *Cym. antarctica*, from Henley Beach, S. A. *a*, An erect shoot with leaves and the apical fruit. *b*, A seedling with its "comb"-fruit cleft longitudinally. ($\frac{3}{4}$ nat. size.)

After the fertilisation the carpels begin to grow, and especially four small outgrowths on their surface increase rapidly in size to form four flat cuneate spreading lobes. Inside them and more toward the apex of the carpel there are some smaller and more pointed protuberances which form a kind of protection around

the apex (see Fig. 14 *b*). The stigmas and the distal part of the style break off soon after fertilisation while the basal part of the style remains. The wall of the pericarp consists of a thin fleshy outer layer and a hard inner layer, and the fruit is consequently a drupelet, as in the other species. Sometimes both carpels of a flower are fertilized and grow out as fruits (Fig. 14 *b* and *c*), but generally one is abortive (Fig. 15 and 16). As I have had only herbarium material at hand, I cannot say how the embryo develops. On making a section through a fruit, we find a fully grown embryo with a long cotyledon, a short axis and no primary root. This embryo bursts the apex of the pericarp (fig. 14 *b*) and appears as a little seedling (fig. 14 *c*), which by and by becomes larger. For a long time it remains attached to the mother plant. The figures show two different stages; in the first (fig. 15 *b*) the pericarp has been cleft longitudinally to show the base of the seedling inside the pericarp. The first leaves of the seedling have a minute blade and a large sheath, but gradually the size of the blades increases and at last we find, still attached to the apex of the mother shoot, a new shoot 6—10 cm long and with well developed foliage leaves; the apices of these leaves are always truncate and blunt (Fig. 16 *a*). At a certain moment the new plant (the seedling) is loosened from the mother shoot, but it takes the pericarp along with it, and now the pericarp begins to alter, the fleshy outer part decaying while the hard inner layer remains. The hard parts of the four lobes become divided into many parallel bristles, and only now does it really deserve its name of a "comb" (Fig. 16 *b*). The dark green seedlings with their pale yellowish "comb"-bases float in the water until they become anchored in the ground or to some fixed body at the bottom. Then the stem begins to grow more rapidly, and at the same time lateral shoots issue from the lower internodes and produce creeping rhizomes which develop as described above (see p. 22).

This peculiar kind of vivipary here found has — as rightly pointed out by Mr. BLACK — a certain resemblance to the vivi-



Fig. 16. *Cym. antarctica*. *a*, "Seedling" still adhering to the mother shoot, from Henley Beach, S. A.; *p*, remains of the involucre; *x*, of the abortive carpel. *b*, Detached seedling from Bunbury, W. A. ($\frac{3}{4}$ nat size).

pary in *Bruguiera*, in which plant the seedling also falls to the ground together with the pericarp, while in *Rhizophora* the empty pericarp remains on the mother plant.

The floating power of the seedling makes it possible for it to be carried away by the currents, and in this way the dispersal of the species is furthered. This is an interesting exception to the ordinary rule that sea-grasses do not possess any special adaptation for an effective dispersal of their seeds or fruits. Another exception is seen in *Posidonia australis* (see p. 35), but it is remarkable that these two species nevertheless have unusually restricted geographical areas of distribution.

4. *Diplanthera uninervis* (Forsk.) Ascherson,

in Engler u. Prantl, Natürl. Pflanzenfam., Nachtr. (1897) 37; in Das Pflanzenreich, IV 11 (1907) 152; *Zostera uninervis* Forskål, Fl. ægypt. arab. (1775) 159; *Halodule australis* Miquel, Fl. Nederland. Ind. III (1855) 227; *Diplanthera tridentata* Thouars; F. v. Müller, Sec. Census Austral. Plants I (1889) 204.

This species, not previously recorded from West Australia, was found sparingly cast ashore at Carnarvon (No. 261).

The specimens collected were all sterile. They have an elongated creeping rhizome and short-jointed upright leaf-bearing branches, some of which are more or less transformed into younger long-jointed rhizome branches. The leaves are short (4—6 cm long) and moderately broad (varying from 0.5 to 1.5 mm). The apex of the leaf-blade has generally three teeth, the marginal ones being more pointed than the central, which, in the narrower leaves, is not much developed, in some cases wholly wanting, thus making the apex two-toothed.

D. uninervis is widely distributed along the tropical coasts of the Indo-Pacific region, extending from the Red Sea to Oceania. As to Australia I have seen specimens of this species from Rockingham Bay ("Dugong Plant") and Port Denison, Queensland, both (unnamed) in the National Herbarium of Victoria. Probably it will be found in other places along the tropical coasts of Australia¹; on the other hand it can hardly be expected farther south than Carnarvon, the most southerly record hitherto known.

¹ F. v. MÜLLER (l. c., 1889) records it from "N. A.", but I have not succeeded in finding his source for this record, as his quotation, "Fragm. Phytogr. Aust. VIII, 218", only says, that it should be sought for along the tropical coasts of Australia.

5. *Posidonia australis* J. D. Hooker,

Flor. Tasman. II (1860) 43; F. v. Müller, Fragm. Phytog. Austr. VIII (1872—74) 218; Sec. Census (1889) 204; Bentham, Fl. Austr. VII (1878) 175; Ascherson, in Das Pflanzenreich IV 11 (1907) 38; *Caulinia oceanica* R. Brown, Prodr. Nov. Holl. I (1810) 339; *C. australiana* F. v. Müller, Fragm. Phytogr. Austr. VI (1868) 198.

Next to *Cymodocea antarctica* this species is the most common sea-grass along the coast of West Australia. It is known from several places between King George's Sound and Sharks Bay.

Outside West Australia it occurs on the coasts of South Australia, Victoria and Tasmania, that is along the whole southern side of the continent, and extending further to the extra-tropical west coast.

It has only one congener, *P. oceanica* (L.) Del., an inhabitant of the Mediterranean. The genus which stands very isolated within the family, is evidently a very old type, and the restricted and discontinuous areas of the two species point to a much wider distribution in former times.

We know the morphology, the structure and the biology of the Mediterranean species comparatively well through investigations by French and Italian scientists¹. In general the Australian species seems to be similar, but as far as I have seen, little has been written about it, and as I found the plant in fruit and observed the dispersal of the fruits, I think it worth while to publish my observations. Both at Geraldton (No. 269) and at Carnarvon (No. 268) the fruits and leaves of the plant were cast ashore in quantities (28th and 31st Octob. 1914). The following is an extract from my note-book regarding this phenomenon, as it was observed at Geraldton:

"The fringe of cast-up material on the coast at Geraldton consisted mostly of *Posidonia australis*. Besides leaves — both foliage leaves and the short involucreal leaves of the inflorescence — the material included numerous fruits of this plant. Most of them had opened. The basal part of the fleshy pericarp had

¹ PH. CAULINUS, : *Zosteræ oceanicæ* Linnei anthesis, Neapoli, 1792.

GERMAIN DE SAINT-PIERRE, in Bull. Soc. bot. de France IV (1857) 575, et VII (1860) 474.

CH. GRENIER, *ibid.* VII (1860) 362, 419, 448.

AD. BRONGNIART et ARTHUR GRIS, *ibid.* VII (1860) 472.

CH. FLAHAULT, in Kirchner, Loew u. Schroeter, Lebensgesch. der Blütenpfl. Mitteleurop. vol. I, 1 Abt. (1908) 537.

