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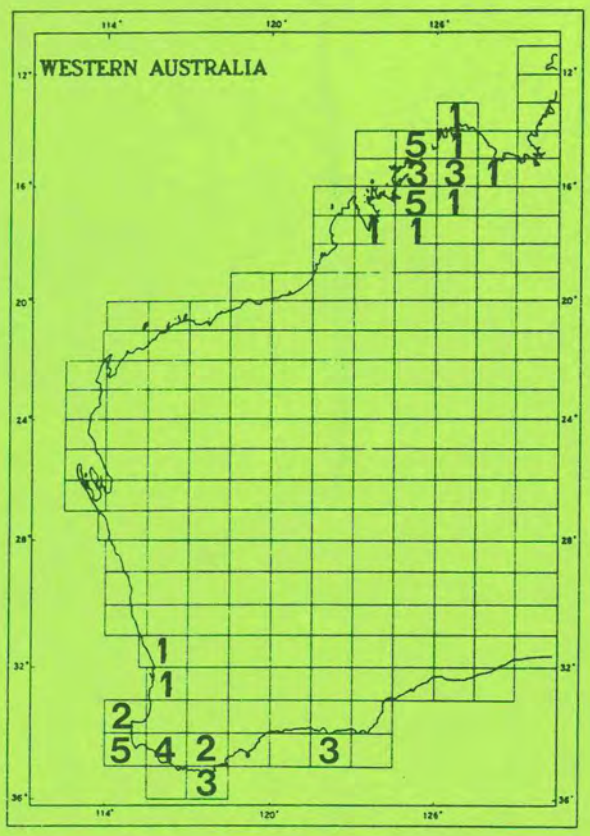

Species Diversity in the Xyridaceae

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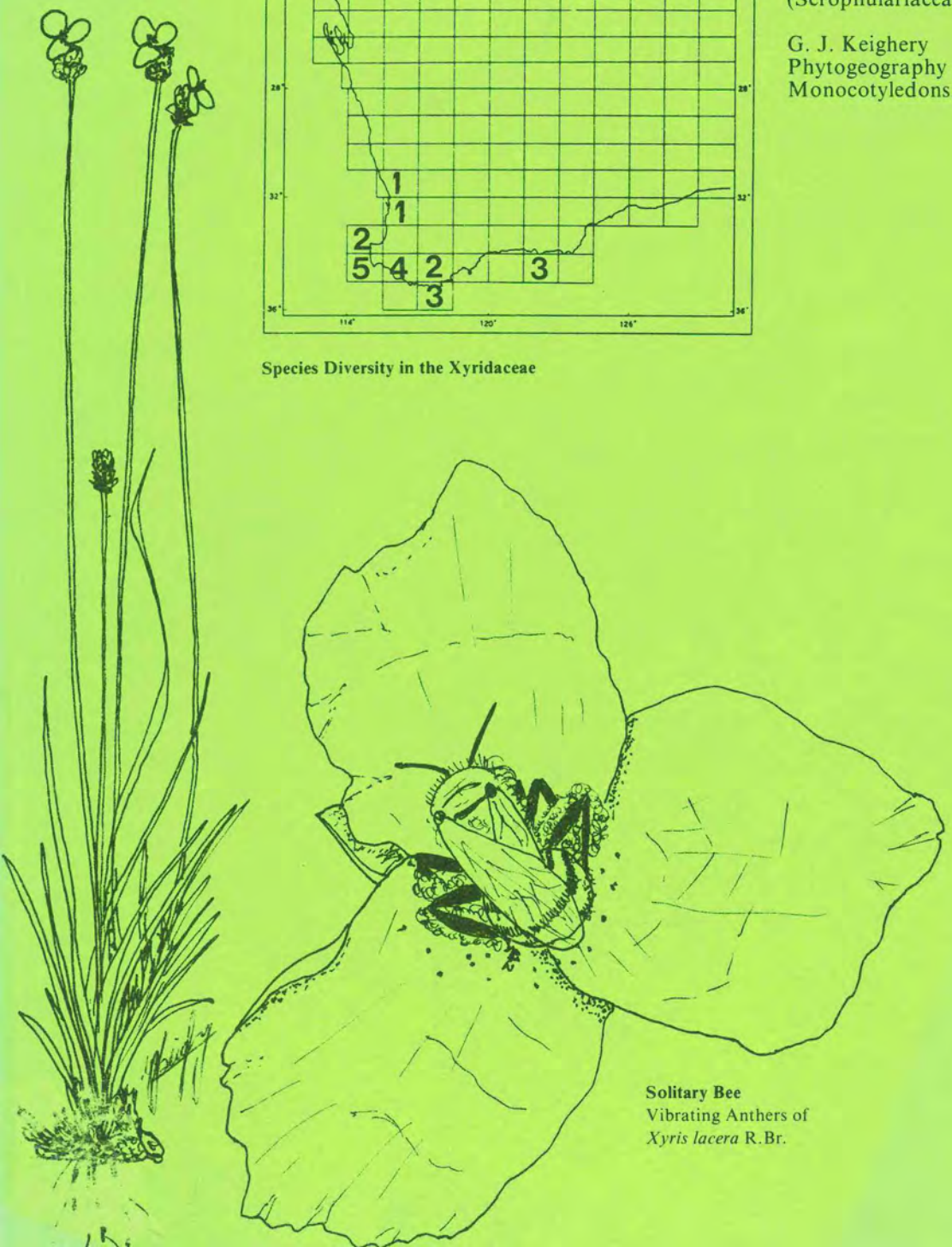

Solitary Bee
Vibrating Anthers of
Xyris lacera R.Br.

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Phytogeography of Cassia L. (Caesalpiniaceae) in Western Australia*

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Abstract:

Distributions of 36 species of the genus Cassia occurring in Western Australia were plotted onto State maps divided into 1^{o} latitude x 1.5^{o} longditude grids. The number of species per grid were plotted and found to be highest in the upland desert regions of the Pilbara, Ashburton and the southern margins of the Northern Botanical Province.

*Part IV of the series Biology of Western Australian Leguminosae.

Introduction

During the 1978 International Legume Conference, it was decided that a second meeting should be held to discuss aspects of the biology of this vast group of flowering plants. A second conference is to be held on this subject in Missouri in 1986, and these papers are designed to add to the information on the phytogeography of Western Australian Legumes. Some aspects having already been published (Keighery, 1981,a ; 1981,b ; and 1984,a)

These three related papers discuss aspects of the phytogeography of the Legumes of Western Australia.

The Leguminosae of Western Australia are composed of all three major groups : Mimosaceae (6 genera and ca 496 species) ; Caesalpiniaceae (11 genera and 53 species) and Fabaceae (70 genera and ca 437 species).

Recently the genus Acacia has been subject to phytogeographical analysis by Hopper and Maslin (1978) and Maslin and Hopper (1982). These papers on Cassia, the Fabaceae and naturalized peas are to complete phytogeographical studies on this group.

Cassia L. is a very large genus of over 500 species composed of three distinct subgenera or genera (Cassia L. (30 spp) ; Senna Mill. (ca 240 spp) and Chaemacrista Moench. (ca 250 spp)). Most Western Australian species are members of the subgenus Senna (Irwin and Barneby, 1981), especially section Psilorhegma. Most of the 36 species in Western Australia are confined to arid and semi-arid regions.

Materials and Methods

Distribution data for species included in the present study were derived from specimens held in the Western Australian Herbarium (PERTH) and Kings Park (KPG). The distribution of each species was recorded on a map of Western Australia subdivided into a 1^{o} latitude by 1.5^{o} longditude grid. This grid corresponds to the 1:250,000 topographic survey maps of the Division of National Mapping, Department of Natural Resources. This system covers the state of Western Australia in 179 grids, and each cell has a numeric code number and also a geographic reference name.

Maps were compiled for all taxa of Cassia, Labichea and Petalostylis and are presented in Keighery (1984,b).

Only the genus Cassia is large enough to permit an analysis of phytogeographical patterns.

Results

Ranges of members of the genus Cassis are given in Table 1.

Table I : Geographic Ranges of species of the genus Cassia.

General	Northern Bot. Prov.	N.B.P./Eremaean	Eremaean	South West/Eremeaean
1	8	15	6	6

Most species are wide ranging, and none are confined to the South Western Botanical Province.

A compilation map of species diversity is presented in fig. 1. The greatest species diversity is clearly found in the upland regions of the Pilbara, Ashburton and the southern margin of the northern botanical province. Cassia is absent from the forest regions of southern Western Australia, where it is replaced by members of the genus Labichea.

Discussion

Similar patterns of species diversity are found in many other unrelated groups which have diversified in the desert.

Monocotyledons

Triodia (Burbidge 1953, Jacobs, 1982 and Keighery 1979) have noted that the highest species concentrations occur in the Pilbara and Ashburton areas of the desert.

Dicotyledons

Amarantaceae, Keighery and Marchant L982) noted that the genus Ptilotus has the highest species diversity occurs in the upland desert regions.

Carophyllaceae, the genus Polycarpaea (Keighery, 1983,a) has the highest species concentrations in the Pilbara region of the desert.

Mimosaceae ; the genus Acacia (Maslin and Hopper, 1982) has the highest species concentrations marginal to the sand deserts on the mountains and tablelands of the Pilbara, then the central Australian ranges. Zygophyllaceae, Keighery (1982) found the highest species concentrations is associated with the Pilbara region.

Solanaceae, Symon (1982) noted that the greatest species concentrations are marginal to the sandy deserts on the central Australian ranges in the Western Australian/Northern Territory borders. Nicotiana (Horton, 1981) is similar but is most diverse in the Pilbara region.

Goodeniaceae, Keighery (1983,b) noted that both the family and Goodenia are also species rich in the desert uplands, and especially the Pilbara.

Of course not all groups that have penetrated the desert show this pattern. Many are largely confined to saline soils (or calcareous soils) and are species diverse at the edges of the desert where such habitats are common eg : Atriplex (Parr Smith, 1982) ; Frankenia (Keighery and Cutri, 1983), Gunniopsis (Chinnock, 1983). Similar patterns are found in other groups which prefer loamy soils eg : Dodonaea (West, 1982).

However, consistently the major desert groups (Acacia, Ptilotus, Solanum and Triodia) display highest diversity in the desert uplands and ranges not on the sandy or calcareous soils. Cassia can be noted as conforming to this pattern.

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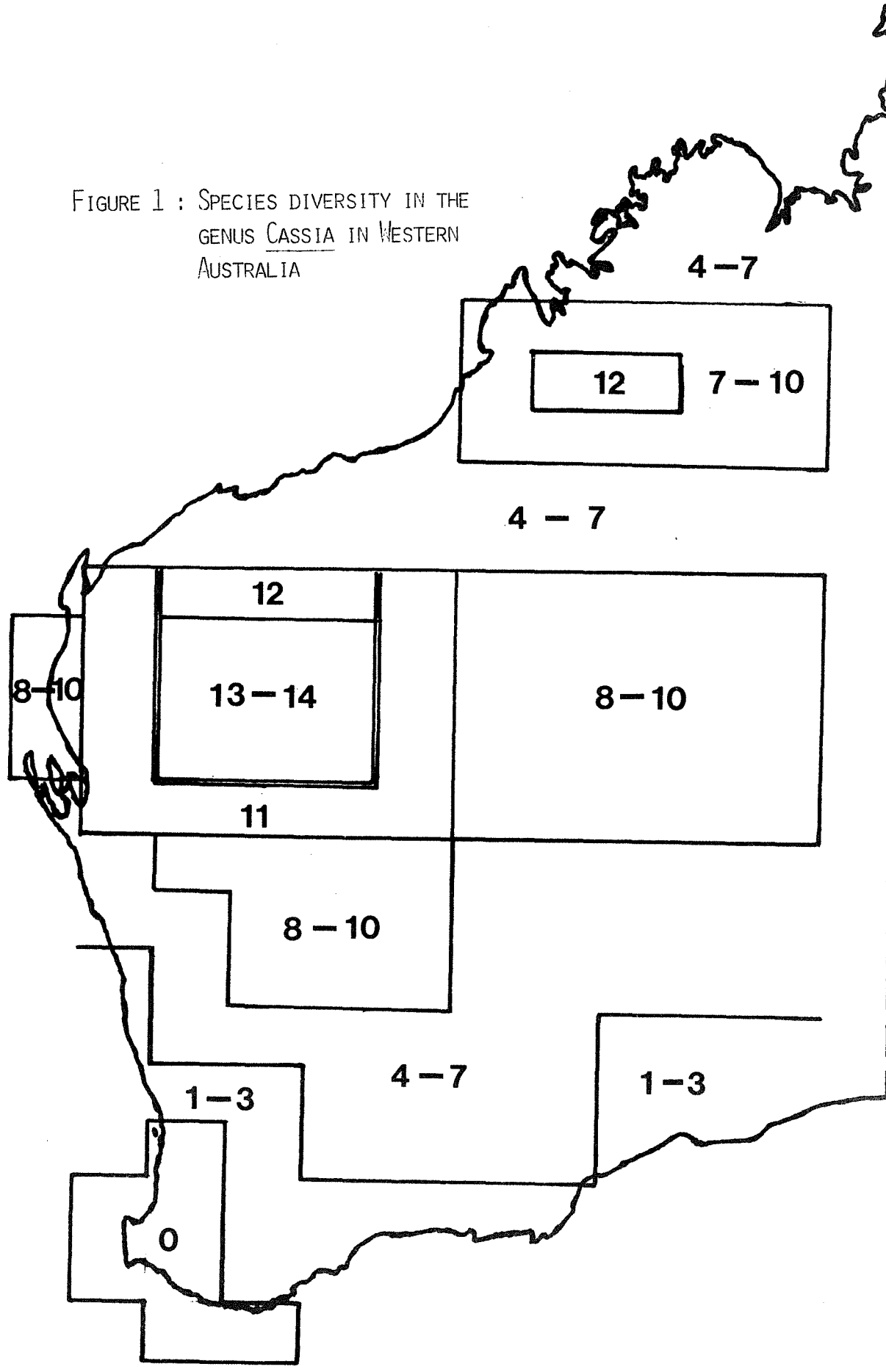
FIGURE 1 : SPECIES DIVERSITY IN THE GENUS CASSIA IN WESTERN AUSTRALIA



Phytogeography of the Fabaceae of Western Australia*

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Abstract:

The Fabaceae of Western Australia display several distinct biogeographical trends. A low rate of generic endemism, but high specific endemism in Southern Western Australia. A distinctive bimodal (Kimberley-Pilbara) diversity map for tropical genera. Temperate genera have diversified in the interzonal region, but the southern coastal heathlands appear to hold the greatest diversity of species for most genera.

* Part V of the series Biology of Western Australian Leguminosae

Introduction:

The Fabaceae of Western Australia comprise 437 species distributed in 70 genera (Keighery 1981, 1982). The family is a major component of the shrub flora of temperate Western Australia (other major families being the Myrtaceae, Proteaceae and Epacridaceae) and an analysis of the distribution patterns of the component genera should add to current biogeographical theories on the evolution of Western Australia's Flora.

Materials and Methods:
Locality data for species were obtained from Herbarium specimens housed at the Western Australian Herbarium (PERTH) and Kings Park and Botanic Garden (KPG). In several groups this information has been supplemented by field surveys. The distribution of each species was plotted onto a map of Western Australia which was divided into 1^{o} latitude x 1.5^{o} longditude grid squares. Maps of all currently recognized species (excluding Daviesia) have been published in Keighery (1981, 1982). Daviesia is currently under revision, and was unable to be considered in this study.

Results
Table one lists all known genera of the Fabaceae occurring naturally in Western Australia, the number of species present in Western Australia, the extra Western Australian distribution of the genus (if any), and the total number of species in the genus.

From this table it is immediately apparent that few genera are endemic to Western Australia (Brachysema (5species); Jansonia (1); Cupulanthus (1); Euchilopsis (1); Erichsenia (1) and Latrobea (6)). Apart from Brachysema and Latrobea none of these genera have speciated in the region.

Specific endemism is low for tropical genera. This is generally true for other groups also, Beard (1969) estimated that 355 species of a known tropical (Kimberley Region) flora of 1445 species were endemic to the region (24% endemism). Data obtained for a review of upland regions of Western Australia (Hopkins et al, 1983) showed low levels for most groups:

Atylosia (Reynolds and Pedley, 1981) - 12.5% endemism.

Terminalia (Byrnes, 1977) - 15%

Eucalyptus (Chippendale and Wolf, 1981) - 21%

Solanum (Symon, 1981) - 62%

Cleome (Hewson, 1982) - 6%

Drosera (Marchant, 1982) - 0%

Apparently most groups (despite wide differences in life forms) show low rates of endemism, and that these endemics (especially in Solanum) are chiefly confined to the western margins of the Kimberley (especially to sandstone soils). Such endemics are generally recently derived species, related to species from the sub-humid sandstones of Arnhem Land which is now seperated from the western Kimberlies by the semi-arid Ord - Victoria basin.

In temperate Western Australia specific endemism in the Fabaceae is much higher, probably averaging 70-80% as revisions continue, eg : Templetonia (Ross, 1981) - 50%, Kennedia (Brittan and Silsbury, 1961) - 91% Temperate Western Australia is the centre of diversity for the genera Bossiaea, Aotus, Oxylobium, Chorizema, Sphaerolobium, Mirbelia, Gompholobium, Burtonia,

Table 1 : Western Australian Fabaceae Genera, Affinities and Distribution.