C. SAUVAGEAU, in Journ. de Botanique IV (1890) 221, 237, et VII (1893) 95.

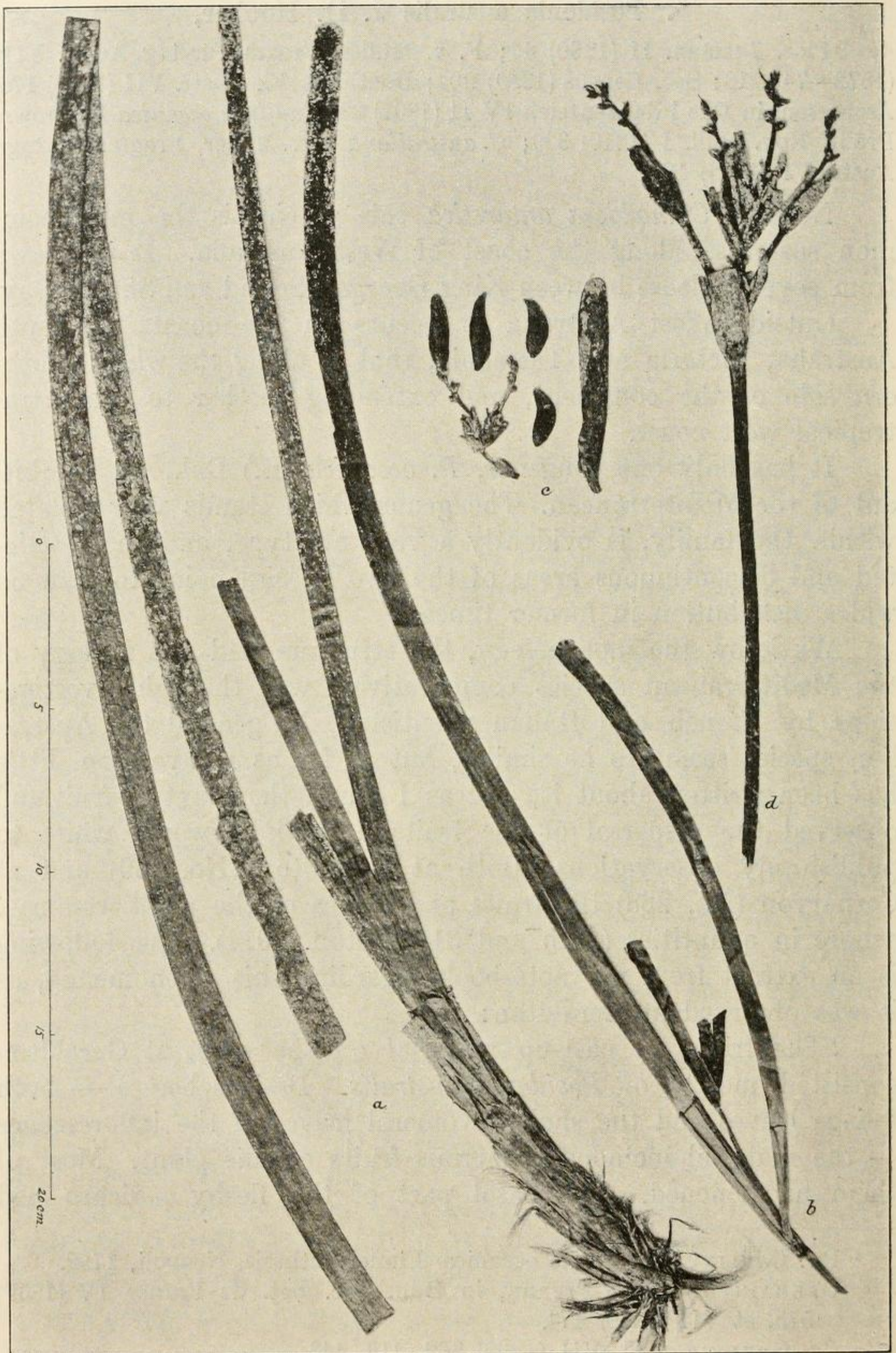


Fig. 17. *Posidonia australis*. *a*, Leaf-blade and upright shoot, from Carnarvon; *b*, Young inflorescence with leaves, from Port Pirie, S. A. (leg. Gunnar Andersson, Aug. 9th 1914); *c*, Inflorescence with ripe fruits and bract, from Geraldton; *d*, Whole inflorescence with bracts and old flowers, the horn-like prolongation of the branches visible; from W. A. (leg. F. v. Müller). (Photo. of herbarium material).

split into 2—3 lobes, and the whole pericarp was spread out as a nearly flat body, thus liberating the seedling which had dropped out. These empty pericarps were present in great masses on the shore, and were also to be seen in immense numbers floating in the water. Amongst the empty pericarps I found several whole fruits which had just begun to open; they are oblique-ovoid in shape and each contains a large green seedling. Unopened fruits were also found, some unripe or barren. Evidently *Posidonia* liberates its fruits when ripe, and owing to presence of air in the tissues of the pericarps they rise to the surface and float. Then they open and the seedling, which is heavier than water, drops out and sinks to the bottom while the pericarp continues to float for a time and then breaks up.”

„The thousands of pale green or yellowish green open pericarps, form, together with the leaves, a fringe along the shore, and present a peculiar sight”.

A later examination of the material collected and of further specimens from South Australia has added to my notes and allows me to make some additions to the descriptions of the species as given in floras.

The creeping rhizome is short-jointed, and in the axil of each leaf there is a short erect shoot with densely arranged leaves. As in the Mediterranean species, the leaf-sheath (8—12 cm long) persists for some time after the shedding of the lamina; the old sheaths split into fine filaments consisting of the sclerenchyma-strands. Thus the erect shoots become enveloped at their base in a cover of these filamentous remains, but hardly to such an extreme degree as is the case with *P. oceanica*. The leaf-blades are long (up to 65 cm measured) and ribbon-like (5—14, generally 8—10, mm broad) with a truncate apex and entire margins. Their structure is known by the investigations of C. SAUVAGEAU (l. c., 1890), and an examination of my material confirms his description. In a transverse section (Fig. 18) the characteristic points are: a small-celled and thick-walled epidermis; numerous small sub-epidermal sclerenchyma-strands, a lacunose mesophyll with septa formed by several cells, and scattered small

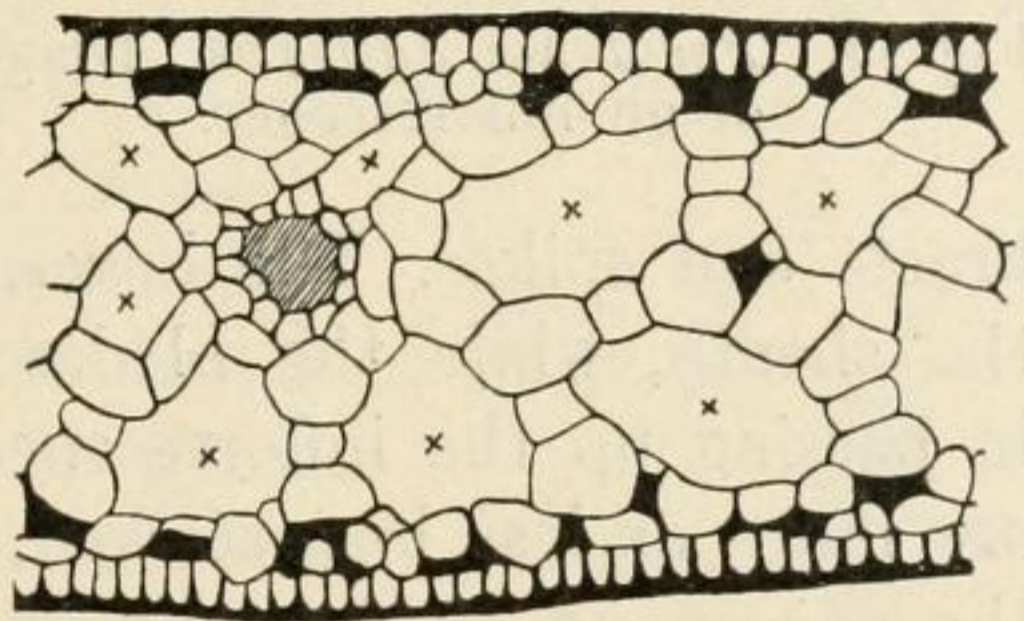


Fig. 18. *Posidonia australis*, from Carnarvon. Transverse section of a leaf-blade. The thick walls of the epidermis and the sclerenchyma-strands are shown in black, the vein (one of the lateral veins) is shaded. x, lacunæ. (About $\frac{150}{1}$ nat. size.)

sclerenchyma-strands at the points where the septa between the lacunæ (air-chambers) meet. (The structure of some doubtful

Posidonia-leaves is dealt with later, p. 37).

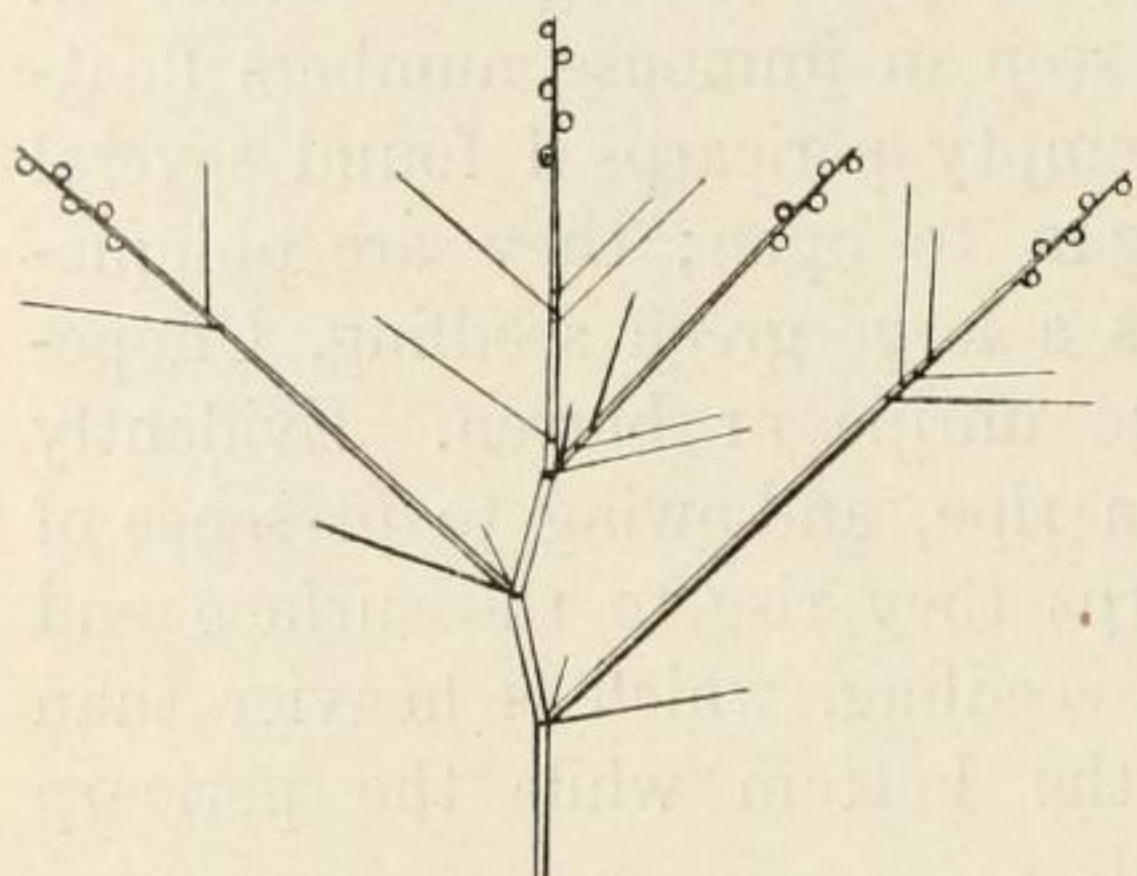


Fig 19. *Posidonia australis*. Diagram of an inflorescence.

The inflorescence is terminal on a long naked axis. It is distichous and branching, and consists of about three branch-spikes and the terminal spike; these are supported by and enveloped in bracts with large sheaths, the leaf-blade being short or absent. A diagram (Fig. 19) of an inflorescence shows the arrangement of the

bracts and spikes. The lowermost bract has a blade longer than the sheath, while the blades become gradually reduced in size in passing up the inflorescence. The two lowermost lateral spikes are more or less long-stalked, and their bracts are placed towards the upper end of the axis, while the uppermost lateral spike has its bracts nearly in the axil of the supporting bract of the main axis. All the lateral spikes begin with a short bladeless prophyllum in the axil between the main axis and the branch. The number of bracts immediately supporting the spikes varies from two to four. Each spike bears 4—6 (perhaps sometimes more) flowers placed at some distance from each other; the axis is continued into a horn-like process above the uppermost flower (which consequently is lateral like the other ones).

In *Posidonia oceanica* it is stated that the uppermost flower of each spike is male while the others are hermaphrodite. I have not had flowering material of *P. australis* at my disposal, but to judge from the fruiting specimens all the flowers seem to be hermaphrodite in this species (see Fig. 20). There is no perianth. The broad connectives of the three sessile anthers are persistent on the fruit. Their shape is somewhat variable, being shorter or longer ovate-lanceolate with a broad base and a more or less obtuse apex (not nearly so acute and pointed

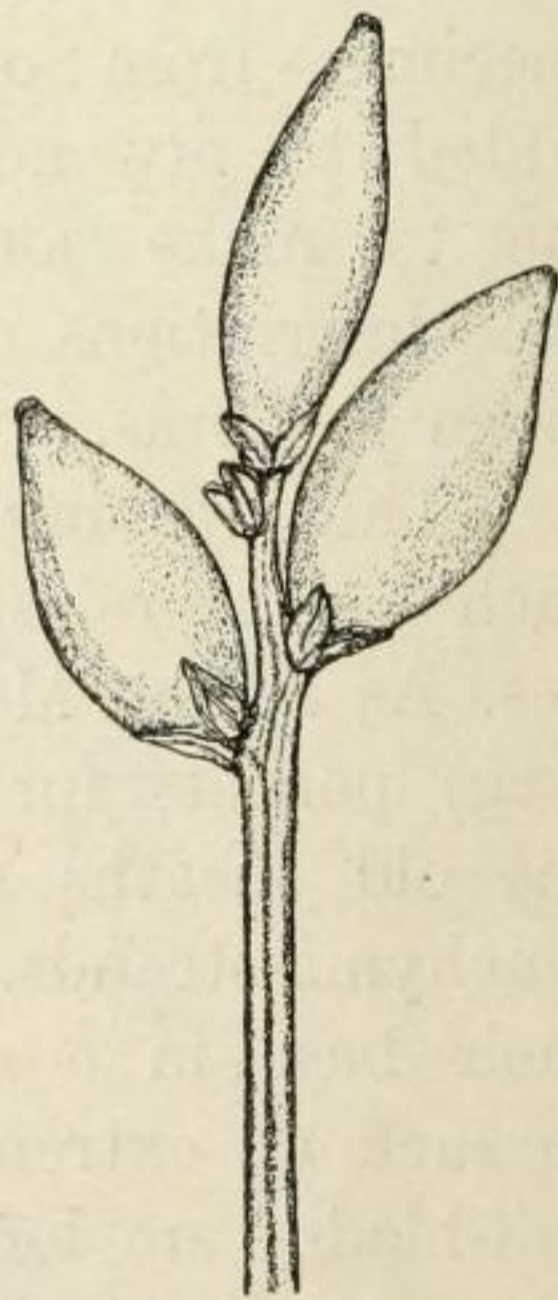


Fig. 20. *Posidonia australis*, from Geraldton. A lateral fruiting spikelet. (Nat. size).

as in fig. 12D of "Das Pflanzenreich", IV 11, p. 37); they differ considerably from the connectives of *P. oceanica* which are broadly obovate-cordate with a long mucro and as a rule are denticulate at the base of the mucro. On their outer face there is a keel on which the pollen sacs were placed, but these are thrown off after flowering (Fig. 21*a*). The base of the fruit is fringed by the persistent connectives as by a cup-shaped perianth (Fig. 20).