Tribe	Genera in W.A.	No. species in W.A.	Extra W.A. distribution	Total sp. in genus
Abreae				
	Abrus	1	tropics	17
Aeschynomeneae				
	Aeschynomene	1	tropics/subtrop.	150
	Cyclocarpa	1	tropics	1
	Zornia	4	tropics/subtrop.	80
Crotalarieae				
	Crotalaria	18	tropics/subtrop.	ca 600
	Rothia	1	Africa-Aust.	2
Desmodieae				
	Alysicarpus	3	Africa-trop, Aust.	25
	Desmodium	4	tropics/subtrop.	ca 300
	Dendrolobium	1	Asia-Aust.	12
	Dicerma	1	Asia-Aust.	1
	Uraria	1	old world tropics	ca 20
Galegeae				
Colutinae				
	Clianthus	1	Aust/N.Z.	2
	Swainsona	30	Aust/N.Z.	ca 50
Glycyorhizinae				
	Glycyrrhiza	1	Eurasia/America	ca 20
Indigoferae				
	Indigofera	15	tropics/subtrop.	ca 700
Bossiaeeae				
	Bossiaea	ca 40	temp. Aust	ca 40
	Goodia	1	temp. Aust	2
	Aenicophyton	1	Nth. Territory	1
	Hovea	6	temp. Aust	12
	Muelleranthus	3	N.T. - N.S.W.	3
	Plagiocarpus	1	N.T. - Qld.	1
	Ptychosema	2	Central Aust	2
	Templetonia	10	temp/arid Aust.	11
Mirbelieae				
	Brachysema	5	endemic	-
	Jansonia	1	endemic	-
	Bugesia	2	N.T.	3
	Leptosema	5	arid-trop. Aust.	10
	Cupulanthus	1	endemic	-
	Oxylobium	24	temp. Aust.	ca 25
	Chorizema	14	temp. Aust.	18
	Mirbelia	17	temp. Aust.	22/24

Mirbelieae					
	Isotropis	6	arid/temp.Aust		10/11
	Gompholobium	16	Aust./New Guinea	ca	25
	Burtonia	10	temp. Aust.	ca	12
	Jacksonia	38	Australia	ca	45
	Sphaerolobium	13	temp. Aust.		14
	Euchilopsis	1	endemic		-
	Viminaria	1	temp. Aust.		1
	Erichsenia	1	endemic		-
	Daviesia	ca 70	temp. Aust.	ca	80
	Aotus	9	temp. Aust.	ca	14
	Phyllota	3	temp. Aust.		5
	Gastrolobium	44	Australia	ca	45
	Pultenaea	27	temp. Aust.	ca	100
	Latrobea	6	endemic		-
	Eutaxia	8	temp. Aust.	ca	9
	Dillwynia	6	temp. Aust.	ca	15
Psoraleeae					
	Psoralea (Cullen)	20	Africa-Aust.	ca	35
Phaseoleae					
Erythrinae					
	Erythrina	1	tropics/subtrop.		108
	Mucuna	2	tropics/subtrop.	ca	100
Diocleinae					
	Canavalia	2	tropics	ca	50
	Galactica	1	tropics/subtrop.	ca	50
Glycininae					
	Glycine	4	Asia-Aust.		9
Kennediinae					
	Hardenbergia	1	Australia		2
	Kennedia	11	temp/arid Aust.		12
Clitoriinae					
	Centrosema	1	tropics/subtrop.	ca	45
	Clitoria	1	tropics	ca	70
Phaseolinae					
	Austrodolichos	1	trop. Aust.		1
	Vigna	2	tropics	ca	150
Cajaninae					
	Atylosia	4	Asia-Aust.		35
	Dunbaria	1	Asia-Aust.		15
	Eriosema	1	tropics	ca	130
	Flemingia	3	Asia-Aust.		30
	Rhynchosia	5	tropics	ca	200

Tephrosieae				
	Tephrosia	24	tropics	ca 400
	Paratephrosia	1	central Aust.	1
Robineae				
	Sesbania	6	tropics/subtrop.	ca 50
Trifolieae				
	Trigonella	1	Eurasia-Africa-Aust.	ca 80
Loteae				
	Lotus	2	temperate regions	ca 100
	Holtzea	1	Asia-Aust.	1

Jacksonia, Daviesia, Gastrolobium, Eutaxia, Kennedia and Phyllota.

Therefore, in summary, the Fabaceae of Western Australia contain few endemic genera, most genera occur outside Western Australia, mainly in Eastern Australia. Specific endemism is low in tropical and desert regions but high in temperate Western Australia.

Considering the genera and tribes detailed in Table one in more detail:

Crotalarieae:

Crotalaria (fig. 1) a very large and widespread tropical genus, is likewise centred in tropical Western Australia, and diverse in the Kimberley and Pilbara region of the Eremaean. However, only 6 species have extended into the central desert regions.

Galegeae:

Swainsona (fig. 2) a moderately sized genus confined to Australia (one species occurs in New Zealand). In Western Australia, despite, being considered an arid zone genus the highest specific diversity is found between the south west Botanical Province and the central desert, only a few species being recorded extending into this inhospitable region. Interestingly this genus is one of the few that has colonized the calcareous soils of the Nullabor Plain, and two species extend to southern Western Australia.

Indigoferae:

Indigofera (fig. 3) another largely tropical genus, has a similar bimodal distribution to Crotalaria, diversifying in the Kimberley and Pilbara region. Unlike Crotalaria, however, Indigofera has occupied the deserts (13 species occur there), and one species (I. australis) extends to temperate Western Australia.

Bossiaeae:

The second largest tribe of the family in Western Australia, consisting of eight genera and 64 species. Bossiaea (fig. 4) the largest genus (ca 40 species) has a bimodal tropical/temperate distribution in Western Australia. Specific diversity in temperate Western Australia is highest on the southern sandplains (Roe, Eyre Botanical Districts). Templetonia (fig. 5) occurs throughout Western Australia, but specific diversity is highest in temperate Western Australia on the southern, northern and central sandplains. Hovea (fig. 6) contains the highest diversity of species in the higher rainfall forest zones of temperate Western Australia. The other genera (fig. 7; Aenictophyton, Goodia, Muelleranthus, Plagiocarpus and Ptychosema) are all very small and display no particular distributional pattern. Collectively the members of the tribe Bossiaeae (fig. 8) appear to have diversified in the semi-arid regions of southern Western Australia, mainly at the edges of the woodland zones.

Mirbelieae:

The largest tribe in Australia (ca 480 species in 25 genera), and largely confined to this continent. All genera (Brachysema, Jansonia, Cupulanthus, Erichsenia, Euchilopsis and Latrobea) endemic to Western Australia are members of this tribe.

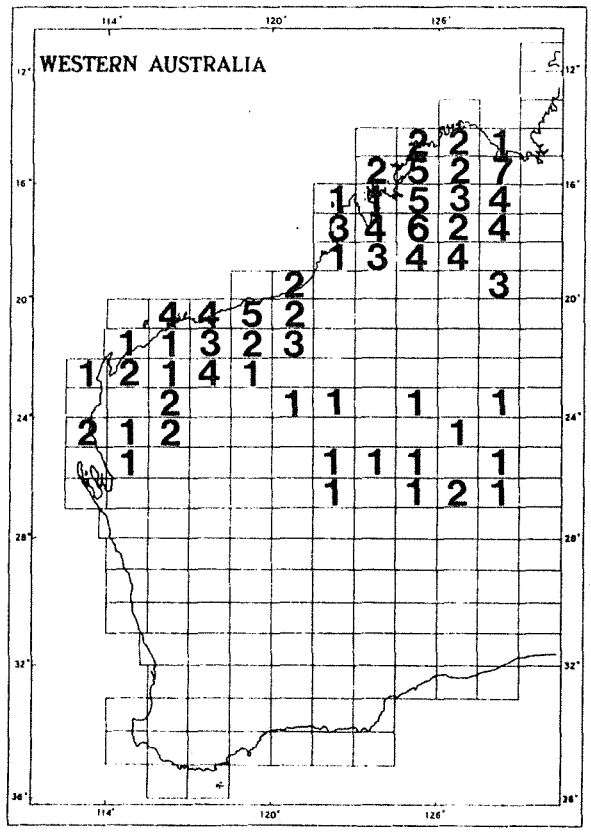


Fig. I : Crotalaria

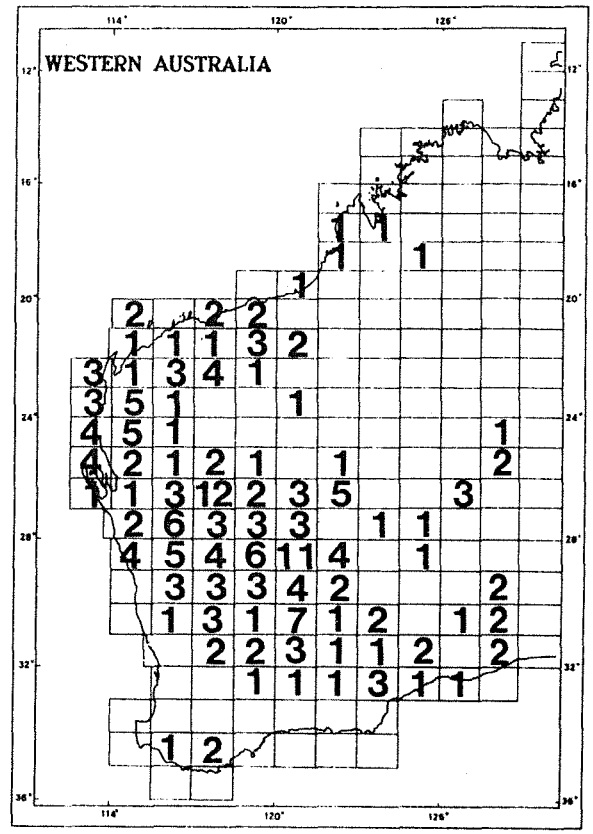


Fig. 2 : Swainsona

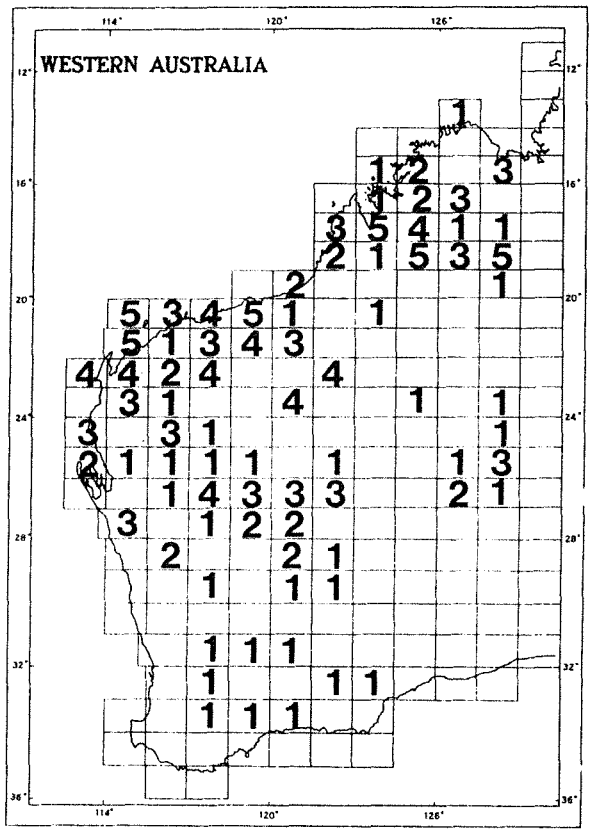


Fig. 3 : Indigofera

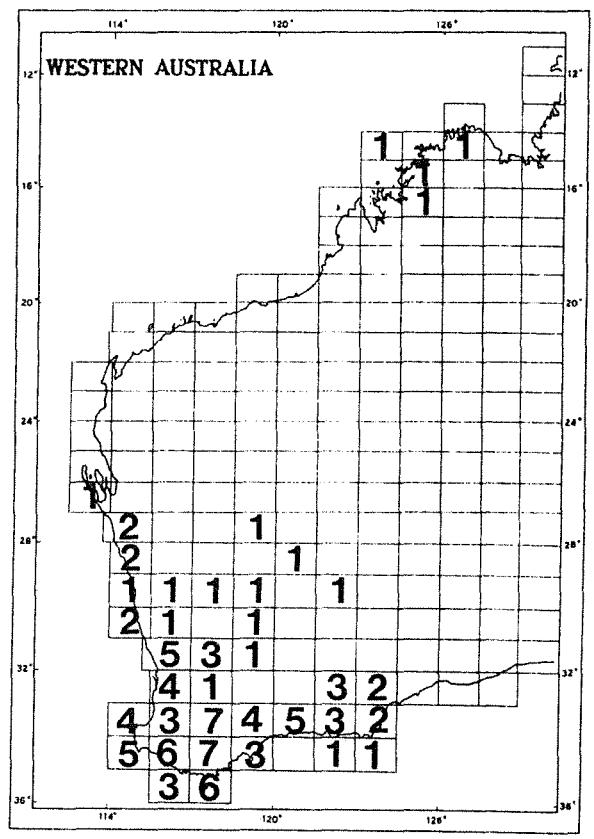


Fig. 4 : Bossiaea

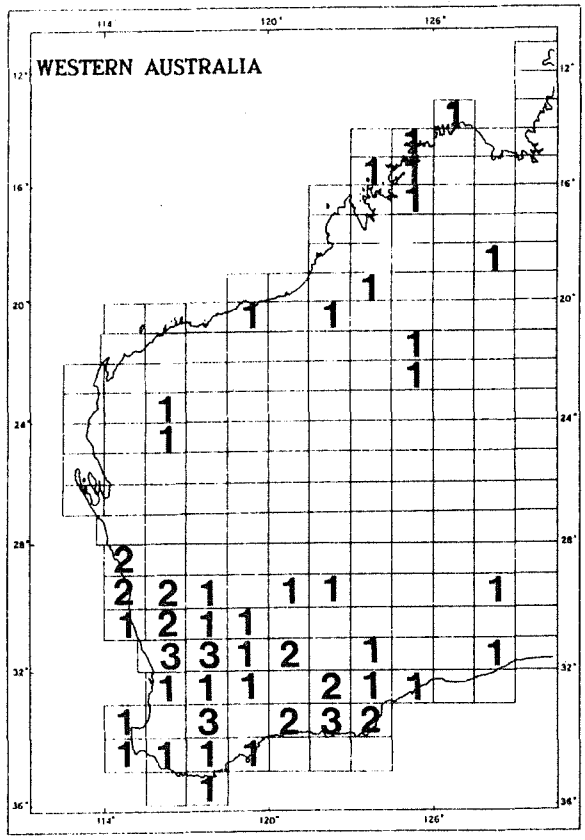


Fig. 5 : Templetonia

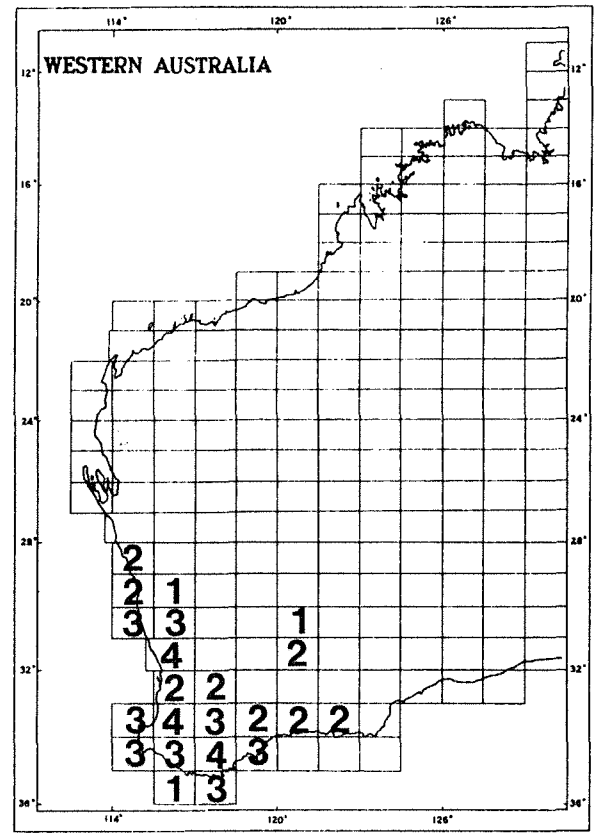


Fig. 6 : Hovea

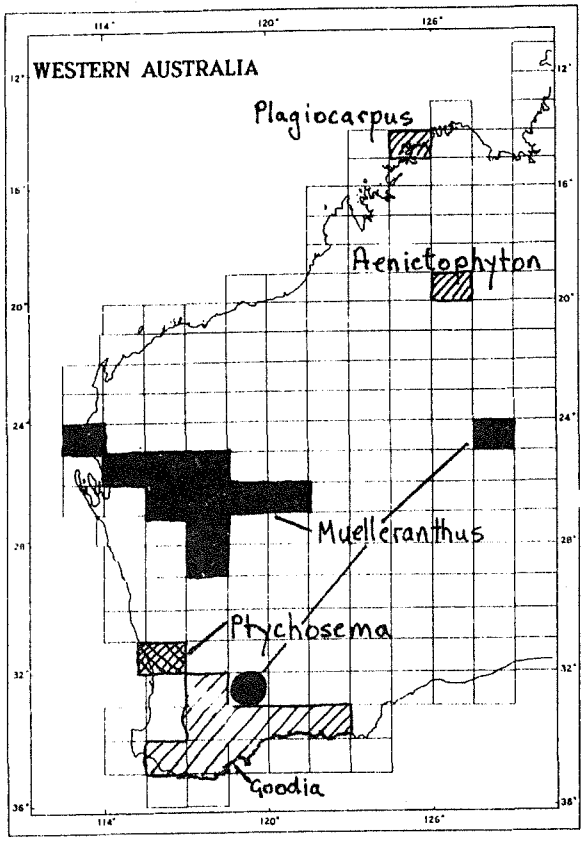


Fig. 7 : Five genera of Bossieae

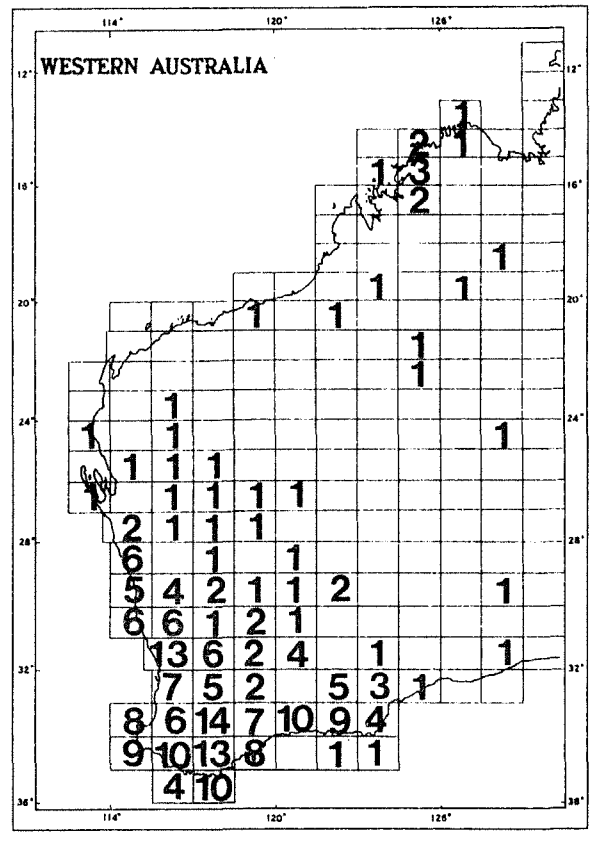


Fig. 8 : Tribe Bossiaeae

The Brachysema group (Brachysema, Bugesia, Cupulanthus, Jansonia and Leptosema) and presented in figures 9-11. Brachysema (fig.9) is most diverse in the region marginal to the higher rainfall regions of southern coastal Western Australia (Mt. Barker sheet has 5 species). Cupulanthus is also confined to this region. Leptosema (fig. 10) and Bugesia (fig. 11) are largely arid zone genera, wheras Jansonia (fig. 11) is confined to high rainfall regions.

The large closely related genera, Gastrolobium (fig. 12 : ca 40 species) and Oxylobium (fig. 13 : ca 25 species) have diversified in different regions. Gastrolobium on the sandplains north and southeast of Perth, whereas Oxylobium is largely southern coastal sandplains.

Jacksonia (fig. 14) is more difficult to analyze, since it is inadequately known both taxonomically and geographically, and the high rate of collecting near Perth has artificially inflated this region's diversity. From a study of individual species' ranges, and discounting the Perth region a northern/ southern split peak becomes apparent (Moora sheet : 12 species ; Mt. Barker : 10).

Gompholobium (fig. 15) and Burtonia (fig. 16) are also closely related genera. Gompholobium has a north/south split almost identical to Jacksonia, while Burtonia has a high diversity from high rainfall zones to the edge of the desert but has a low diversity on the northern fringe of the south west.

Sphaerolobium (fig. 17) has obviously diversified on the southern coastal heathlands, and adjacent Jarrah forest.

Another group of closely related genera are Pultenaea (fig. 18); Eutaxia (fig. 19) and Latrobea (fig. 20). All of these genera have diversified on the higher rainfall southern coastal heathlands. Latrobea apparently being more confined to the higher rainfall zones than Eutaxia or Pultenaea.

Isotropis (fig. 21) is widespread throughout arid and temperate Western Australia, and has apparently diversified on thesemi-arid heathlands of south western Australia.

Aotus (fig. 22) is clearly most diverse in the high rainfall zone of temperate Western Australia (of the 9 species 4 (A. carinata, A. cordifolia, A. ericoides and A. passerinoides) are restricted to this region).

Dillwynia (fig. 23) is a poorly collected and taxonomically confused genus, but has probably diversified in the southern jarrah and south coastal heathlands.

Mirbelia (fig. 24) has diversified markedly on the transitional rainfall heathlands, and is largely absent from the high rainfall forest zones.

Chorizema (fig. 25) is also diverse in the high rainfall zones and adjacent southern coastal heathlands.

Summarizing the genera in terms of their greatest specific diversity:

(A) Northern/Central Heathlands : Erischenia, Gastrolobium, Isotropis and Mirbelia.

(B) Northern/Southern Heathlands : Gompholobium and Jacksonia.