The female organ consists of one sessile carpel terminating in a sessile stigma which is said to be lobed (F. v. MÜLLER (1868): "stigmatē sessili . . . inæqualiter in lobos 3—4 acutos fissō"; BENTHAM gives (1878): "a thick 2- to 4-lobed stigma"). In fruiting specimens the stigma is still discernible as a small, somewhat irregular knob. The fruits (Fig. 20) are oblique-ovoid or ovoid-lanceolate, with a fleshy pericarp; the colour is pale or yellowish olive-green, and the dimensions are: length 20—27 mm, breadth 8—10 mm. At maturity the fruits become detached, rise to the surface of the water and float owing to the lacunose aërenchyma of the fleshy exocarp. This part of the pericarp splits irregularly from the base into two or three lobes (Fig. 22*a*), so that the "stone" drops out and sinks to the bottom as it is heavier than water. The irregular dehiscence of the fruit is comparable of that of the walnut (*Juglans*). The "stone" has no real hard endocarp, only a thin, almost membranous cover for the embryo. The latter protrudes at the apex splitting the membrane into two or three lobes and leaving the way open for the plumule (Fig. 22*d* and *e*). No seed-testa is discernible in the ripe fruits; it has, probably, been absorbed during the development of the fruit. The embryo is large and highly differentiated (Fig. 22*f*); it consists of a thick, starch-containing central body (the hypocotylous axis) and a plumule (Fig. 21*b* and *c*). Probably the main root does not develop much; it is seen as a tap at the lower end of the central body. The first adventitious root appears at an early stage at the base of the plumule, where even in unopened fruits a small protuberance indicates its position (see Fig. 21*c*).

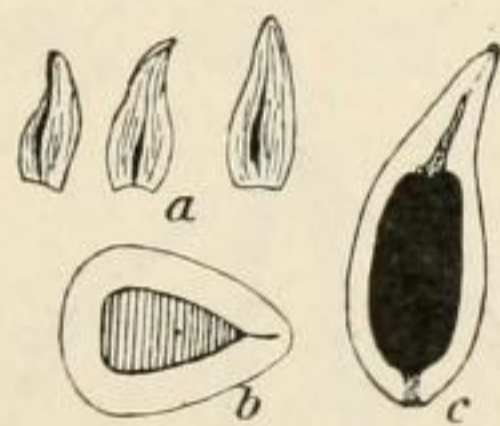


Fig. 21. *Posidonia australis*. *a*, Connectives of the anthers, pollen sacs thrown off (about $\frac{2}{1}$ nat. size). *b*, Transverse section of a fruit (about nat. size). *c*, Longitudinal section of a fruit ($\frac{2}{3}$ nat. size).

This description of the fruits and my notes on their dispersal show that they are adapted for distribution by means of water. The same is the case with regard to the Mediterranean species, as appears from the publications of CAULINUS (l. c.), GERMAIN

DE SAINT PIERRE (l. c.) and others. In this respect the genus *Posidonia* differs from most of the other sea-grasses, since floating of the reproductive organs is a very rare phenomenon amongst them (cf. *Cymodocea antarctica*).

The Mediterranean species (*P. oceanica*) is very like our Australian one, still it differs in several points as regards the inflorescence, the flower and the shape of the fruit, as well as in the structure of the leaves. *P. oceanica* is said to flower and set fruits only very rarely, while it appears that the Australian species flowers more regularly, and the enormous masses of fruits which I found both at Carnarvon and especially at Geraldton, show that the species set fruits in abundance, at least periodically.

At what time it flowers is not known with certainty, but to

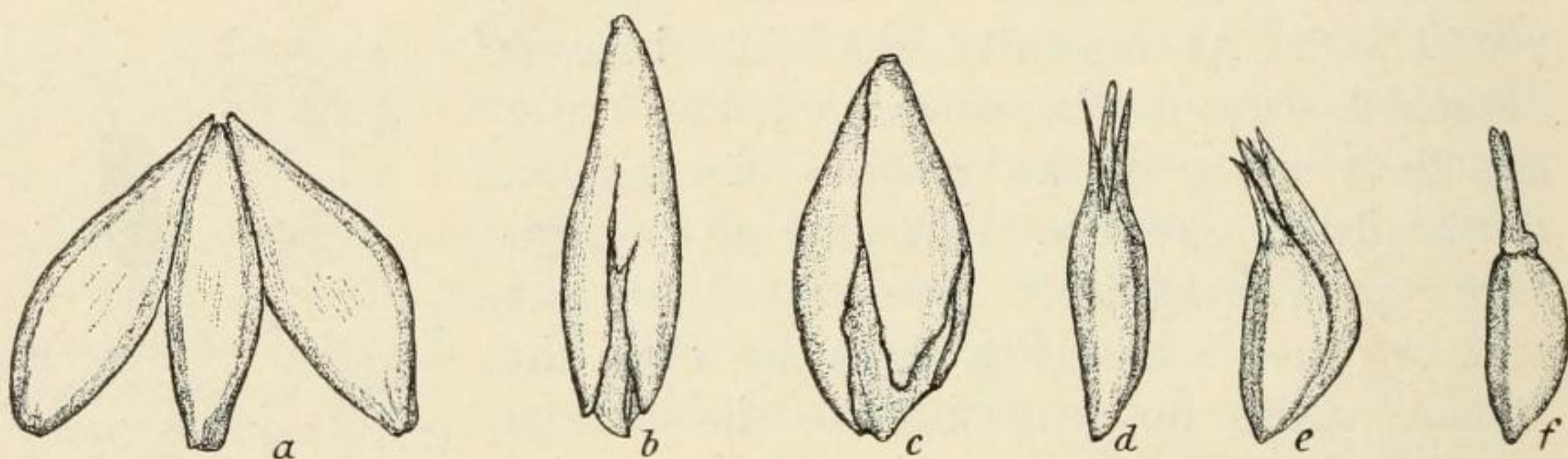


Fig. 22. *Posidonia australis*, from Geraldton. *a*, The irregularly three-lobed exocarp opened. *b* and *c*, Two different fruits, showing the splitting of the exocarp beginning at the base. *d* and *e*, "Stones" of *b* and *c*; the plumule protruding at the apex. *f*, Embryo (of *e*). (About $\frac{5}{4}$ nat. size).

judge from analogy with *P. oceanica*, which flowers in the autumn and ripens its fruits in the next spring, the flowering of *P. australis* should take place during the autumn of the southern hemisphere, i. e. in March—May, and the fruits should ripen in the spring, i. e. September—November; the latter supposition is confirmed by the fact that I collected the ripe fruits during the last days of October.

I hope that some Australian botanist will be able to study on the spot the flowering of this species and the development of the fruit, which has several interesting points still unsolved (e. g. the fate of the coats of the ovule).

Posidonia sp.

I found at Carnarvon, besides the typical broad-leaved *P. australis*, some narrower leaves like those of a broad-leaved *Zostera*.

They were very long; their apex was rounded, not truncate, and they had a much stronger and thicker consistency than the typical ones. I could not find any shoot of this peculiar sea-grass, only the long leaf-blades the bases of which showed that they were thrown off from the sheaths. Two intact leaf-blades were 80 and 105 cm long (thus exceeding *P. australis*, the longest leaf-blade of which was 65 cm). The breadth of the leaves also differs:

<i>P. australis</i>	<i>P. sp.</i>
6—11 mm	3—5 mm
(average of 10 leaves: 8.1)	(average of 6 leaves: 4)

In transverse section (Fig. 23) the aberrant leaves differed in several respects from the leaves of the typical *P. australis*. The epidermal cells have much thicker walls and they are elongated perpendicularly to the surface. The sclerenchyma-strands are more numerous, and while in the typical *P. australis* the strands are practically restricted to a subepidermal layer (besides the few scattered in the septa), in this case they are also common in the outer parts of the mesophyll inside the subepidermal layer. Other interesting points are that the lacunæ in the mesophyll are much narrower than in typical *P. austr.*, and that the ordinary cells of the mesophyll are filled with large starch grains. I have never before met with this rich occurrence of starch in the mesophyll of any sea-grass.

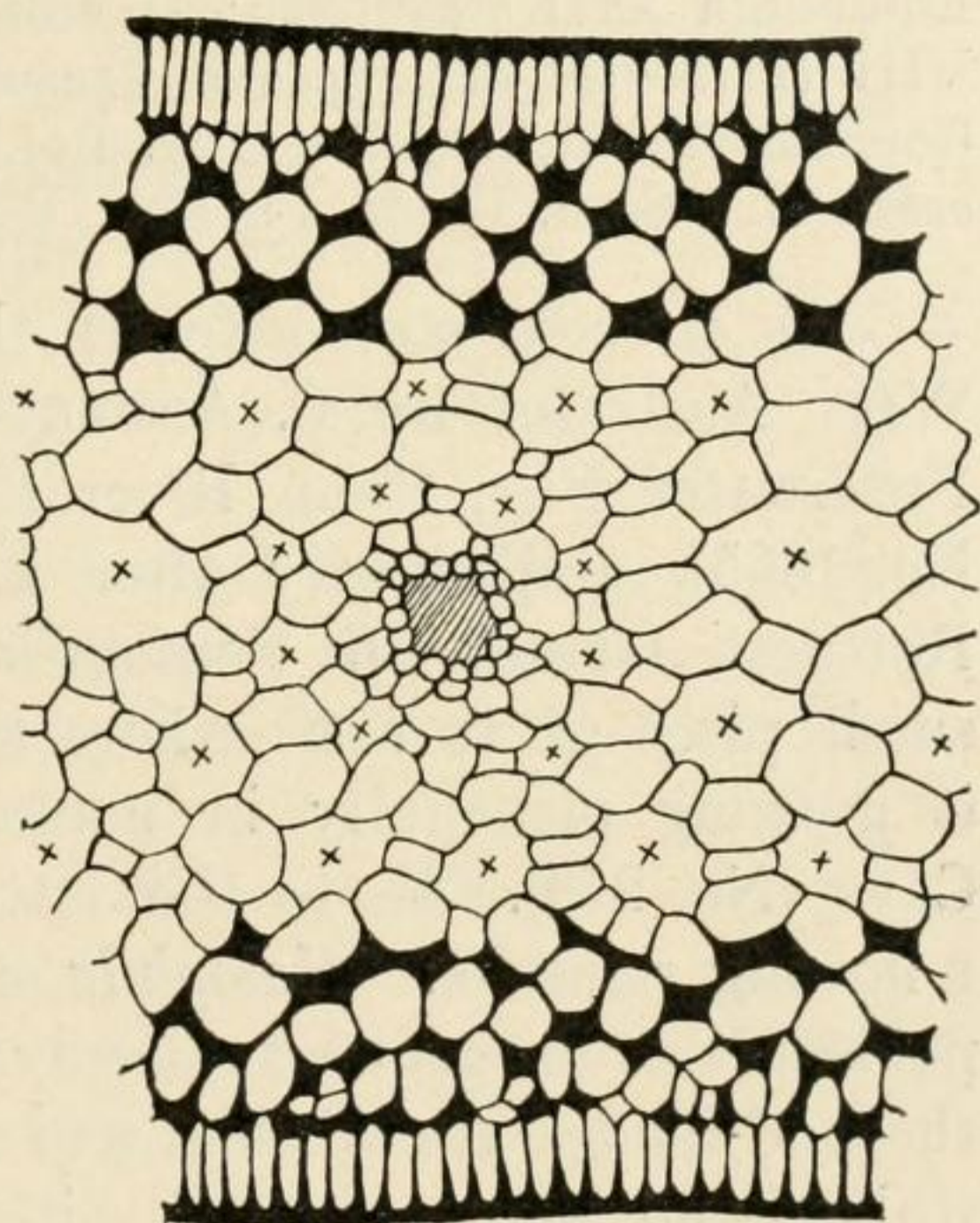


Fig. 23. *Posidonia sp.*, from Carnarvon. Transverse section of a leaf-blade. For explanation see fig. 18, with which it is comparable. (About $150/1$ nat. size.)

Apart from these differences, the structure of the leaf points to *Posidonia*, and the question is, strictly speaking, whether the aberrant leaves belong to some modification of *P. australis*, or represent a new hitherto unknown species of the genus. The insufficient material at hand does not justify any definite decision at present. I have mentioned it here only to draw the attention of some later observer to this problem which seems worth solving.

Fam. II. Hydrocharitaceae.

Two species of *Halophila* are found in the sea off the West Australian coast; both of them also occur on the East coast of the continent. They differ considerably from each other in external appearance and both are quite unlike the ordinary ribbon-leaved type of sea-grasses.

1. *Halophila ovalis* (R. Br.) J. D. Hooker,

Flora Tasman. II (1860) 45; Ascherson, in Linnæa 35 (1867) 173; Bentham, Fl. Austral. VII (1878) 182; I. B. Balfour, in Transact. & Proc. Roy. Soc. Edinburgh XIII (1879) 290; *H. ovata* F. v. Müller, Fragm. Phytogr. Austr. VIII (1872—74) 219; Second Census Austr. Pl. (1889) 193, et aliis; non Gaudichaud, in Freycinet Voy. Bot. (1826) 430, tab. 40, fig. 1; *Caulinia?* *ovalis* R. Brown, Prodr. Fl. Nov. Holland. (1810) 339.

As already stated (p. 7) this species was first recorded for West Australia by C. ANDREWS (l. c., 1902), who found it in Freshwater Bay, Swan River Estuary in 1902 (Fl. of W. Austr., No. 1065), and shortly after it was discovered on the coast of Rottnest Island, off Fremantle (by MARKWELL). I collected a small piece of it cast ashore at Geraldton (No. 272) and found it growing plentifully in pools on the coast off the Yallingup Cave (No. 273). As to the latter record my diary contains the following remarks: "*Halophila ovalis* inhabited mostly the smaller pools. It often grows so deeply imbedded in the sand, that only the leaf-blades are visible, and in this case the leaves are long-stalked and the shoot-apex with the young leaves is quite hidden, pale-yellow and etiolated. No flower was found". The leaf blades were 24—27 mm long, 10—12 mm broad, and the stalk attained to 40—45 mm long.

The four localities now known are all along the southern part of the west coast of West Australia, and seem to indicate a common occurrence of the species.

H. ovalis is widely distributed along the coast of the Indian and Pacific Oceans, and has the widest area of occurrence of all the *Halophila* species. Around Australia it is known from West Australia, South Australia, Tasmania, Victoria, New South Wales and Queensland, and, probably it occurs on all parts of the coast where the conditions permit it to grow.

The specimens collected and also all the other specimens seen from Australia are rather uniform: vigorous and robust with long and large leaves (the blades are 25—50 mm long);

they may be referred to the larger variety which is called *Lemnopsis major* by H. ZOLLINGER (Verzeich. der im indisch. Archipel in den Jahren 1842—48 gesamm. etc. Pflanzen (1854) 74; quoted from Ascherson (1867) 172).

The species seems to vary very much with regard to the size and shape of the leaves, and perhaps some of the more divergent forms are really independent species. But until flowering and fruiting specimens are found in greater abundance than hitherto, it is better to follow ASCHERSON (1867, 200), who united *H. ovalis*, *H. madagascariensis* Steud., *H. major* (Zoll.) Miq., *H. lemnopsis* Miq. (= *Lemnopsis minor* Zoll.) into one species. With regard to *H. ovata* Gaudichaud (l. c.), I have elsewhere (OSTENFELD, in Philippine Journ. of Sc., IV No. 1, Sect. C. Botany, 1909, 67) shown that it is a good species, at present only known from the Philippines and Mariannes.

The morphology of *H. ovalis* has been thoroughly investigated by I. B. BALFOUR (1879), and later the structure of the leaves was studied by C. SAUVAGEAU (Journ. de Botanique IV, 1890, 293).