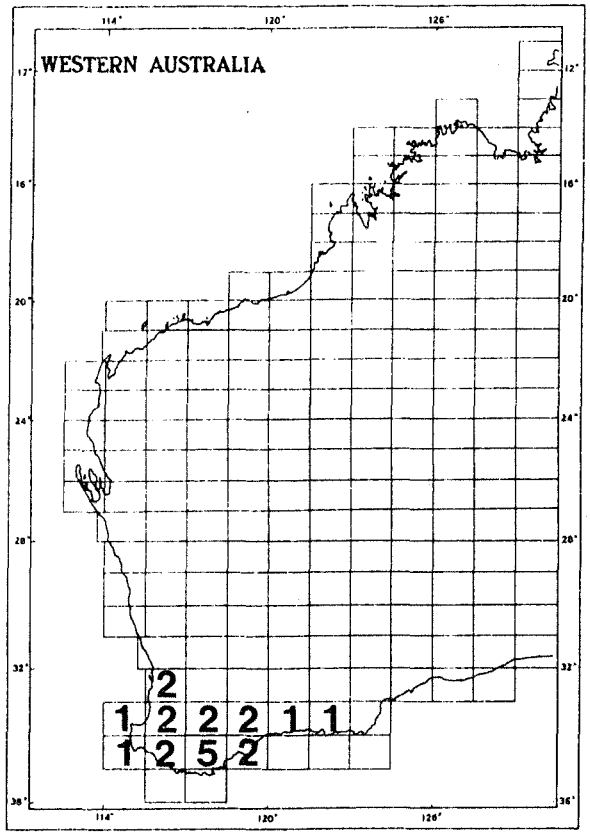


Fig. 9 : Brachysema

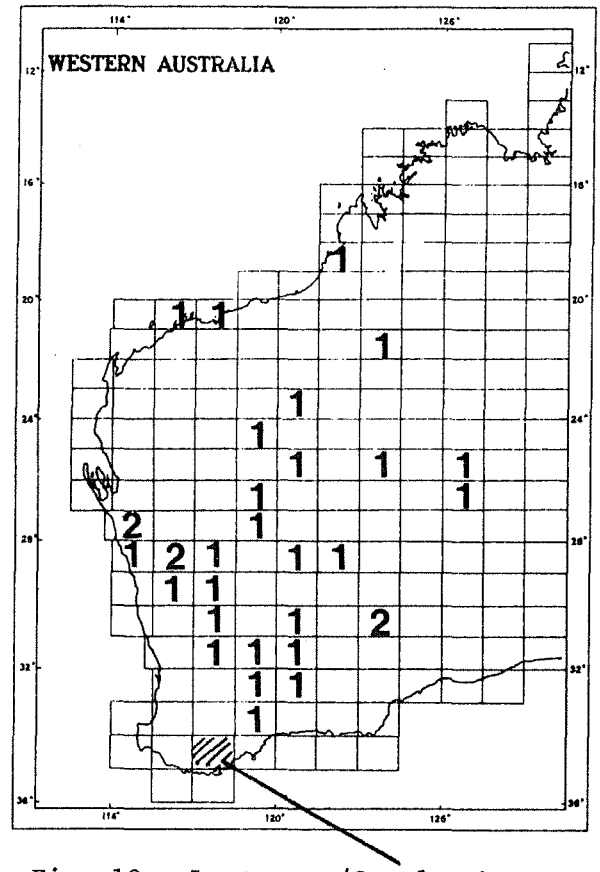


Fig. 10 : Leptosema/Cupulanthus

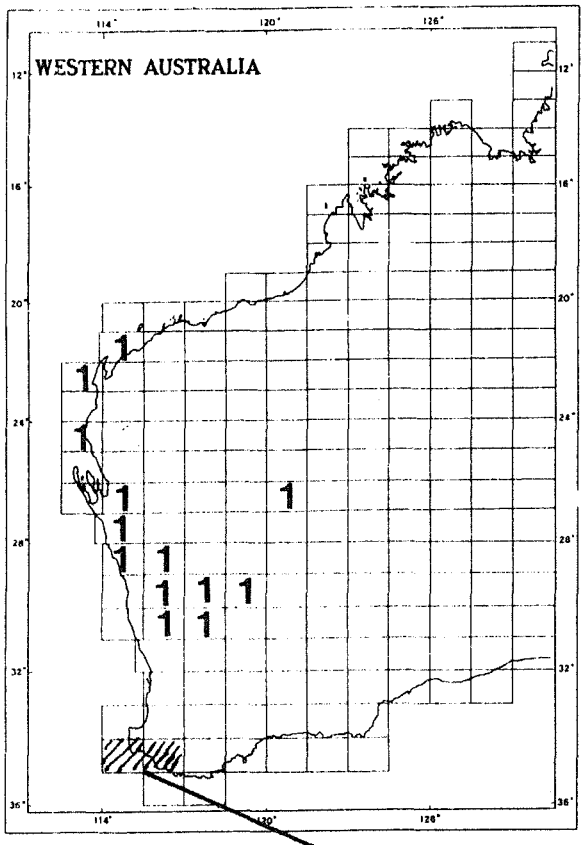


Fig. 11 : Bugesia/Jansonia

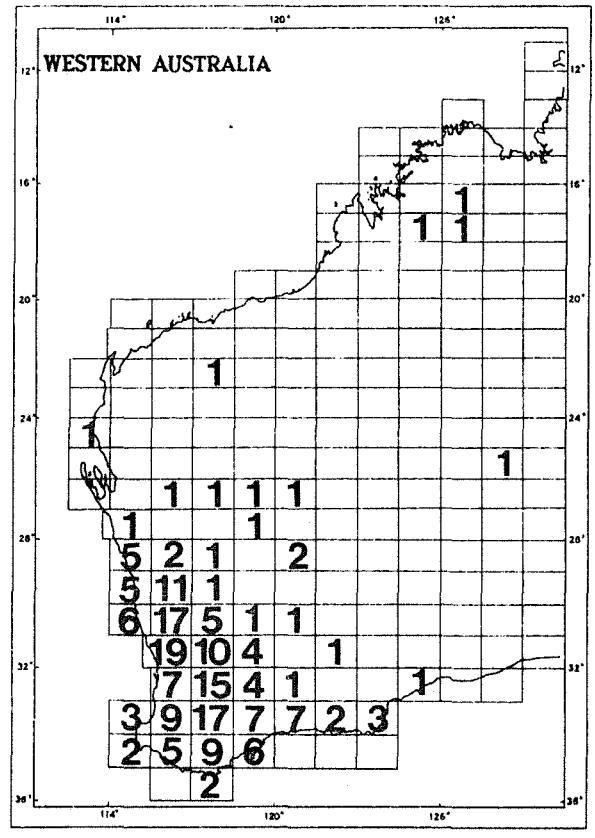


Fig. 12 : Gastrolobium

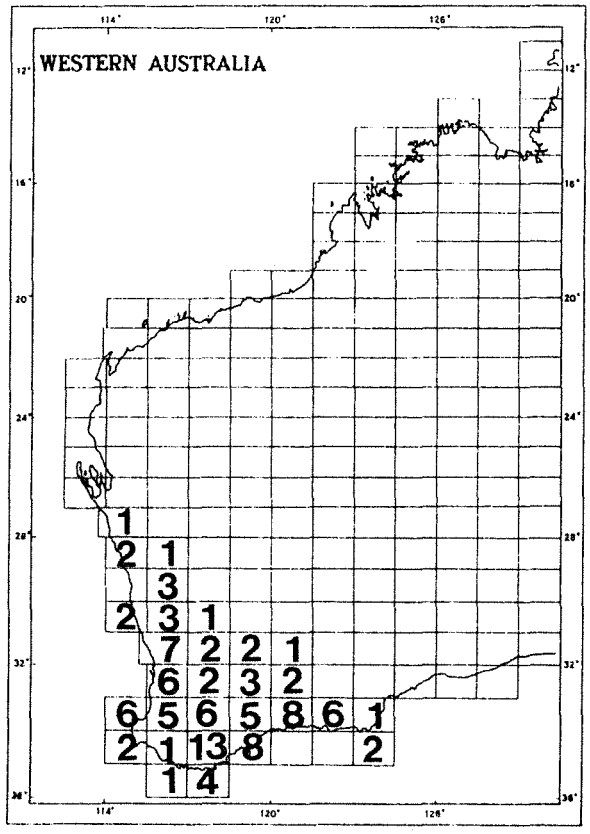


Fig. 13 : Oxylobium

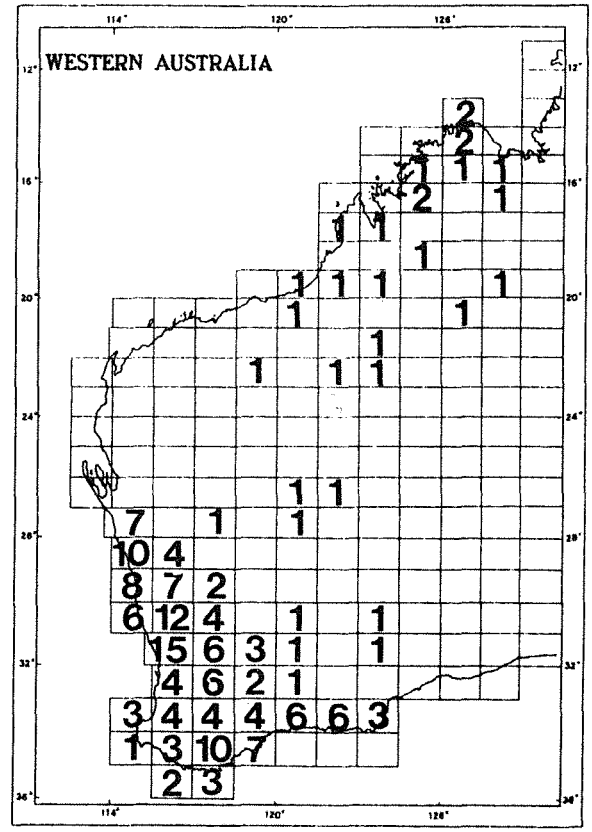


Fig. 14 : Jacksonia

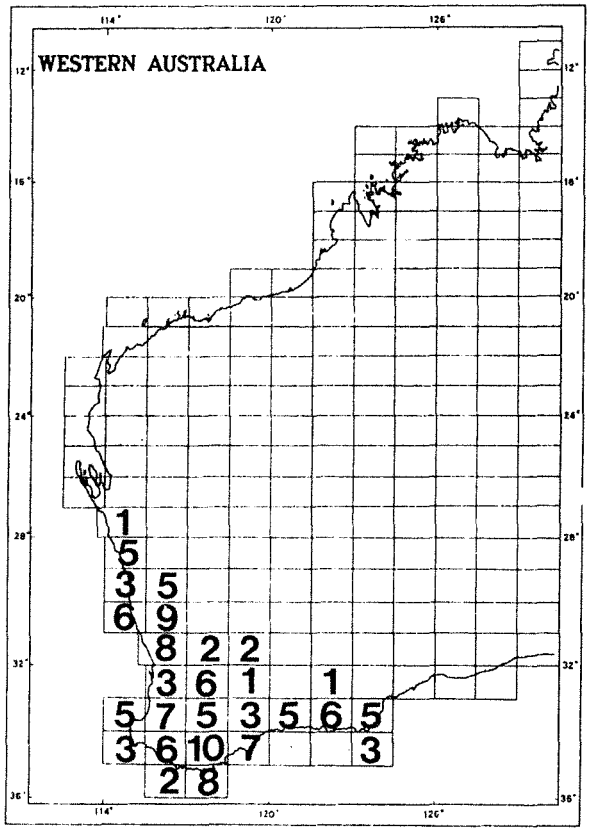


Fig. 15 : Gompholobium

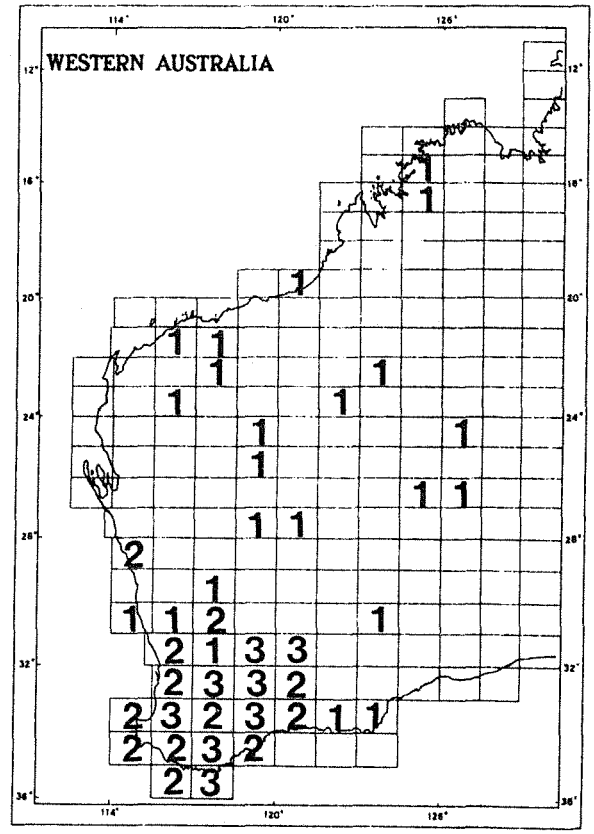


Fig. 16 : Burtonia

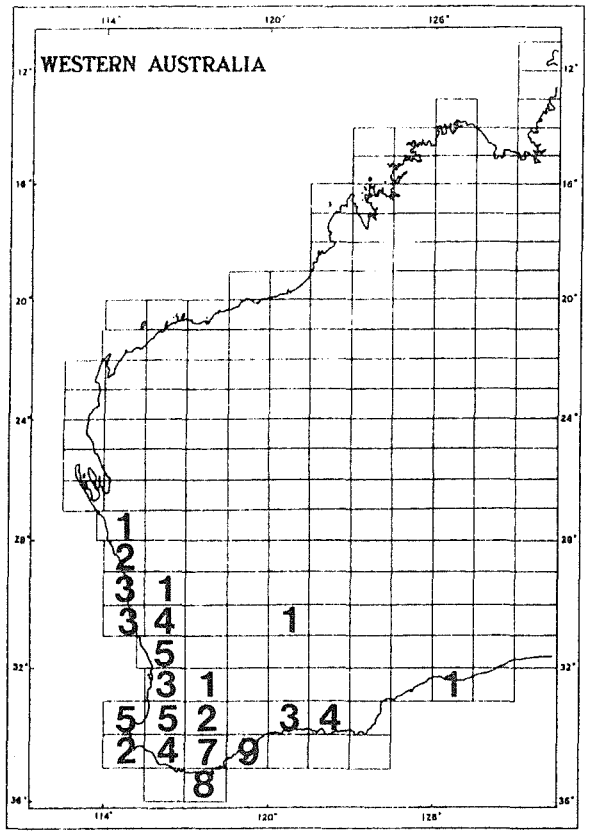


Fig. 17 : Sphaerolobium

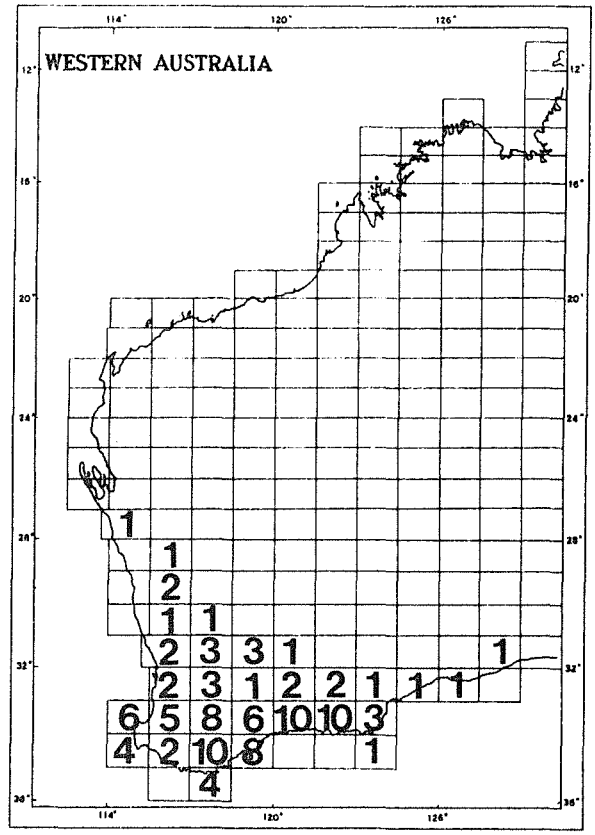


Fig. 18 : Pultenaea

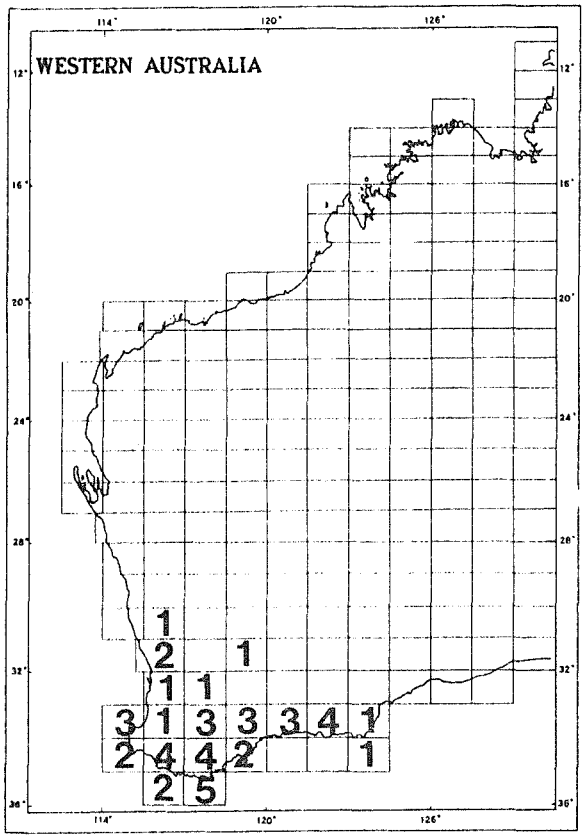


Fig. 19 : Eutaxia

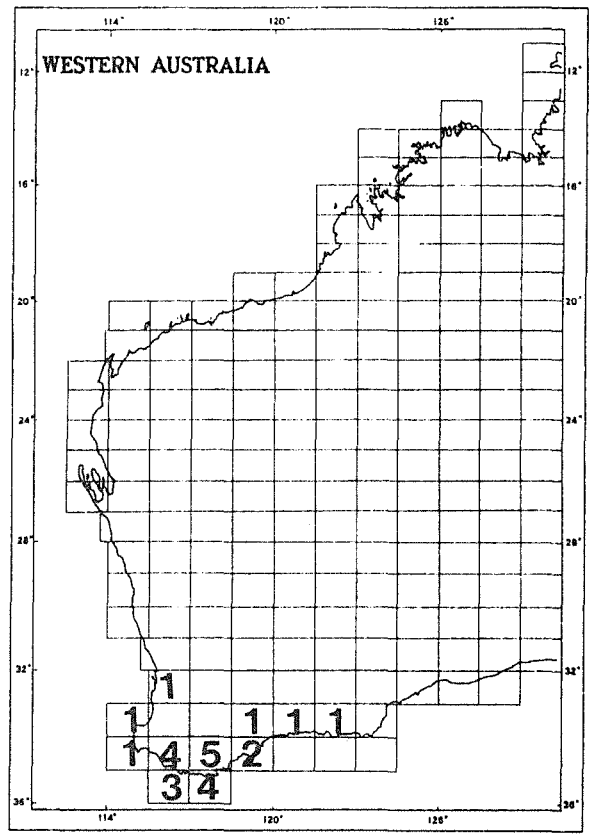


Fig. 20 : Latrobea

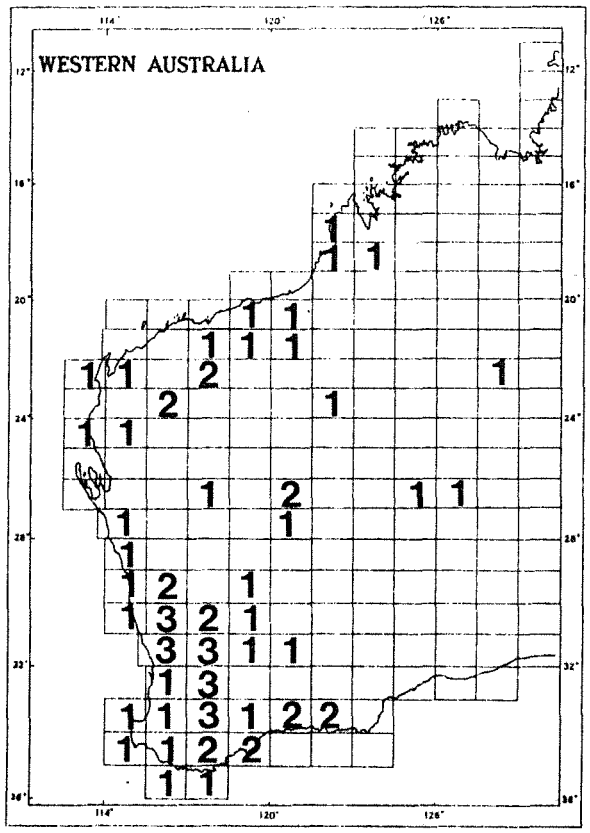


Fig. 21 : Isotropis

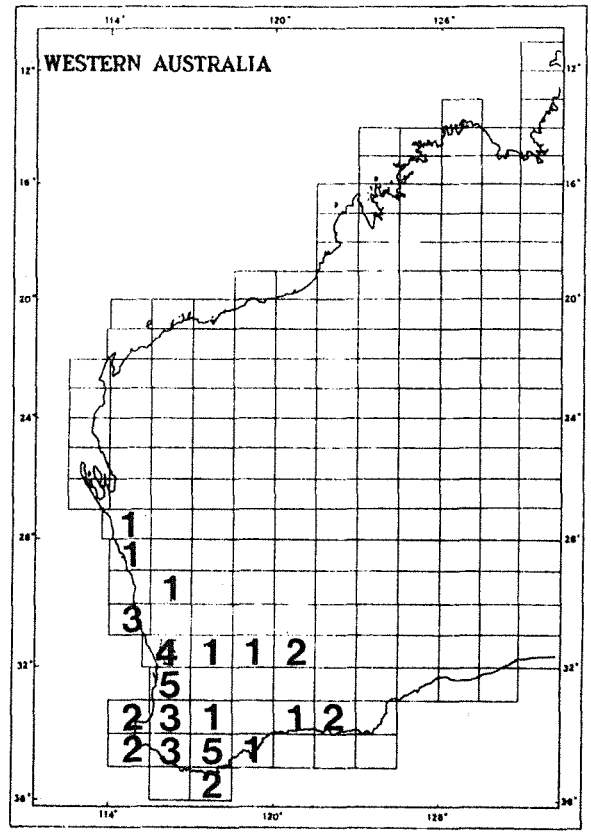


Fig. 22 : Aotus

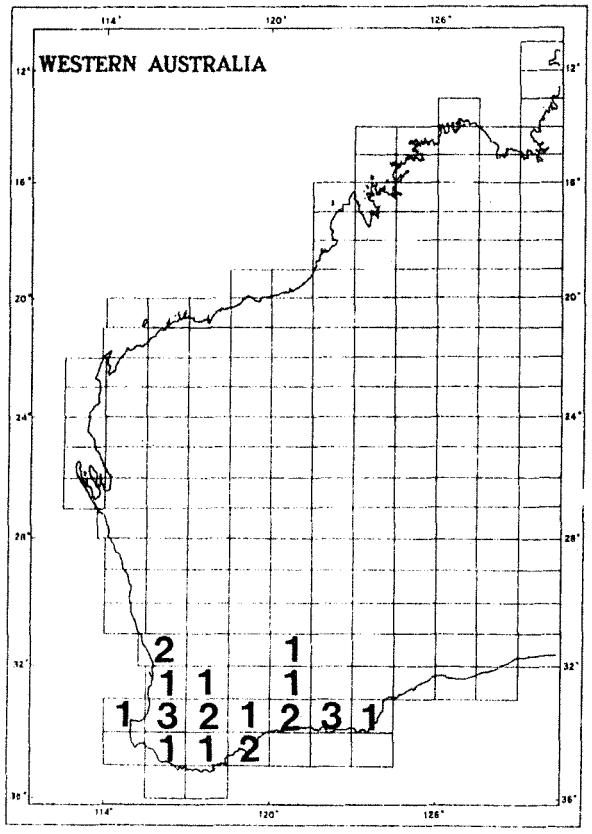


Fig. 23 : Dillwynia

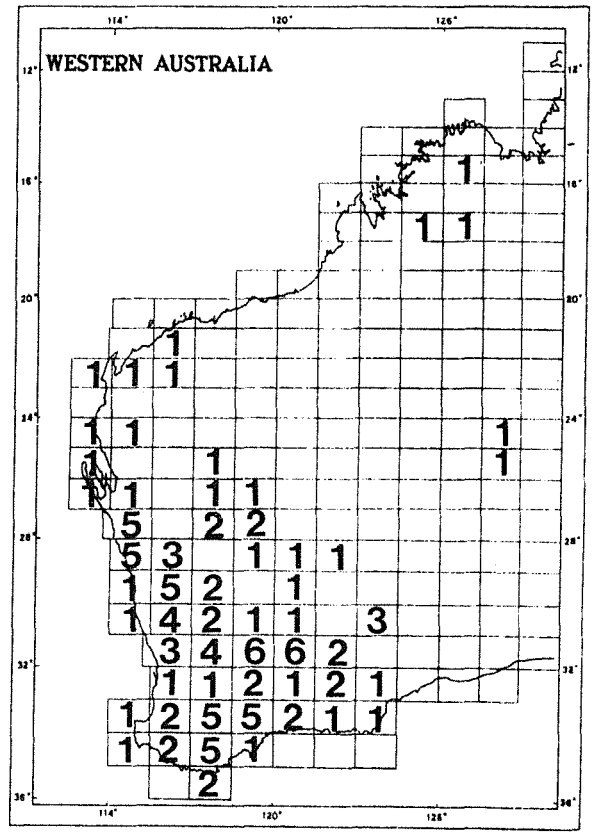


Fig. 24 : Mirbelia

(C) High Rainfall Zone : Aotus, Euchilopsis and Jansonia.

(D) Southern Heathlands : Brachysema, Chorizema, Cupulanthus, Dillwynia, Eutaxia, Latrobea, Oxylobium, Pultenaea and Sphaerolobium.

(E) General : Burtonia.

Since all large genera are well represented on the southern heathlands and several are centred there, it is not surprizing that the tribal map of species diversity (fig. 26) also shows this trend (101 species on Mt. Barker sheet and 67 on Bremer Bay sheet).

Psoraleeae:

Psoralea (fig. 27) a largely tropical genus, is again most diverse in the southern Kimberlies and Pilbara region of the Eremaean.

Phaseoleae:

A large and diverse almost cosmopolitan tribe, which despite being represented in Western Australia by 16 genera spread through 6 subtribes is difficult to analyze because only a few species are present in most genera (Table 1). Only Kennedia (fig. 28) is large enough to be analyzed, and this genus is most diverse in the higher rainfall forest zones and southern coastal heathlands of temperate Western Australia. The tribe Phaseoleae (fig. 29), however, reflects the genus Kennedia as the southern component and the many genera of tropical origin present in the Kimberlies.

Tephrosieae:

Tephrosia (fig. 30) like all other largely tropical genera has a bimodal distribution of diversity in the Kimberlies and Pilbara.

Robinieae:

Sesbania (fig. 31) also displays the Kimberley - Pilbara distribution.

Conclusion:

All largely tropical genera (Crotalaria, Indigofera, Psoralea, Sesbania and Tephrosia) display highest levels of diversity in the Kimberley and Pilbara regions of tropical Western Australia.

The arid zone edge with the south western botanical province is the centre of diversity for the genus Swainsona, a very unusual centre which deserves further study.

Within the south west botanical province genera have diversified in several areas:

(i) high rainfall zone : Aotus, Hovea

(ii) interzone: northern : Bossiaeae, Gastrolobium, Isotropis, Mirbelia and Burtonia.

(iii) Northern/Southern sandplains : Gompholobium and Jacksonia.