Quite recently H. SOLEREDER¹ has examined the structure of the leaves of *H. ovalis* and other species, and has found some interesting features which were overlooked by the earlier authors: The central area of the outer walls of the epidermal cells is thinner than the remaining parts, and when seen from above, a circular spot is more or less distinctly visible. This observation I can corroborate after examination of my West Australian material of *H. ovalis*. SOLEREDER's other discovery is not quite so convincing: The leaves consist only of the two epidermal layers except where traversed by the veins. Between these two layers SOLEREDER found, singly or a few together, some idioblasts which he calls "Schlauchzellen". My material showed here and there smaller cells between the two epidermal layers, but they did

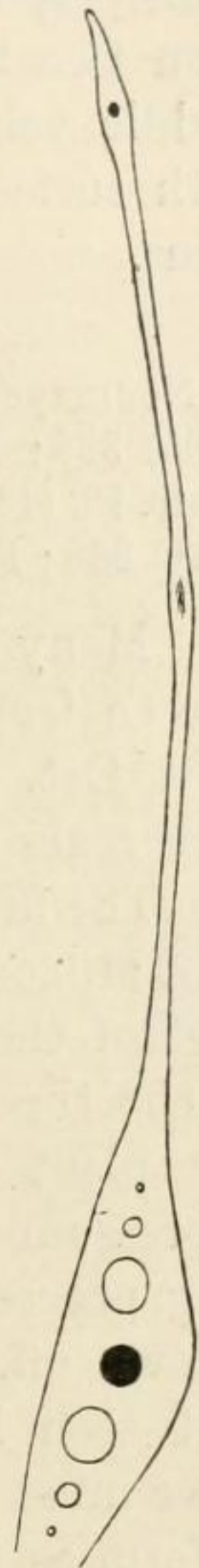


Fig. 24. *Halophila ovalis*, from Yallingup Cave District. Transverse section of part of a leaf. The black dots are the veins (the big one the central vein) and the circles the air chambers. (About $\frac{20}{1}$ nat. size).

¹) H. SOLEREDER: Systematisch-anatomische Untersuchung des Blattes der Hydrocharitaceen. — Beih. Botan. Centralbl., Bd. XXX. 1. Abt. 1913, pp. 24—104.

not differ in any important point from the other cells, and to me they appear to be only cells produced by a more or less irregular tangential division of the epidermal cells. Around the veins, especially around the middle vein, the leaves are more than two layers thick, and air chambers are present around the middle vein (Fig. 24). The lateral walls of the epidermal cells of both surfaces are much undulated, less so above and under the veins.

2. *Halophila spinulosa* (R. Br.) Ascherson,

in Neumayer, Anleit. z. wiss. Beobacht. Reisen, 1. ed. (1875) 368; 3. ed. (1905) 395; Bentham, Fl. Austr. VII (1878) 183; F. v. Müller, Sec. Census Austr. Pl. (1889) 193; *Caulinia? spinulosa* R. Brown, Prodr. Fl. Nov. Holland. (1810) 339; F. v. Müller, Fragm. Phytogr. Austr, VIII (1872—74) 219 and 283.

Many specimens of this rare species, which was not before known from West Australia, were found cast ashore at Carnarvon (31st Oct. 1914; No. 274); some specimens were sterile, others bore male flowers (Fig. 25).

The first more complete account of this species was given by F. v. MÜLLER in Fragm. VIII, 219. He described the vegetative part of the plant and the fruit, but owing to a misinterpretation of the thread-like apical prolongation of the fruit, he believed that the plant had “stylo setaceo stigma simplex dimidio crassius depressum gerente”. No doubt he had only the fruit with its long process before him, after the stigmas had withered and were thrown off. His “depressed stigma” is the rudimentary perianth, first seen by I. B. BALFOUR (l. c.) in *H. ovalis*; and arising from it we must imagine the stigmas — probably three in number and filiform as in other *Halophila* species. The above misinterpretation led F. v. Müller to suggest a separate genus for the species in question, but in an addition to the same volume (VIII) of his “Fragmenta” he places it (p. 283) “juxta Halophilam”.

A good description of specimens from the same collection was given by BENTHAM in Fl. Austr. (l. c.).

F. v. MÜLLER did not find any male flower, and I have seen no description of it at all. BENTHAM (l. c.) says: “Male flowers unknown”, while ASCHERSON (1905, 395) mentions “die nur unvollkommen bekannte männliche Blüte”, but gives no other information about it. My material contained a number of shoots with male flowers and thus enables me to give a full description of their appearance. The vegetative parts of the plant also show several points of interest which are included in the following description of the whole plant.

As in other species of *Halophila*, there is a transversally creeping, thin and fragile rhizome. On its younger parts two membranous and early deciduous amplexicaul scale-leaves are present at each node, from which an erect assimilative shoot and an unbranched root arise. The assimilative shoots attain to 17—18 cm in length, and bear numerous pairs of foliage leaves. These

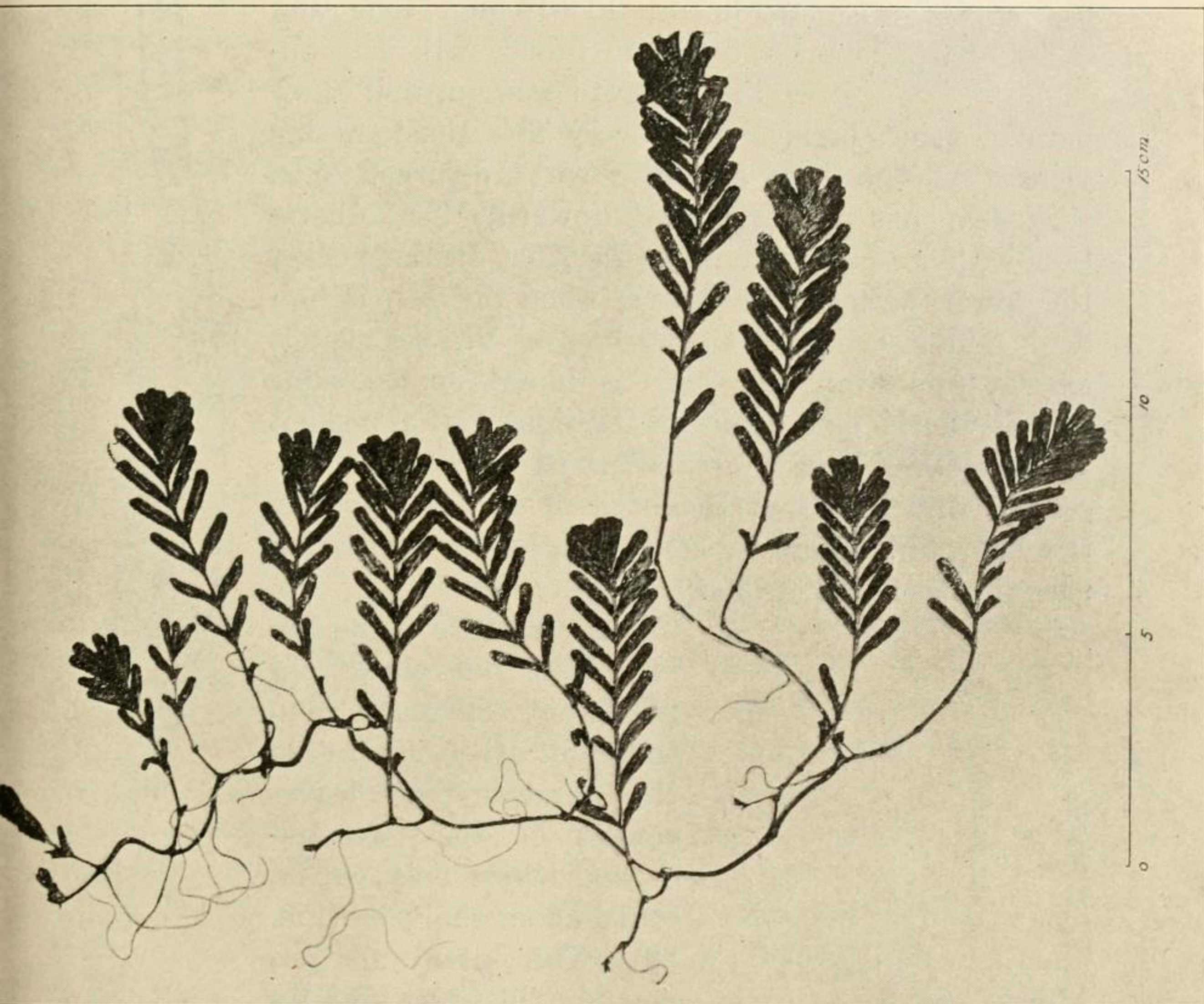


Fig. 25. *Halophila spinulosa*, from Carnarvon. A Flowering male plant with creeping rhizome and erect assimilative shoots. The flowers are hidden in the upper parts of some of the assimilative shoots. (Photo. of herbarium material).

leaves are opposite and distichous, and are turned in such a manner that they stand edgewise; therefore the whole shoot is quite flat. Such a distichous arrangement of opposite leaves is rare, though there is a somewhat similar arrangement in *Potamogeton densus* and in *Euphorbia buxifolia* (cfr. E. WARMING, in Bull. Acad. Roy. sc. et lettr. de Danemark, pour l'année 1896).

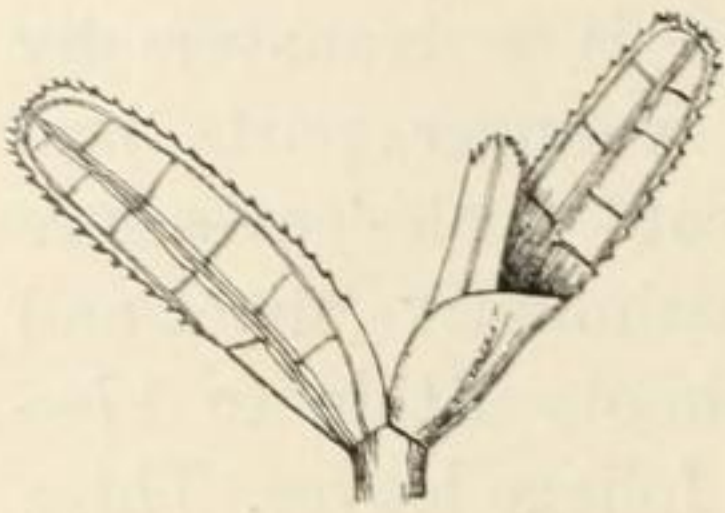


Fig. 26. *Halophila spinulosa*. A pair of leaves one of which encloses a male flower bud. ($\frac{3}{2}$ nat. size).

The shoots of *H. spinulosa* (see Fig. 25) have a superficial (ecological) resemblance to the assimilative shoots of some species of *Caulerpa* (e. g. *C. crassifolia*).

The leaves are broad-linear, 13—16 mm long and 3—4 mm broad, with a spinulose-serrate margin, and three parallel veins, besides some very fine anastomosing veins. At the base of the downward-turned side, each leaf has an ear-shaped upwardly bent dilatation with an entire margin (Fig. 26). In this pocket the lower part of the flower, when present, is hidden. The insertion of the two leaves of each pair is exactly opposite; the "ear" is found on the same side of all the pairs; thus on the right half of a shoot all the leaves have the ears turned towards the observer, while he sees the back of all the leaves of the left half. There is, consequently, no alternation as is the case with ordinary opposite leaves.

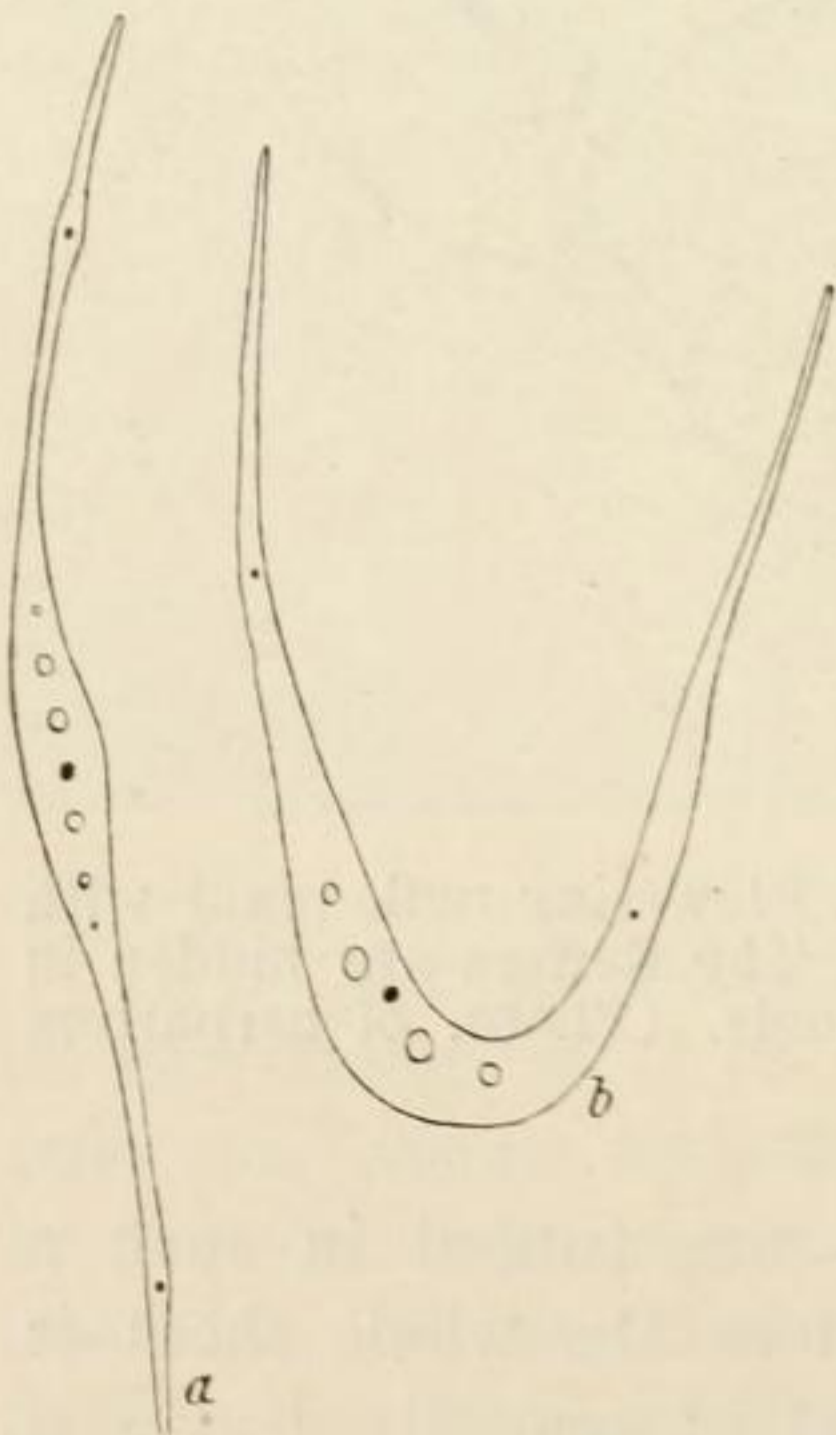


Fig. 27. *Halophila spinulosa*. Transverse sections of a leaf: *a*, at the middle; *b*, near the base. Air chambers are shown as circles, veins as black dots. (About $\frac{20}{1}$ nat. size).

The structure of the leaves¹ does not show any important difference from those of other species of the genus. The leaves consist of the two epidermal layers only, except round about the veins (Fig. 28). The outer walls are not undulating (faintly undulating on the outer side of the ear-shaped dilatation). Around the middle vein some small air channels are present. The spinulose margin is made up

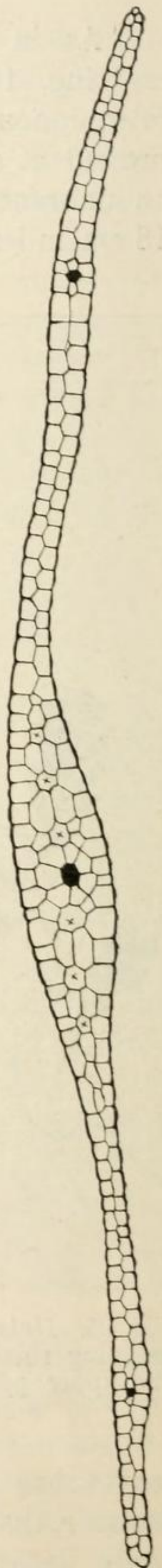


Fig. 28. *Halophila spinulosa*. Transverse section of a leaf. The veins are shown as black dots. *x* denotes air chambers. (About $\frac{50}{1}$ nat. size).