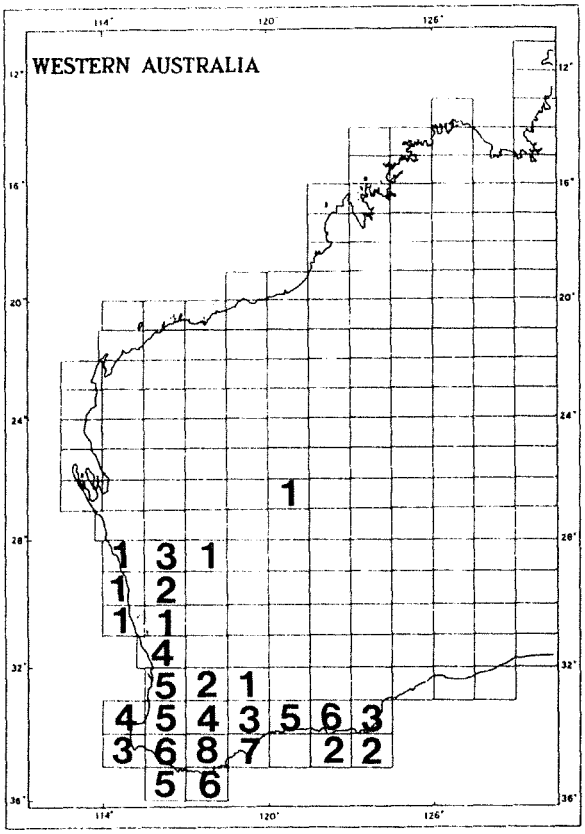


Fig. 25 : Chorizema

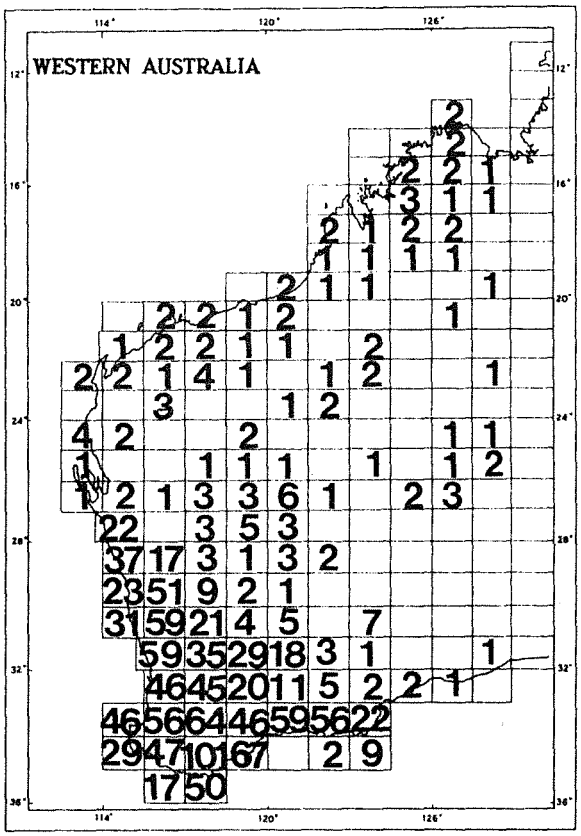


Fig. 26 : Mirbeleae

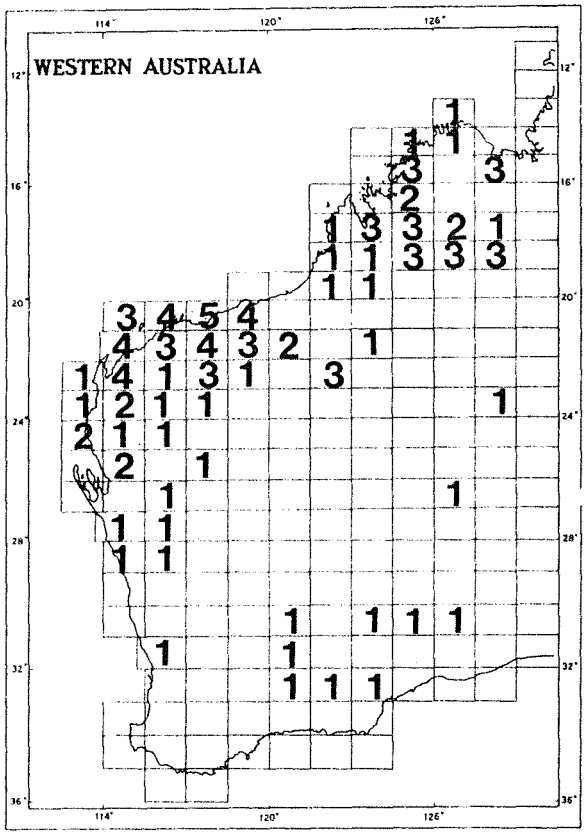


Fig. 27 : Psoralea

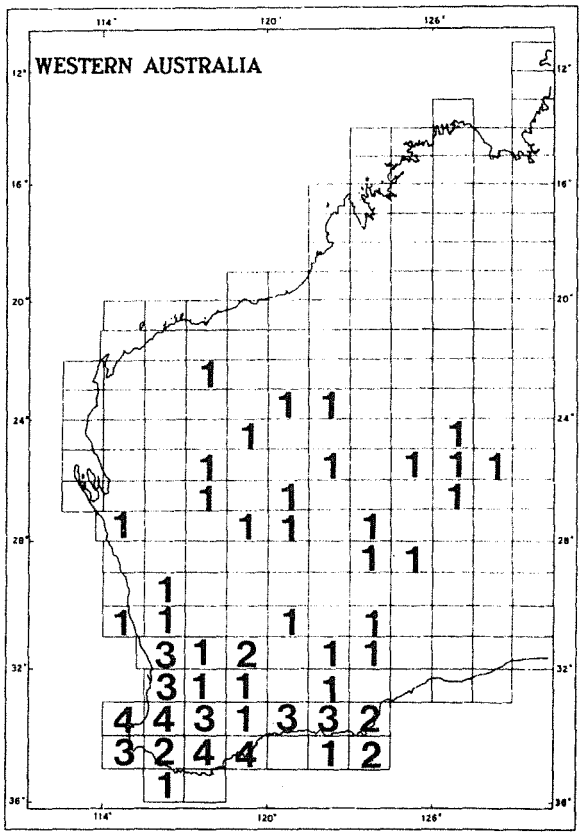


Fig 28 : Kennedia

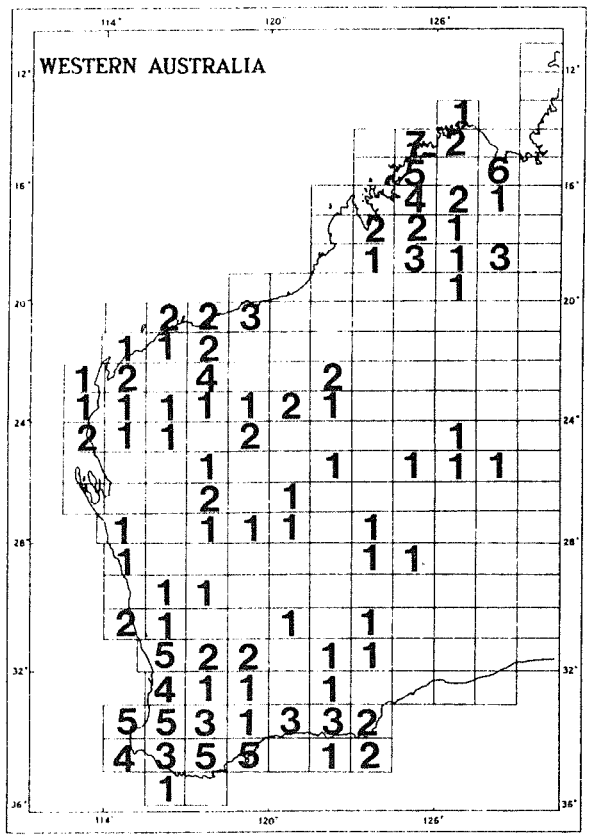


Fig. 29 : Phaseoleae

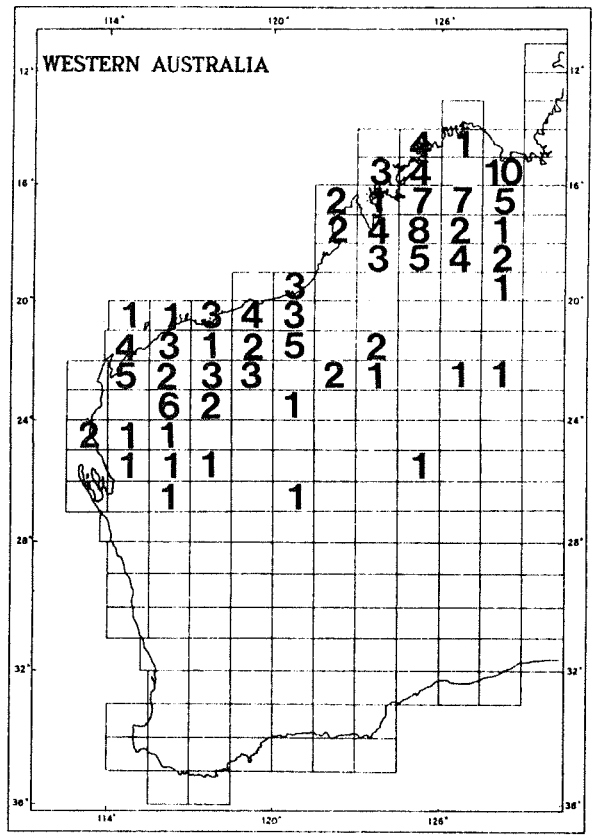


Fig. 30 : Tephrosia

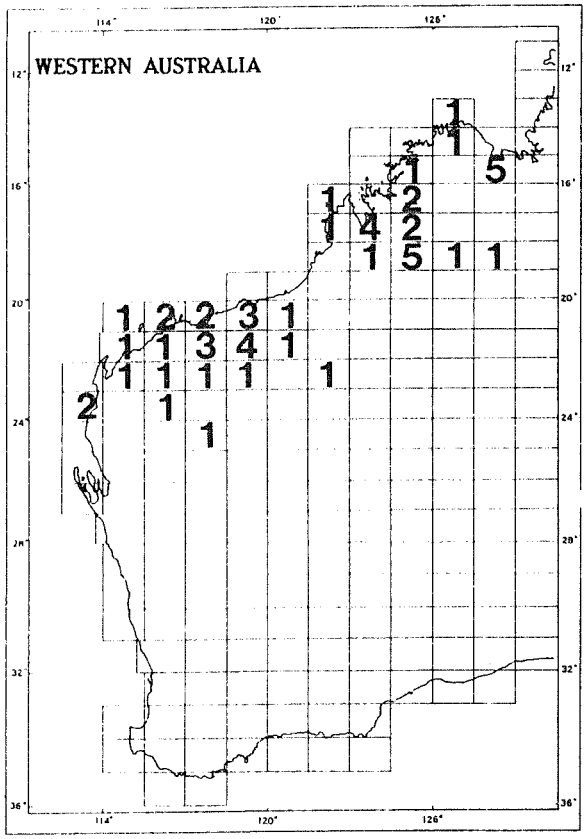
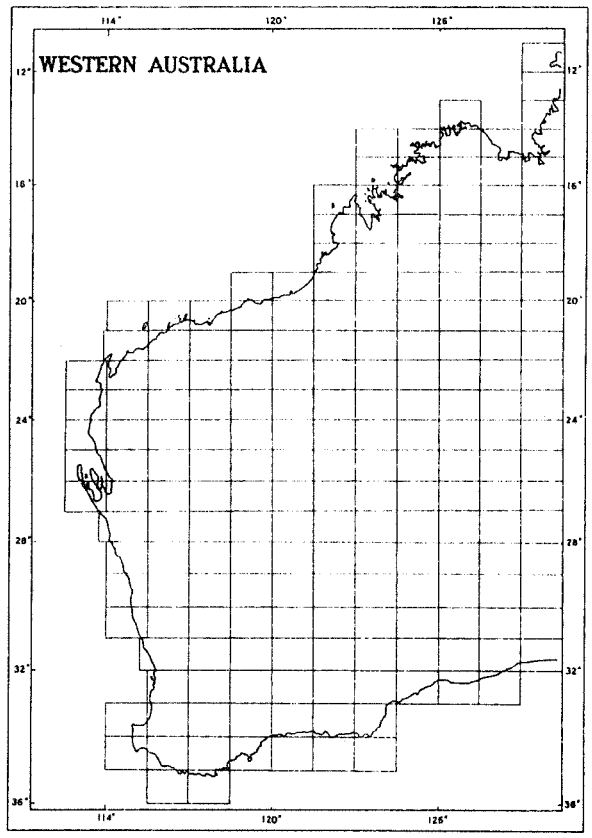


Fig. 31 : Sesbania



(iv) High rainfall zone and adjacent southern sandplains: Bossiaea, Brachysema, Chorizema, Dillwynia, Eutaxia, Kennedia, Latrobea, Oxylobium, Pultenea and Sphaerolobium.

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The Naturalized Fabaceae of Western Australia*

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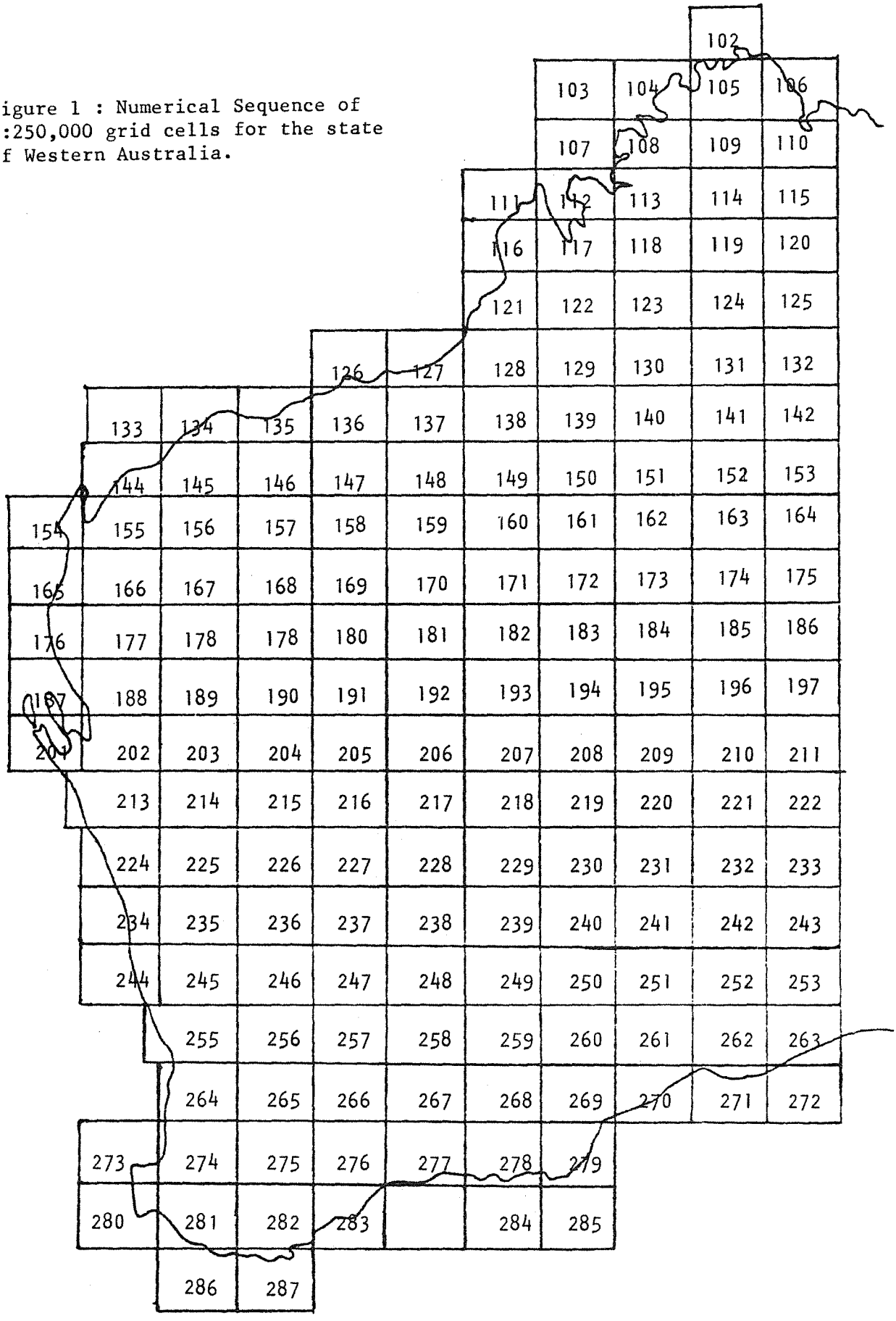
Abstract:

Seventy seven species of Fabaceae are considered to be naturalized in Western Australia. Six species are considered best regarded as garden escapes, and sixteen species are not considered to be truly naturalized. Most species occur in southern Western Australia, and are almost invariably self fertile and capable of autogamy. Self pollination, while the rule in some species, is usually supplemented by cross pollination by feral or hive honey bees in most populations observed. Further collecting is needed to establish the true ranges of most species, and the genus Trifolium is in need of review.

*PartVI : Biology of Western Australian Leguminosae.

Figure 1 : Numerical Sequence of 1:250,000 grid cells for the state of Western Australia.



Introduction

The Legumes of Western Australia comprise four groups, the Mimosaceae, Caesalpinaceae, Fabaceae and the naturalized members of these families. The largest component of this naturalized flora originates from the Fabaceae. Little has been published on the biology of this group of Legumes, and this paper details what is currently known of the distribution, flowering times, pollination breeding systems and composition of the naturalized Fabaceae of Western Australia.

Materials and Methods

Distribution data is recorded as occurrence within the numbered grid squares, given in Figure 1. These records are based on herbarium specimens held in Perth, Kings Park and UWA (or those quoted in reviews of particular groups eg McComb, 1974).

Observations on pollinator activity were made whereever possible at varying times of the day in a large stand of flowering plants. Material obtained from the wild was held under insect free conditions to determine the ability to self pollinate.

Results and Discussion

Seventy seven species of Fabaceae are naturalized in Western Australia. Six garden escapes (Crotalaria agatiflora, Genista horrida, Hedysarum coronarium, Lathrys sylvestris, Podalyria sericea, Robinia pseudoacacia) have been recorded. Some sixteen species considered at times to have been naturalized are shown not to be deserving as this tile, on data available in the herbarium.

Honey bees are almost always the sole agent of cross pollination, probably because native bees are not able to survive in the disturbed habitats these species are found in. At least one species (Psoralea pinnata) has become a major summer food source for hive bees.

Self pollination is probably the rule for many members of the genera Lotus, Lupinus, Medicago, Melilotus, Ornithopus, Trifolium and Vicia species. All 33 species tested were found to be self fertile, and capable of autogamy. McComb (1974) and Gladstones (1974) note that all Medicago and Lupinus are capable of self pollinating. Hence, it appears that all naturalized species may be self fertile. Further collecting is needed to clarify the ranges of most taxa, and to ascertain the true status, of some of those species listed as doubtfully naturalized. The genus Trifolium is in need of a special effort to collect and review this important genus in Western Australia.

Notes on Individual Species

Alhagi

*A. maurorum Medik
grid 248 flowers 10-2

Arachis

A. hypogaea L.
not naturalized, only record : Kununurra Research Station, Perry sn.

Astragalus

*A.sp (? prolixus)
only collection : Merredin, Smith. sn. 31.10.1979.

Cajanus

C. cajan (L.) Mill.
Not naturalized, all collections from Agricultural Research Stations.

Canavalia

*C. ensiformis (L.) DC.
grids 108, 112, 113, 118. flowers 5-7

Centrosema

C. pubescens Benth.
not naturalized, only record : Carlton Reach Experimental Plots, C.A. Gardner sn.

Cicer

C. arietinum L.
not naturalized, 4 records from South Perth and Harvey, all probably cultivated or crop escapes.

Clitoria

*C. ternatea L.
grids 111, 113, 134 flowers all year. Material of this recorded for Albany is Dolichos lignosus, recorded as cultivated from Carnarvon. Material of this species ex One Arm Point, Demarz 8778 is self fertile and capable of autogamy.

Crotalaria

C. agatiflora L.
Occassional garden escape. grid 280. flowers 10-2

*C. goreensis Guill. et Perr.
grids 110, 114. flowers 3-5

*C. juncea L.
grids 108, 110, 115, 124. flowers 3-6.
Material ex Ord River Station, Kozlenko 620 is self fertile and autogamous.

Cytissus

*C. proliferus L.f.
grids 255, 264, 265, 273, 274, 281. flowers 7-10

Pollination : Honey Bees - Perth, Greenbushes, Dryandra.

Material ex Greenbushes, G. Keighery 7001 is self fertile and autogamous.

Desmodium

*D. tortuosum (Swartz.) DC
grids 104, 113 flowers 2-6

Material ex Mitchell Plateau Campsite, G. Keighery 4667 is self fertile and autogamous.

Dipogon

*D. lignosus (L.) Verdc.
grids 255, 273, 274, 279, 280, 281, 287. flowers 10-11
Pollination : Honey Bees - Bunbury
- Metricup

Material ex Israelite Bay, Demarz 4917 and Kings Park S 1987 is self fertile and autogamous.

Genista

*G. canariensis L.
grids 273, 280, 281. flowers 9-11

Pollination : Honey Bees - 7km West Manjimup
Margaret River

Material ex Shannon River Mill, Demarz 6789 is self fertile and autogamous.

*G. linifolia L.
grid 255m 264, 274, 282. flowers 10-11
Pollination : Honey Bees - Brunswick
Material ex Brunswick Junction, G. Keighery 3470 is self fertile and autogamous.

G. horrida (Vahl.) DC.
Garden escape, doubtfully naturalized, only one record Red Hill, near Perth.

Hedysarum

*? H. coronarium L.
grids 256, 264, 273. flowers 11-12
Garden escape persisting around old settlements.

Lablab

*L. purpureus (L.) Swelt
grids 176, 224, 234, 255, 264. flowers 5-10-(2)

Lathrys

L. sylvestris L.
?naturalized grid 281, flowers ?-11-?
Nornalup A. Fische sn 11/44

*L. tingitanus L.
grids 255, 264, 273, 274, 280, 281, 287, flowers 10-11
pollination : Honey Bees : Manjimup
: Witchliffe

Material ex 8km S.W. Witchliffe, G. Keighery 3569 is self fertile and autogamous.

Lespedza

*L. juncea (L.f.) Pers.
grid 255, flowers 5-11
Pollination : Honey Bees : Mahogeny Creek
Material ex Mahogeny Creek, G. Keighery is self fertile and autogamous

Lotus

*L. angustissimus L.
grids 255, 264, 273, 274, 280, 281. flowers 11-1

*L. suaveolens Pers.
grids 255, 264, 273, 274, 280, 281, 275, 282. flowers 11-1
Pollination : largely self pollinating only rarely visited by honey bees at Subiaco.
Material ex Subiaco, G. Keighery 6973 is self fertile and autogamous.

*L. uliginosus Schkuhr.
grids 255, 264, 273, 274, 280, 281, 287; flowers 11-2-(3)
Pollination : Honey Bees : Torbay
: Denmark
: Maylands
Material ex Maylands, G. Keighery 4460 is self fertile and autogamous.

Lupinus

Gladstones (1969, 1974 and 1977) has listed the species cultivated and naturalized in Western Australia. He noted that all species are self fertile with a gradation in outcrossing from Lupinus luteus through L. albus and L. angustifolius to L. cosentinii which is almost exclusively self pollinating. Honey bees are the agents of pollination, which is borne out in the observations below on naturalized stands.

*L. albus L. var albus
grids 264, 273, flowers
Pollination : Honey bees : Bunbury

*L. angustifolius L.
grids 255, 264, 273. flowers
Pollination : Honey bees : Bunbury

*L. cosentinii Guss.
grids 224, 234, 244, 245, 255, 264, 273, 274. flowers 8-11

*L. luteus L.
grids 244, 264, 274, 281. flowers 8-11
Pollination : Honey bees : Subiaco

L. mutabilis Sweet
not naturalized, no records

*L. pilosus Murray
grid 255, occasional on road sides

Macroptilium

*M. atropurpureum (DC) Urban
grids 110, 111, 112. flowers 3-5

Material ex Cygnet Bay, Demarz 8781 is self fertile and autogamous

*M. lathyroides (L.) Urban.
grid 110 flowers ?-3-?

Medicago

Based on McComb (1974), who notes that all annual species are self fertile and largely self pollinating.

*M. arabica (L.) Huds
grids 255, 264, 280, 281. flowers 9-11

M. hispida Gaertn. = M. polymorpha

M. intertexta (L.) Mill. var intertexta
recorded for grids 273, 274, McComb (1974) considers it doubtful that this species is naturalized.

*M. littoralis Rhode ex Lois - Delong.
grid 224, occurs as crop escape on grids 245, 257.
floers 9-10.

*M. laciniata (L.) Mill. var laciniata
grids 224, 235, 245, 249, 257, 264. flowers 8-10

*M. laciniata var brachyacantha Boiss
grids 224, 235, 245, 249, 257, 264. flowers 8-10

*M. lupulina L.
grids 265, 274, 278, 281, 282, 287. flowers 10-4 McComb (1974) noted that although there are many collections most are from cultivated sources, only one truly naturalized population occurs at Deeside (grid 281).

*M. minima (L.) Bart. var minima
grids 224, 238, 245, 255, 256, 257, 264, 265, 268, 269, 277, 282. flowers 7-10.

*M. minima var brevispina Benth.
grid 257

M. orbicularis (L.) Bart
grid 257, McComb (1974) doubts that this species is naturalized.

*M. polymorpha L. var polymorpha
grid 176

*M. polymorpha var brevispins (Benth.) Heyn.
grid 213, 255, 280, 282. flowers 7-10-(2)

*M. polymorpha var vulgaris (Benth.) Shin.
grids 224, 255, 264. flowers 7-10

*M. praecox DC.
grids 234, 257, 275. flowers 8-10

*M. sativa L.
grids 255, 264, 273, 274, also recorded as a crop escape from grids 257, 176, 206. flowers 5-2.
Pollination : Honey Bee : Kings Park
: Bunbury

Material ex Kings Park, GK 6531 is partially self fertile and partially autogamous.

*M. scutellata (L.) Mill.
grids 265, 275, 287, but probably not naturalized according to McComb (1974)

M. tornata (L.) Mill.
McComb (1974) notes that although this species is not yet naturalized, it could become so in the Geraldton district.

*M. trunculata Gaertn. var trunculata
grids 201, 213, 224, 229, 235, 245, 246, 257, 268, 277, 278, flowers 7-11.

*M. trunculata var longiaculeata Urb.
grid 201, flowers ?-7-?

Melilotus

*M. alba Medik
grids 255, 264, 274, 278, 282. flowers 7-2
Material ex Bunbury, G. Keighery 3860 is self fertile and autogamous.