¹ Compare C. SAUVAGEAU, l. c. (1890) 294.

of one-celled acute teeth. A transverse section at the middle (Fig. 27 *a*) shows that the middle vein is somewhat nearer the one margin than the other. This obliqueness is more pronounced in a transverse section near the base where the ear-shaped part is met with (Fig. 27 *b*). Here the middle vein is found in the upper half of the clasping leaf-base.



Fig. 29. *Halophila spinulosa*. The apex of an assimilative shoot, twisted by the pressure of the male flowers. (About $\frac{3}{4}$ nat. size).

The first leaves of an assimilative shoot are transitional in form between the scale-leaves of the rhizome and the foliage leaves. The pairs are somewhat distant in the lower part of the assimilative shoot; further up they are more closely placed, partly covering one another.

Probably the assimilative shoots are comparatively short-lived, while the creeping rhizome steadily renews itself by new shoots, the older dying away behind.

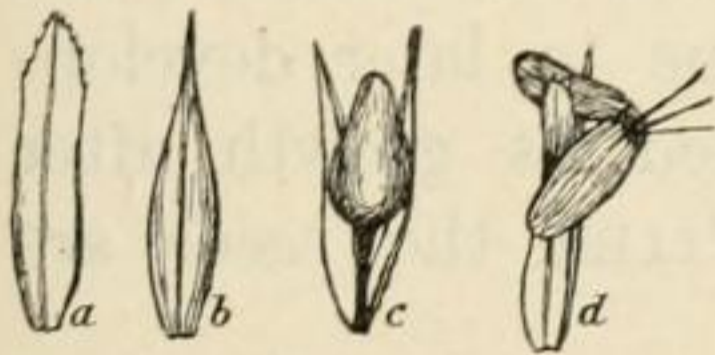


Fig. 30. *Halophila spinulosa*. Male flower. *a* and *b*, outer and inner involucre leaves; *c*, flower bud with involucre; *d*, open flower with emptied anthers and backwards bent perianth. (About $\frac{3}{2}$ nat. size).

Towards the apex of some assimilative shoots male flowers were present in the axils of the leaves, and owing to their presence the regular edgewise arrangement of the leaves is somewhat disturbed. The flowers press the leaves apart, and by this pressure the upper part of the shoot becomes more or less spirally twisted (Fig. 29).

The male flower is placed solitary in the axil of an ordinary foliage leaf, and is enclosed in a two-leaved involucre (Fig. 30). The outer involucre leaf is nearly two-keeled (one acute and one blunt angle) with a flat back; towards its apex it is somewhat spinulose-serrate (Fig. 30 *a*). The inner involucre leaf encloses the flower bud; it is one-keeled and has a long-pointed apex (Fig. 30 *b*). The flower itself consists of three perianth leaves which, when they open, bend backwards and force the edgewise-set leaf a little aside. The perianth leaves are obtuse ovate-oblong faintly one-nerved. Inside the peri-

The male flower is placed solitary in

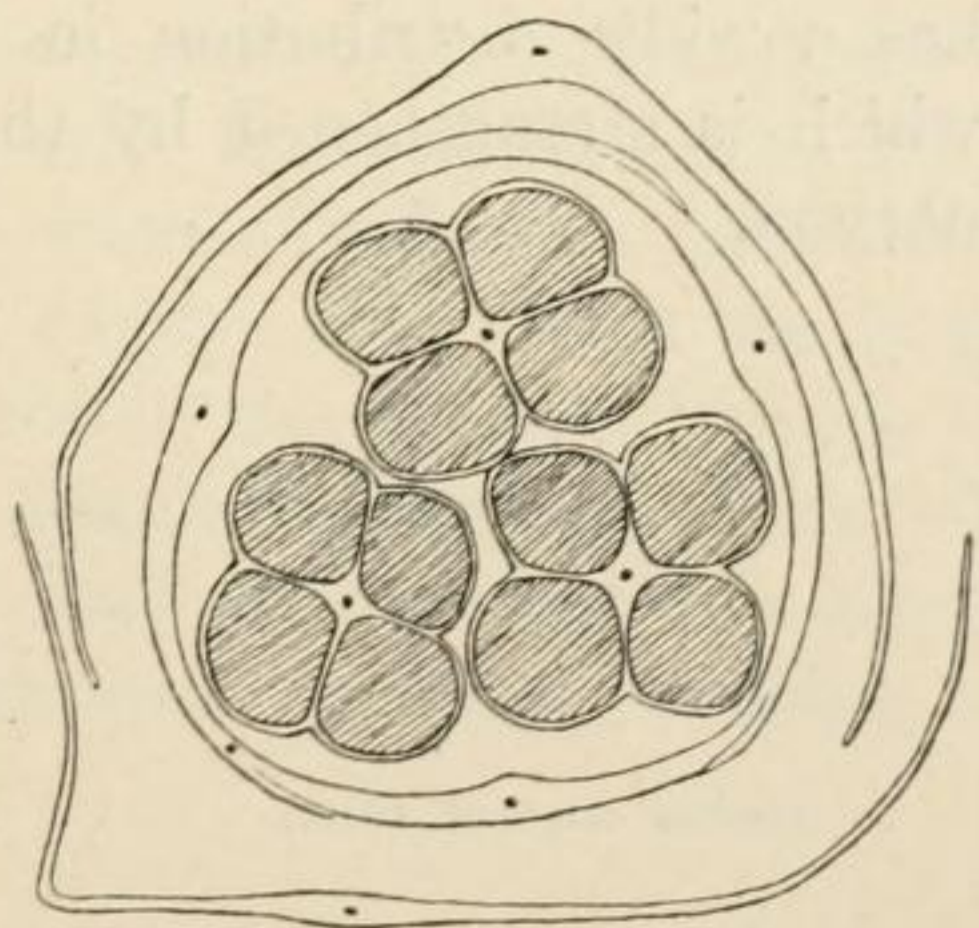


Fig. 31. *Halophila spinulosa*. Transverse section through a male flower, showing the two involucre leaves, the three-leaved perianth and the three anthers. (About $\frac{25}{1}$ nat. size).

anth are the three four-locular sessile anthers (Fig. 31) which are cast off when emptied, but the central strands remain for some time (Fig. 30*d*). The pollen is moniliform (confervoid) as in other *Halophila* species (see I. B. BALFOUR, fig. 52); the cell walls are gelatinous and swell in water.

The female flower has the same position, and is enclosed in two involueral leaves of the same shape as in the male flower. It consists of an ovoid ovary with a long filiform process on the apex of which the rudimentary perianth and the three filiform stigmas are supposed to be placed (cf. p. 40). I have seen herbarium specimens of female plants in the collections of the Imp. Botan. Garden of Petrograd and of the Roy. Botan. Garden, Calcutta, both from Port Denison, Queensland, and both with young fruits. The fruits were placed below the middle of the assimilative shoot, not at the apex as in the case of the male flower. But this difference may be due to later development, the assimilative shoot having continued its growth after the flowering time. According to F. v. MÜLLER the seeds are globose, transparent and smooth.

The features given above indicate that *H. spinulosa* does not differ from the other species of the genus in floral characters. As regards the vegetative parts, the rhizome and the shoot-formation follow the type, but the numerous opposite and distichous leaves are peculiar.

The species is known from several places on the north and east coasts of Queensland, from the Philippines, and I have also seen specimens from Java (Andjer, leg. Andrea, 1868). Probably it has a wider distribution in the Melanesian region, a suggestion which is strengthened by the discovery of its occurrence at Carnarvon.