*M. indica (L.) All.
grids, 201, 213, 224, 255, 264, 273, 274, 277, 278, 280, 282, 287
flowers 8-11-(3)
Pollination : no observations of visitors, except one honeybee at Bunbury.
Material ex Bunbury, G. Keighery 3858 is self fertile and autogamous.

*M. messanensis (L.) All.
grids 273, 274 flowers 12-2
Pollination : rare Honeybee visits : Bunbury
Material ex Bunbury, G. Keighery 1289 is self fertile and autogamous

*M. officinalis Lam.
grids 265, 282 flowers 9-12

Ornithopus

*O. compressus L.
grids 244,255, 264, 273, 274, 278, 282 , flowers 9-11
Material ex Bunbury, G. Keighery 1863 is self fertile and autogamous.

*O. pinnatus (Miller) Druce
grids 235, 264, 273, 274, 282, 287; flowers 10-11-(3).

*O. sativus Brot.
grids 255, 264, 273, 278. flowers 10-2

Phaseolus

P. mungo L. = Vigna radiata

Pisum sativum L.
rarely recorded as crop escape, not naturalized.

Podalyris

P. sericea R.Br.
Garden escape, grid 255

Material ex Karragullen, Demarz 9387 is self fertile and autogamous.

Psoralea

*P. pinnata L.
grids 255, 264, 282, 287, flowers 11-3
This species is used as a major honey source by Western Australian beekeepers in the Albany region where it is abundant.

Robinia pseudoacacia L.
Garden escape, persisting by suckering grids 255, 264
Pollination : Honey Bees : Nanga

Stylosanthes

?S. guianensis (Aubl.) Sw.
doubtfully naturalized on grid 136, recorded as cultivated on grid 10.

S. guineensis G. Don
Not Naturalized, only collections:
Rutland Plains, cultivated, 28.7.1984. Flecker sn Carlton Reach Irrigation Plots, 11.6.1944. C.A. Gardner 7397.

*S. humilis Humilis
grids 104, 117 flowers 4-6
Material ex Mitchell Plateau, G. Keighery 4655 is self fertile and autogamous.

*S. mucronata Willd.
grids 166 , flowers ?-9-?

Sutherlandia

*S. frutescens (L.) R.Br.
grids 225, 255, 273, 281 . flowers 8-11
Pollination : Singing honeyeater/Brown Honeyeater : Eagle Bay
Material ex Eagle Bay, G. Keighery 4539
Wanneroo, Demarz 3112 are both self fertile and autogamous.

Trifolium

T. alexandrinum L.
not naturalized, one record : Perth, 11.1922. C.A. Gardner sn.

*T. angustifolium L.
grids 255, 264, 273, 274, 282, 287. flowers 8-11-(12)

Pollination : Honey Bees
Material ex Bickley, G. Keighery sn is self fertile and autogamous.

T. argutum Banks et Sol.
not naturalized, two collections : C.S.I.R.O. Plots, 1956, E.T. Bailey, sn. and Muresk, 3.1963., P, Garstone sn.

*T. arvense L.
224, 245, 255, 264, 265, 273, 278, 282, 287,
flowers 9-12
Pollination : rarely visited by Honeybees : South Perth

T. aureum Poll.
not naturalized, no collections at PERTH.

T. balansae Boiss
not naturalized, only collections :
C.S.I.R.O. plots, 1956, E.T. Bailey sn
Denmark Research Station, 1952, Annon.

*T. campestre Schredber
grids 213, 235, 255, 264, 273, 274, 275, 282. flowers 8-11
Pollination : occassional Honeybee : Bunbury
: Kings Park

Material : ex Bunbury, G. Keighery 4222 is self fertile and autogamous.

T. carmeli Boiss.
not naturalized, only collection, C.S.I.R.O. plots, 1956, E.T. Bailey sn.

*T. cernuum Brot.
grids 213, 235, 255, 264, 273, 281. floers 8-11

*?T. cheleri L.
? not naturalized, only collections C.S.I.R.O. plots, 1956 E.T. Bailey sn, and Government House, Perth, 11-1925, C.A. Gardner sn.

T. desvauxii Boiss. et Blanche
not naturalized, one collection (3 duplicates),
C.S.I.R.O. plots, 1956, E.T. Bailey sn.

*T. dubium Sibith.
grids 255, 264, 273, 274, 275, 282. flowers 8-11
Material from Kings Park, G. Keighery 1850 is self fertile and autogamous.

*T. fragiferum L.
grids 264, 265, 273. flowers 12-3
Pollination : Honeybees : South Fremantle
Material ex South Fremantle, G. Keighery 6538 is self fertile and autogamous.

T. globosum L.
not naturalized, only collections : C.S.I.R.O. Plots, 1956, E.T. Bailey sn . University Plots, 11.1955, CRW Meadley sn.

*T. glomeratum L.
grids 213, 235, 255, 264, 265, 273. flowers 7-11
Pollination : no visits : Kings Park
Material ex Kings Park, G. Keighery 1851 is self fertile and autogamous.

*T. hirtum All.
grids 245, 255, 264, 265, 274, 275, 282. flowers 10-3

*T. hybridum L.
grids 255, 274. flowers 11-1

*T. incarnatum L.
grids 255, 264, 265, 273, 274. flowers 10-11

*T. lappaceum L.
grids 255, 264, 273 flowers 11-12

*T. ligusticum Boiss. ex Loisel.
grids 264, 273, 274, 280. flowers 11-12

*T. micranthum Viv.
grids 273 flowers ?-11-?

*T. ornithopodioides L.
grids 255, 264, 273, 274. flowers 9-12

*T. pilulare Boiss.
grids 264 flowers ?-10-?

*T. pratense L.
grids 255, 264, 273, 274, 278, 282. flowers 10-4

*T. repens L.
grids 255, 274, 282, 287 flowers 10-2
Pollination Honeybees : Herdsman Lake
:West Perth
Material ex West Perth, G. Keighery 7002 is self fertile and autogamous.

*T. resupinatum L.
grids 255, 264, 273, 274, 281 flowers 10-11
Material ex Bunbury, G. Keighery 4223 is self fertile and autogamous

*T. scabrum L.
grids 255, 264, flowers 10-11-(4)

*T. spumosum L.
grids 255, 256. flowers 9-10

*T. stellatum L.
grids 265, 274, 275, 282 flowers 9-11
Material ex Stirling Range, G. Keighery 1116 is self fertile and autogamous.

*T. striatum L.
grids 264, 273, 274, 275, 278, 282. flowers 10-12-(3)

*T. subterraneum L.
grids 234, 235, 255, 264, 273, 274, 275, 281, 282. flowers (6)-8-11
Gladstones (1966) notes that this species is largely self pollinating.

*T. suffocatum L.
grids 255, 264, 281 flowers 8-11

*T. tomentosum L.
grids 213, 255, 264, 274, 287. flowers 9-11
No pollinator visits observed at Kings Park. Material ex Kings Park, G. Keighery 1847 is self fertile and autogamous.

Trigonella ornithopodioides synonym of Trifolium ornithopodioides

Ulex

*U. europeus L.
grids 255, 273, 280, 282, 287. flowers 5-9
Pollination : Honeybees : Albany

Vicia

V. atropurpurea is a synonym of V. benghalensis

*V. benghalensis L.
grids 255, 264, 274, 281 flowers 10-11

Pollination : Honeybees : Eaton
: 8km S. Bridgetown

Material ex 8km S. Bridgetown, G. Keighery 4292 is self fertile and autogamous.

V. calcarata is a synonym of V. monantha

*V. hirsuta (L.) S.F. Gray
grids 255, 264, 266, 274, 282. flowers 8-11
No pollinator visits
Material ex Kings Park, G. Keighery 2460 is self fertile and autogamous.

*V. monantha Retz.
grids 248, 256, 265, 277 flowers 8-10
Material ex Ravensthorpe, G. Keighery 6071 is self fertile and autogamous.

*V. sativa L. ssp. sativa
grids 255, 264, 266, 274, 282, 287. flowers 8-11
Material ex Bunbury, G. Keighery 1296 is self fertile and autogamous.

*V. sativa ssp nigra (L.) Ehrh.
grids 264, 273, 275, 287. flowers 9-11

V. tetrasperma (L.) Schreber
not naturalized, no collections at Perth.

Vigna

*V. radiata (L.) Wilezek var setulosa (Dalz.)

Ohwi et Ohaski
grid 110, flowers 3-5

Acknowledgements

Access to the collections of the Western Australian Herbarium and UWA were provided by their curators. Mrs. J. Dewing obtained material used in this

study. Bronwen Keighery provided space and care for many Legume weeds in our home garden.

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Breeding System of Glossotigma drummondii Benth. (Scrophulariaceae)

G. J. KEIGHERY

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WEST PERTH, 6005 WESTERN AUSTRALIA

The genus Glossotigma Wight and Walker-Arnott ex Walker-Arnott is centred in Australia, with one species occurring also in New Zealand and another extending through India to tropical Africa. Currently no information is available on the breeding systems of this genus. Within Western Australia a least four taxa have been found, but the genus is poorly collected and it's taxonomy considerably confused. Both taxa studied in this report are presently attributal to Glossostigma drummondii.

Glossostigma species form colonies on the muddy bottoms of shallow ephemeral pools or swamps (hence the common naem : mud mats). The adult plant may flower above or below water depending on weather conditions. Pollen is released directly onto the stigma at anthesis ; hence automatic selfing occurs as the flower opens. Viable seed is produced by autogamy and selfed plants have passed through three generations at Kings Park.

Plants are strictly annual, producing fruits till early summer when the adult plant dies. Seeds are released by the rotting of the sunken indehiscent capsule, and germinate as temperatures fall when the winter rains occur.

Figure 1 :

a - e : Glossostigma drummondii : collection 15km. W. Mt Ragged (30^{o} 25's 123^{o} 35' E) Wittwer 1905.

f - g : Glossostigma sp. : High Island (33^{o} 55's 122^{o} 35'E)

a) gynoecium ; scale bar 1mm

b) stigma ; scale bar 0.5mm (black dots are pollen grains)

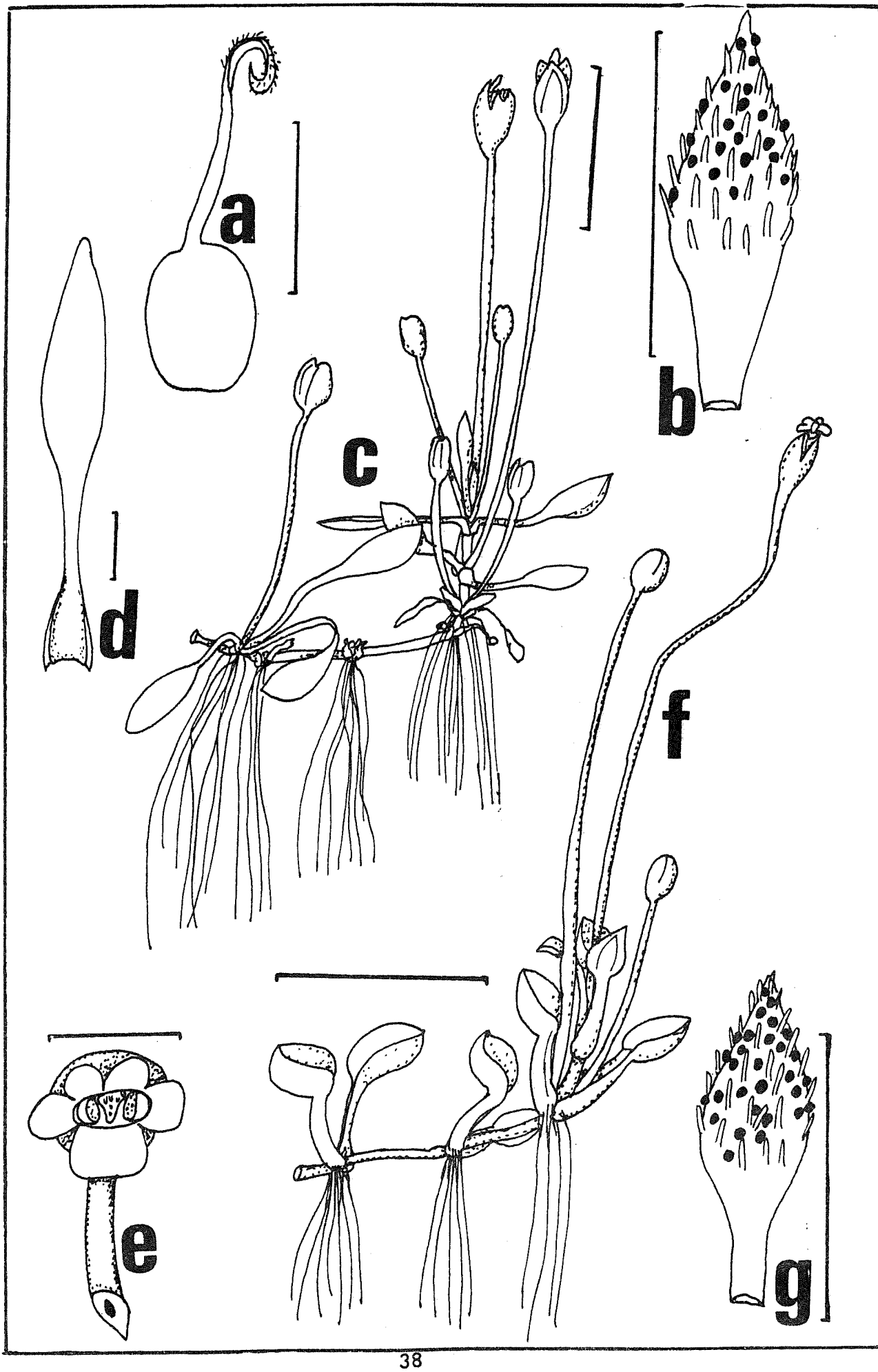
c) portion of plants ; scale bar 5mm

d) leaf, scale bar 1mm

e) flower, scale bar 1mm.

f) portion of plant, scale bar 1cm

g) stigma, scale bar 0.5mm


a
b
c
d
e
f
g

Phytogeography of Western Australia's Monocotyledons

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Abstract:

Examination of species diversity patterns and distributions of the ca 1300 species of native Monocotyledons of Western Australia has revealed striking differences between groups. The families Restionaceae, Iridaceae, Juncaginaceae, Juncaceae, Xyridaceae, Hypoxidaceae, Centrolepidaceae and Poaceae are species rich in the high rainfall zones of southern Western Australia. In comparision, the families Haemodoraceae, Liliaceae, Orchidaceae and some Cyperaceae are species rich in the transitional rainfall zone (northern and southern sandplains).

Within the desert, the Nullabor is always species poor, compared to regions of relief and habitat diversity (especially the Pilbara and the Central Australian ranges). The sandy deserts are also comparatively species poor.

Phytogeographical patterns are poorly understood in the Kimberley, but the wetter western Kimberley contains the highest diversity of Xyridaceae, Liliaceae and probably Cyperaceae. Further collecting is needed to confirm this trend.

Most groups are in need of systematic collecting on a geographical basis.

Introduction

Western Australia with a land area of 2,525,500 square kilometres, comprises approximately a third of the total area of the Australian continent.

Much of the state is desert, but the temperate region (the South Western Botanical Province) is considered one of the major areas of phytogeographical interest on the continent (Brown, 1812 : Hooker, 1860 ; Diels, 1906 ; Gardner, 1944 ; Burbidge, 1960 ; Marchant, 1973 and Hopper, 1979).

Previous reports on the phytogeography of the flora of Western Australia, have been based on vegetation types (Gardner, 1944 and Beard, 1980) or on the distribution of genera (Burbidge, 1960). More recently studies have been undertaken on groups at the species level, for the Proteaceae (Speck, 1958), Acacia (Burbidge, 1960, Hopper and Maslin, 1978), Eucalyptus (Burbidge, 1960 and Chippendale, 1981) and Fabaceae (Keighery 1981c, 1984).

Information on the distribution of all known species according toBotanical Districts was given in Beard (1970).

Currently the auther is revising Beard (1970), and has recently completed the monocotyledons. This paper is the result of this study.

Materials and Methods

Distributions of all ca 1300 (1231 named species listed in Green (1981)) native and naturalized monocotyledons were compiled from specimens held in PERTH, Kings Park and UWA. Localities were recorded on a 1^{o} latitude x 1.5^{o} longditude grid, which is a widely used biogeographical grid for Australia, and covers Western Australia in 179 grids.

Base maps for the monocotyledons have been compiled into a series of reports (Keighery, 1979, a and b ; 1980, 1981 a,b, c and d ; 1982 a, b, c and d; 1983. Keighery and Brighton, 1982, 1983, Keighery and Marchant, 1979).
The Haemodoraceae are not covered by these reports, but have been compiled in part by the author, except for Conostylis where the information was supplied by S.D. Hopper.

Phytogeographic analysis of these distributions has consisted chiefly of compiling these maps into species diversity maps to compare these groups to previously undertaken studies. Naturalized aliens are mapped in the reports but are not further considered here.

RESULTS

Geographical Patterns in small families.
Table 1 lists those families (24) which are too small to permit any further analysis than a species' map. Significant outliers are noted in Table 1. Several of these groups would be ameneable to study but are too poorly collected (Pandanaceae, Areaceae and Lemnaceae) or are very confused taxonomically (Eriocaulaceae).

RESTIONACEAE

The Restionaceae of Western Australia comprise 64 species distributed in 16 genera. All are wind pollinated, perennial rhizomatous, generally dioecious herbs. Recently Cutler and Shaw (1965) divided the Australian Restionaceae into three separate families; Anarthriaceae, Ecdeiocoleaceae and Restionaceae

Table 1: Minor Monocotyledon Families

Family	No. Genera	No. Species	Geographical Notes
20: Typhaceae	1	1	wetlands : S.W., coastal, NBP, Eremaean: Pilbara.
21: Pandanaceae	1	6(+5 varieties)	tropics, N. 19°s outlier, P. spiralis var flameus, at Logue Spring 18°50's 123°47'e.
22: Ruppiaceae	1	4	1 genus: marine, tropics 3: brackish water, S.W.
23: Potamogetonaceae	3	9	Potamogeton: 3 tropical, 2 S.W., 1 both: freshwater. Thalassodendron: 1 tropical, 1 SW: marine Syringodium- marine, s.24°s.
23a: Posidoniaceae	1	5	Marine-s.22°s.
23b: Zosteraceae	2	2	Marine-S.22°s.
23c: Zanichelliaceae	4	10	Marine-Amphibolus s.21° -Cymodaceae s.21° -Halodule n.30° Saline marshes - Lepilaena
24: Najadaceae	1	3	Aquatics, largely tropical.
25: Aponogetonaceae	1	2	1 tropical, 1 temperate
27: Alismataceae	2	2	Caldesia, freshwater, n. 18°s. Damasonium, fresh water, S.W.
29: Hydrocharitaceae	5	9	Maidenia, freshwater, n.18°s. Halophila, marine, 1.S.W., 3 tropical, Hydrilla, freshwater, n.19°s. Ottelia freshwater, 1 S.W./N.W. Vallisneria; 2. n24°s.
29a: Blyxaceae	1	2	freshwater, n17°s.
33: Areaceae	1	5	N.W., 4 Kimberley, 1 outlier (L. alfredii, at 21°35's, 117°04'e.)
35: Araceae	3	4	Wet tropics, n.15°s.

36: Lemnaceae	3	8	Lemna, 4 S.W., 1. N.W. Spirodela, 2. S.W. Wolffia, 1 N.W.
38: Flagellariaceae	1	1	Wet tropics, n.17°s
43: Eriocaulaceae	1	7	tropics, n.18°s.
47: Commelinaceae	4	9	8 tropical, 1.S.W.
48: Pontederiaceae	1	1	tropics, n.18°s.
50: Philydraceae	2	2	lendemic genus (Philydrella) in S.W. Philydrum N.W.
56: Amaryllidaceae	2	4	2 tropics, 1 eremaean/ tropics.
58: Taccaceae	1	2	tropics, n.16°s.
59: Dioscoreaceae	1	3	2 tropics, 1 S.W./ eremaean.
65: Burmanniaceae	1	1	tropics, n.17°s.

s.s. If this treatment is followed, the Anarthriaceae (a monogeneric family) is endemic to Southern Western Australia. Anarthria (6 species) is clearly most diverse on the southern heathlands where 5/6 species are recorded per grid square (fig. 1., see also Keighery and Marchant 1979).

The Ecdeiocoleaceae currently contains the sole species Ecdeiocolea monostachya, but an undescribed genus closely related to Ecdeiocolea is found in the Eneabba area. (Johnson and Briggs, 1981). Both genera occur in sandy soils in the north-eastern regions of Southern Western Australia (fig. 2).

However Johnson and Briggs (1981) do not consider that segregation of the Restionaceae into smaller units can be justified on current evidence. The Restionaceae (including Anarthria and Ecdeoicolea) are largely confined to Southern Western Australia and the interzonal region. (except for Loxocarya flexuosa and Lepidobolus preissianus which occur on Dirk Hartog Island ; Lepidobolus preissianus also occurs at Queen Victoria Springs on the edge of the Great Victoria Desert. Loxocarya flexuosa extends along the southern margin of the Nullabor to at least Madura, while Anarthria gracilis extends to Eyre).

The Restionaceae have a very high degree of generic endemism in Southern Western Australia. The following genera are endemic : Anarthria (6 species, fig. 1) ; Alexgeorgea (2 species, centred northern sandplains) ; Chaetanthus (2 species, high rainfall zone) ; Ecdeiocolea (1 species, fig. 2) ; Harperia (1 species, central heathlands), Hopkinsia (2 species, semi-arid regions) ; Lyginia (1 species, throughout south-west); Meeboldinia (1 species, high rainfall zone) Onychosepalum (1 species, widespread in heathland). No particular distribution patterns is discernable in most of these small genera.

Species diversity is greatest in the climatically moderate regions of the Jarrah forest zone and southern coastal heathlands (fig.9.). This is reflected in all major genera (Anarthria, fig. 1 : Leptocarpus, fig. 3 ; Lepyrodia, fig. 4, Loxocarya, fig. 5 and Restio, fig. 6.

This is somewhat at variance with the observations of Diels (1906) and especially Gardner (1944) who stated that (page lxii)". The Restionaceae unlike the Cyperace are mainly psammophilus and are equally at home in the periodically swampy areas, or on the dry sands where they sometimes assume a position of importance".

Iridaceae

Perhaps more renowned in Western Australia as naturalized flora (some 37 species in 7 genera in South Western Australia), several of which are serious agricultural weeds. Two native genera, Patersonia (11 species) and Orthrosanthus (4 species, 1 with 2 varieties) are found in South Western Australia (Keighery, 1980).

Both genera are perennial rhizomatous herbs, with diurnal blue or purple (one species has yellow) flowers, which are pollinated by pollen collecting bees. One species Patersonia babanoides, has a remarkable "corm" like rhizome and general "Babiana" appearance, and deserves furhter study as to it's generic placement.

Patersonia appears to have diversified in the forest zones of Western Australia. (fig. 7) Patersonia babianoides and P. xanthina are confined to this area; P. umbrosa in the wetter southern margins and P. pygmaea in the north. Secondary areas are the heathlands (norhtern - P. drumondii, P. graminea and P. rudis ;southern - P. inaequalis and P. lanata).

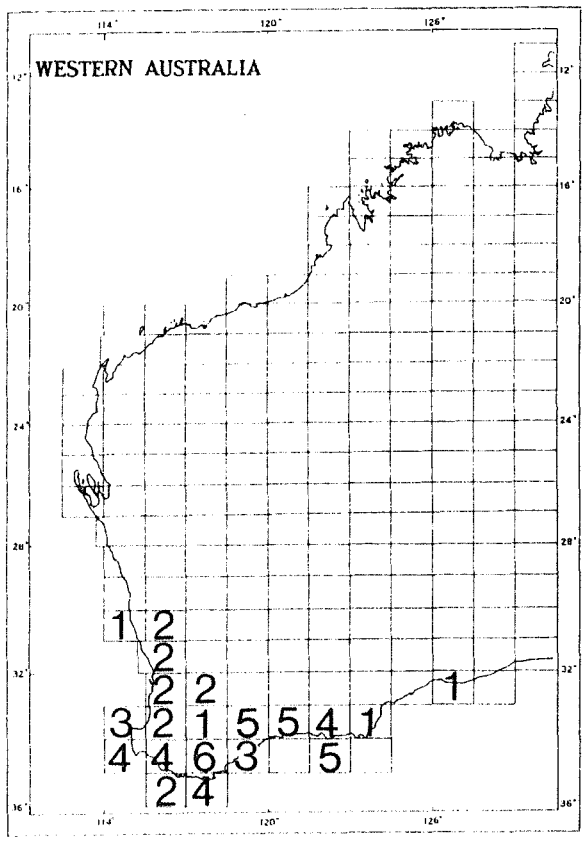


Fig.1: Species Diversity in Anarthria

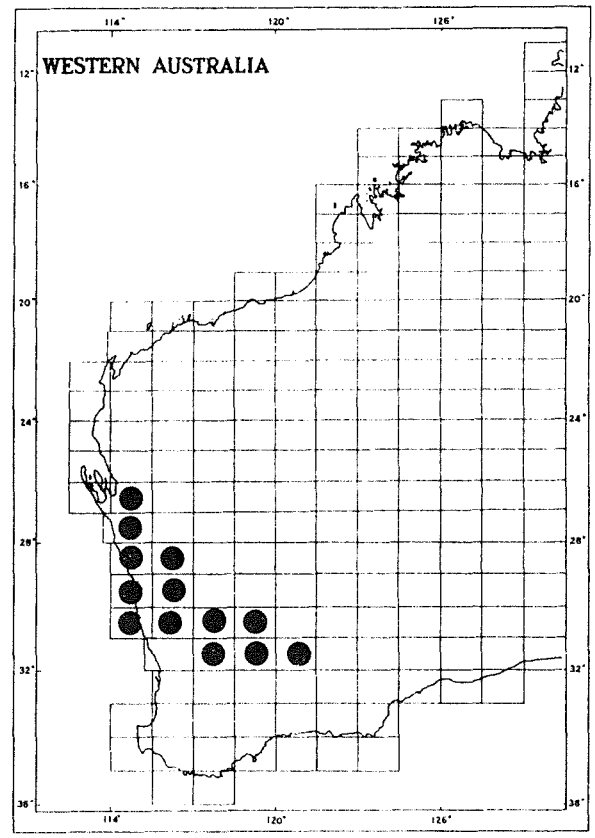


Fig.2 : Distribution of Ecdeiocolea

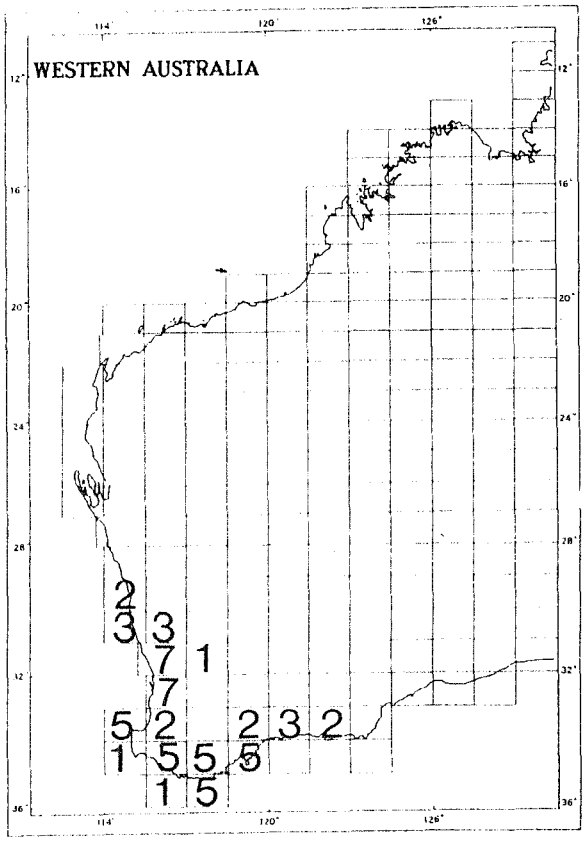


Fig. 3 : Species Diversity in Leptocarpus

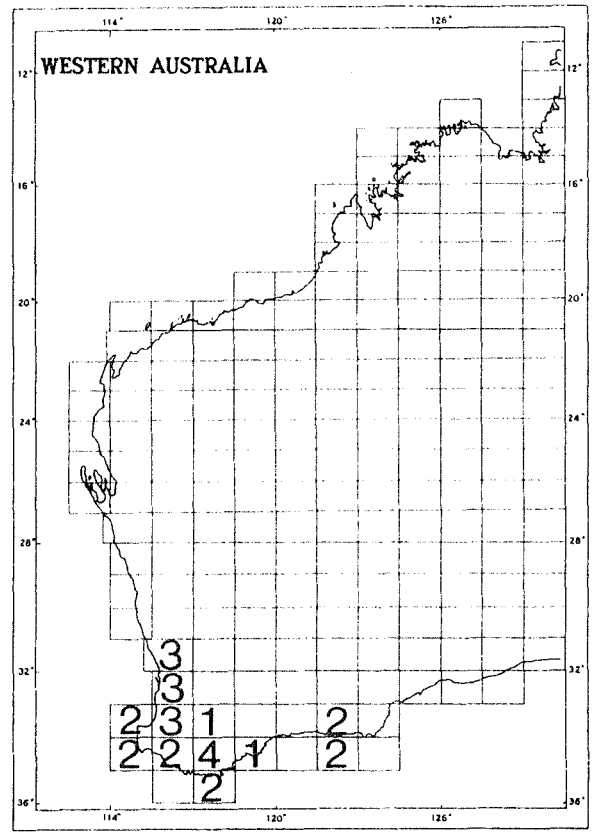


Fig. 4 : Species Diversity in Lepyrodia

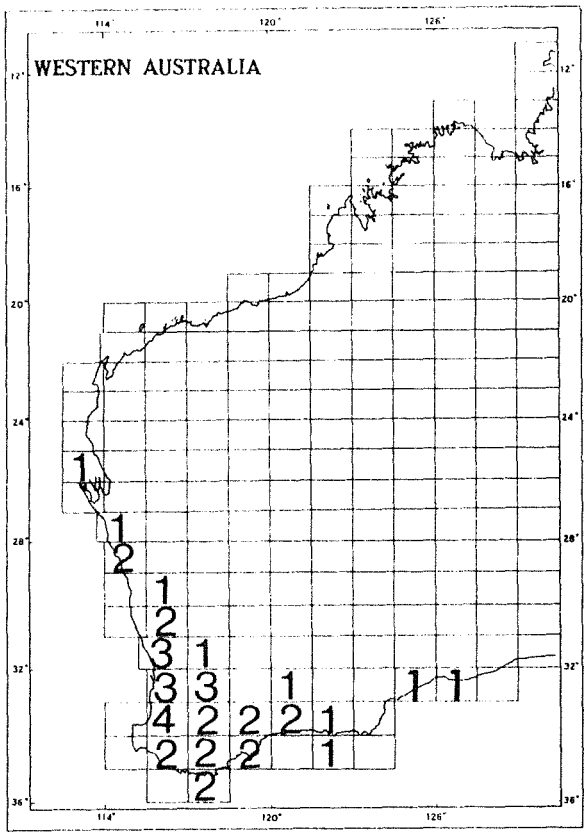


Fig. 5 : Species Diversity in Loxocarya

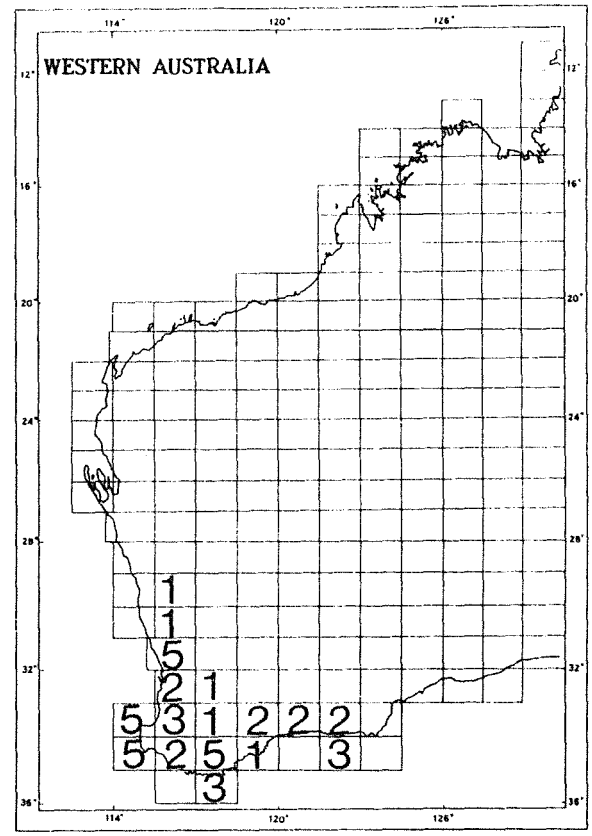


Fig. 6 : Species Diversity in Restio

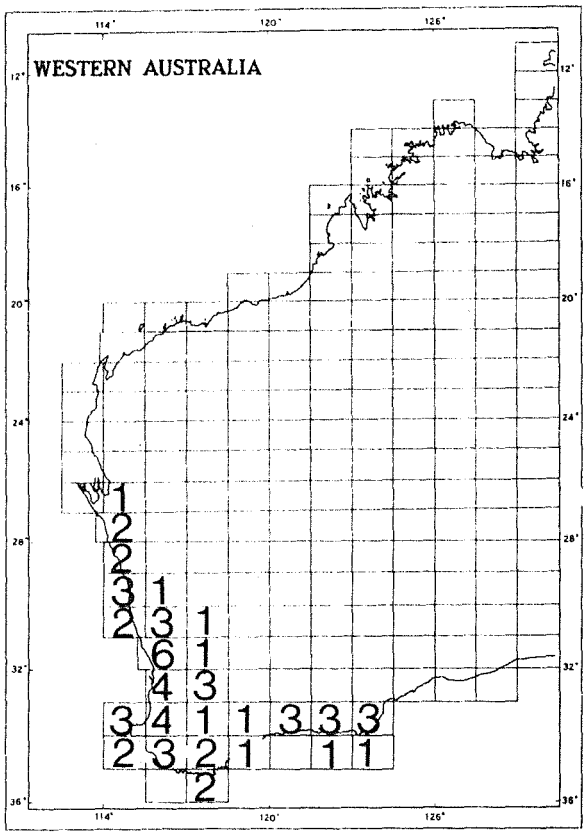


Fig. 7 : Species Diversity in Patersonia

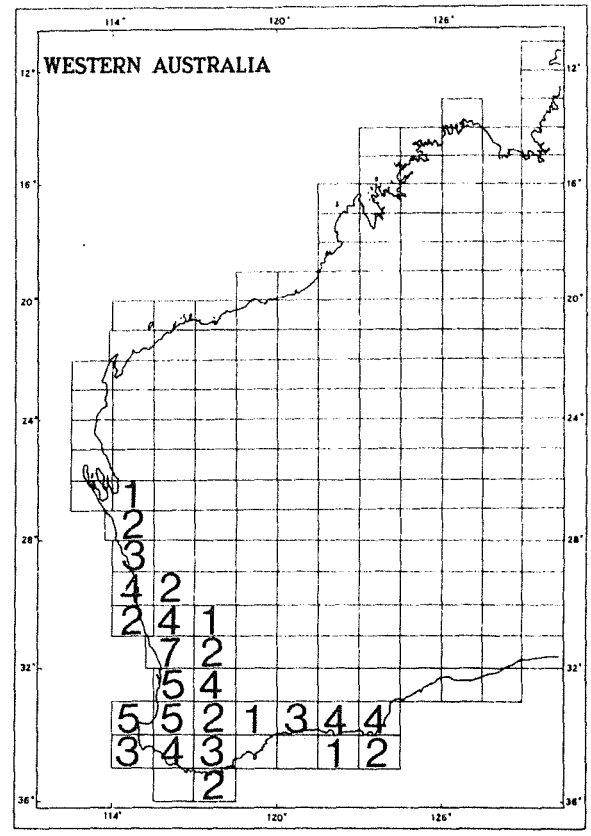


Fig. 8 : Species Diversity in the Iridaceae

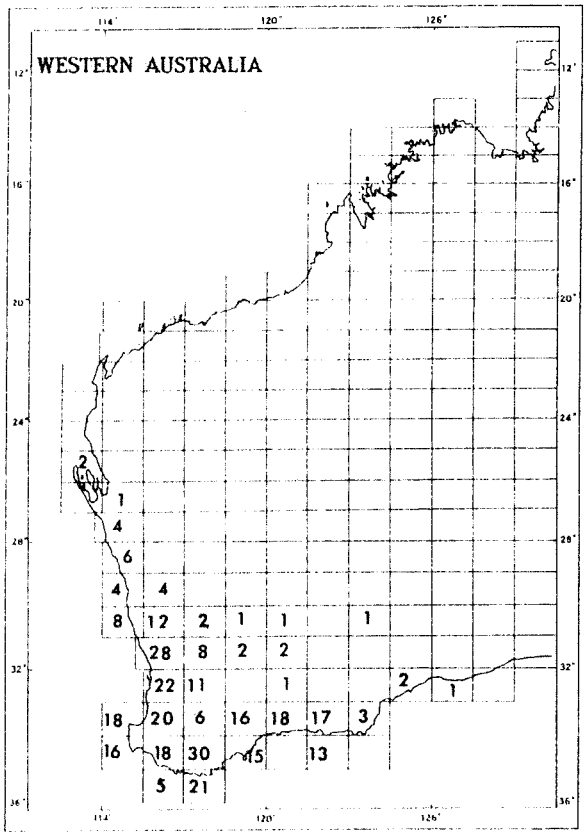


Figure 9 : Species Diversity in the Restionaceae

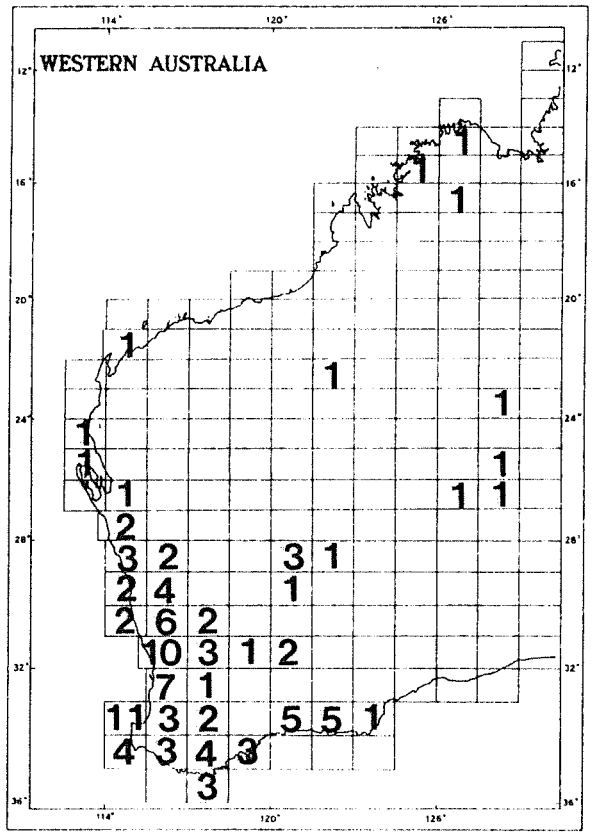


Figure 10 : Species Diversity in the Juncaginaceae

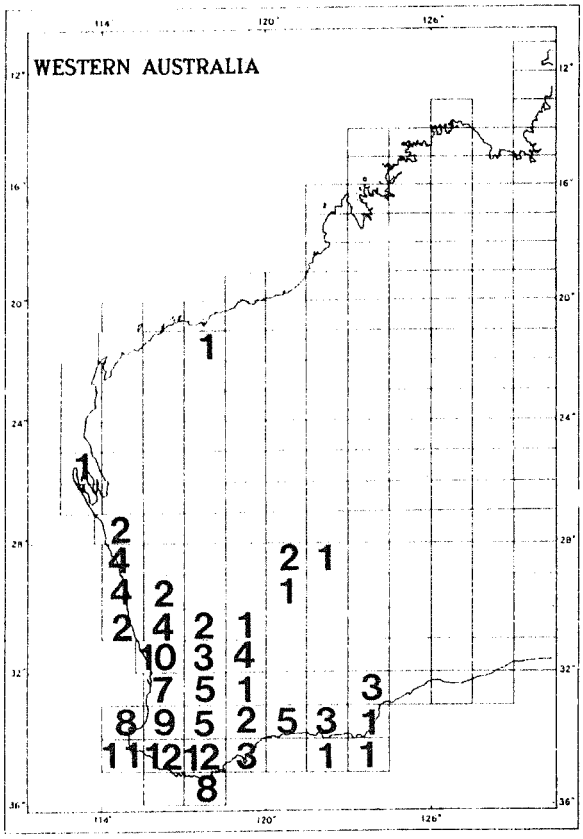


Figure 11 : Species Diversity in the Juncaceae

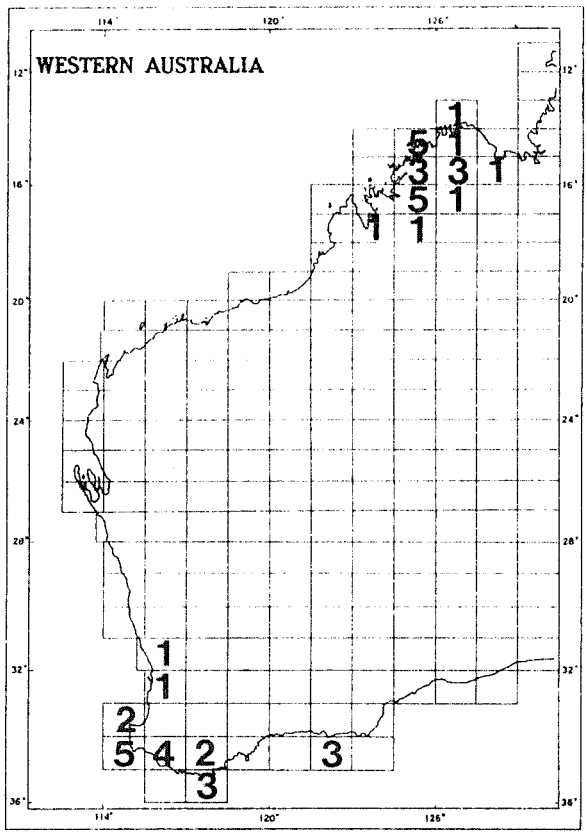


Figure 12 : Species Diversity in the Xyridaceae

Orthrosanthus has 2 species in the southern heathlands, one in the forest zone and one in the forest zone and northern heathlands. The species are largely mutually exclusive in distribution.

One of the family scale (fig, 8) the family is centred in the forest zone, with considerable speciation in the transitional rainfall zone.

Juncaginaceae

One (occassionally two genera, if Triglochin procera, is segregated as a separate genus Cycnogeton Endl., differing chiefly in the lack of sterile carpels or anthers) genus, Triglochin of 14 species (3 undescribed). The genus is cosmopolitan, but the majority of species are restricted to Australia. Two / ? three species occurring in Western Australia are perennial rhizomatous tuberous herbs found in very moist habitats. One (T. striata) is largely coastal in brackish or semi-saline habitats, south of 31° latitude. The other (T. procera) occupies ephemeral or permanent freshwater wetlands, and may be remarkably disjunct between the Kimberley region and south-western Australia (sometimes the tropical form is segregated as a separate species T. pterocarpa - Keighery, 1979b.)

The annual species of Triglochin (12 in south-western Australia) are all small herbs which occupy ephemeral micro-wetlands. The annuals are self fertile generally more inbreeding than the perennials (Keighery, 1975), and in the wetter regions of south western Australia up to 5 species can be found growing sympatrically though no evidence of hybridization has been recorded.

Several species are very widespread in Southern Western Australia and the adjacent desert regions (T. calcitrapa and T. centrocarpa) and another (T. mucronata) extends marginally into the desert. Two species (T. hexagona and T. aff. hexagona) are restricted to the desert. All species which occur in the desert are capable of growing in brackish seepages edging saline lakes common in this region. The other species unable to cope with brackish water occur only in the higher rainfall regions (fig. 10).

While the family is relatively poorly collected, due perhaps to the small size of many of it's members, species' diversity (fig. 10) is clearly greatest in the high rainfall regions of south Western Australia (eg Perth sheet : 10 species/Busselton : 11).

Juncaceae

The Juncaceae of Western Australia consists of 22 species distributed in two genera (Juncus - 21 species and Luzula - 1 species). Five species are naturalized aliens, and one species (J. bufonis) is composed of native and introduced forms.(Keighery (1981,a))

All members of the family are wind pollinated, and self fertile, though most appear outbreeding. One species (J. bufonis) is often cleistogamous throughout much of it's range (Keighery, unpub. data).

The introduced species are found only in souther Western Australia, chiefly in irrigated pastureland or disturbed wetland regions. The majority of native taxa are also confined to this region, since most only occur in winter wet swampy or permanently wet habitats. It is not suprizing, therefore, that the highest species diversity (fig. 11) occurs in the high rainfall zones. No species of the family is endemic to south Western Australia, but at least one remarkable disjunction is known (Juncus cf holoschoenus at Millstream 21°35'S 117°04'E

Xyridaceae

One genus, Xyris with 8 species in southern Western Australia, and 6 species in the Kimberly region of Western Australia. All species bear diurnal yellow flowers pollinated by pollen collecting bees, except one small tropical species which is apparently inbreeding, Keighery 1982,c. Being confined to seasonally wet sites, species diversity in both tropical and temperate Western Australia (fig. 12) is highest where the annual rainfall is greatest.

Hypoxidaceae

Two genera, Curculigo (1 species) and Hypoxis (5 species). The genus Curculigo and Hypoxis marginata are found in the western Kimberley. Within southern Western Australia the greatest species diversity of Hypoxis species (fig. 13) is found in the high rainfall forest zone, but the genus is poorly collected and taxonomically confused (Keighery and Brighton, 1982).

Centrolepidaceae/Hydatellaceae

These two closely related families in Western Australia consists of the Centrolepidaceae (3 genera, ca 21 species) and Hydatellaceae (2 genera and 4 species). This family grouping has long been recognized as a major component of the "old" endemics of the Australasian region (Diels, 1906 and Gardner, 1944), but have been poorly collected (Keighery, 1982,d).

All bar one species (Centrolepis hummillima) are annual herbs, wind or self pollinated confined to seasonally wet habitats (Keighery, unpub data). In temperate Western Australia flowering occurs during spring (Aug. - Nov.) and seed is released during summer.

The species of Hydatellaceae present in Western Australia, are largely confined to temperate Western Australia, except for one species of Trithuria (T. ? lantera recorded for the Kimberley (fig. 15). Two of the three genera (Aphelia/ Brizula) of the Centrolepidaceae are also confined to southern Western Australia. Only 3 of the 16 species of the Centrolepidaceae (all Centrolepis spp) are fou nd in the Northern Botanical Province, where they occur in summer wet habitats. No species of Centrolepis have been recorded from the Pilbara or central desert regions.

The centre of species richness of the Centrolepidaceae is south Western Australia, with a few species extending marginally into the desert (fig. 14). Since members occupy very moist habitats (small pools on granite rocks, claypans, moss swards, creek beds and seepages) one would imagine that the high rainfall zones would contain the highest levels of specific diversity. It is true that this region does contain high numbers of species, but since members of these genera are very small they can occupy micro-wetlands, eg bear granite modanocks, hence the forest margins and southern coastal heathlands are also species rich.

These families are in need of careful systemtic collecting and survey.

Haemodoraceae

This family is one of the major monocotyledon groups of southern Western Australia. Containing 5 endemic genera and 57 endemic species. Only one genus Haemodorum occurs outside this region, chiefly in tropical Australia.

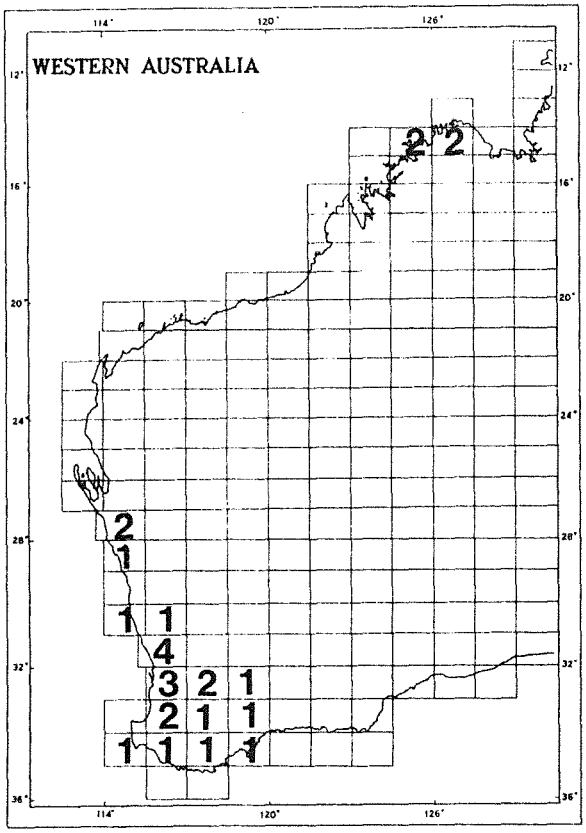


Figure 13 : Species Diversity in the Hypoxidaceae

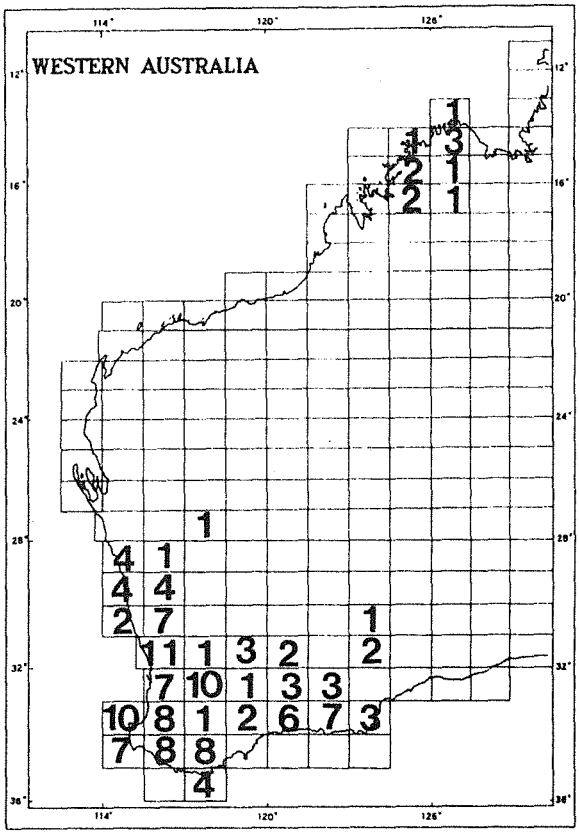


Figure 14 : Species Diversity in the Centrolepidaceae

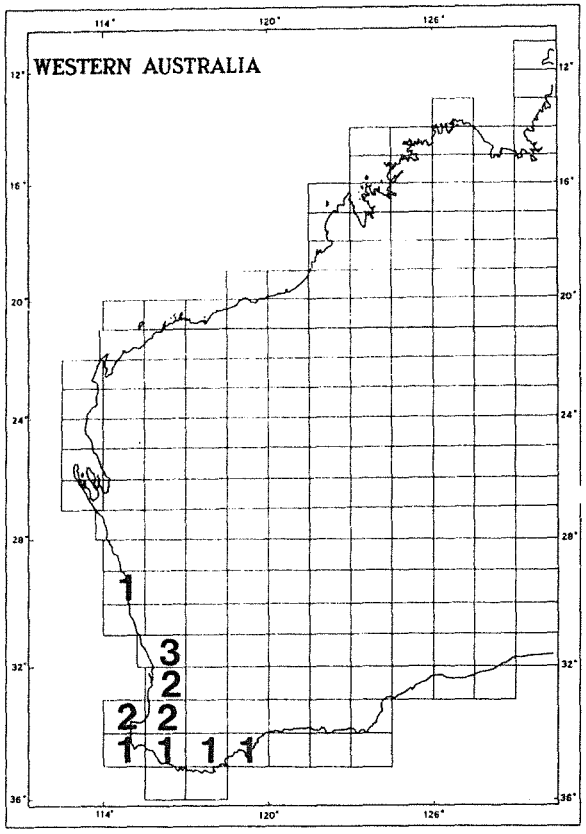


Figure 15 : Species Diversity in the Hydatellaceae

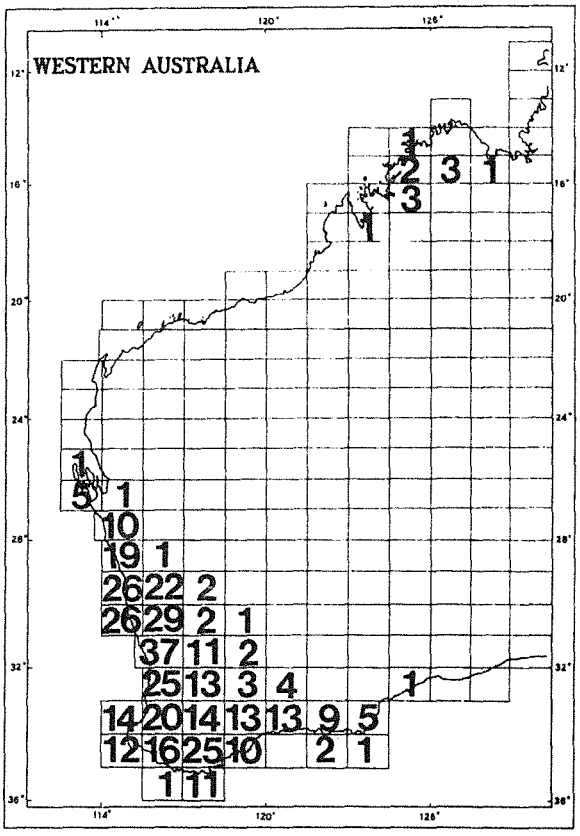


Figure 16 : Species Diversity in the Haemodoraceae

Haemodorum is a member of the Haemodoreae, whereas all other genera (Anigozanthos, Blancoa, Constylis, Macropidia and Phlebocarya) comprise the tribe Conostylideae, which is endemic to southern Western Australia.

The family is species rich on the northern heathlands and northern jarrah forest with a secondary centre on the southern heathlands (fig. 16).

Considering the component genera : Anigozanthos (fig. 18) is species rich on the Southern heathlands.

Blancoa, a monotypic genus occurs on the northern sandplains.

Macropidia, a monotypic genus occurs on the northern sandplains and northern jarrah forest.

Phlebocarya, with 3 species, 2 confined to the northern sandplains and 1 to the forest zone.

Conostylis (fig. 17) is clearly most diverse on the northern sandplains.

Both Haemodorum (fig. 19) and Tribonanthes (fig. 20) contain highest species numbers outside the forest zone, but more collecting and study is needed.

The Haemodoraceae are also unique amongst the monocotyledons of Western Australia in having a large number of species adapted to bird pollination (Anigozanthos (11 species), Blancoa (1), Conostylis (2) and Macropidia (1)).

The Larger Families

Liliaceae (including Xanthorrhoeaceae)
This family contains 167 species distributed in 37 genera. The great majority of species (131) are confined to southern Western Australia, and 12 genera are endemic to this region (Acanthocarpus (4 species), Agrostocrinum (1), Arnocrinum (3), Baxteria (1), Chamaexeros (4), Dasypogon (2), Hensmania (3), Hodgsoniola (1), Johnsonia (4), Kingia (1), Murchisonia (1), and Stawellia (2)), although all are relatively small.

Examining the larger genera in more detail, we can note that five are large enough to permit separate analysis. Borya (Keighery,1981,b)is most diverse in the northern jarrah forest and adjacent sandplains. Laxmannia (fig. 22) on the southern coastal sandplains. Lomandra (fig. 23) in the jarrah forest zone and edges of the karri forest. Thysanotus (fig. 24) in the jarrah forest and southern sandplains. Wurmbaca (fig. 25) in the northern jarrah forest and adjacent sandplains.

Considering the higher groupings, Keighery (1981,b) found the endemic tribe Johnsonieae to be most diverse in the jarrah forest and northern sandplains. The grouping of genera (Acanthocarpus, Baxteria, Calectasia, Dasypogon, Kingia, Lomandra and Xanthorrhoea) usually considered as the family Xanthorrhoeaceae (fig. 26) are species rich in the jarrah forest.

The family Liliaceae (fig. 21) while found throughout Western Australia, and having a minor centre of species richness in the Western Kimberley is clearly centred in southern Western Australia. Here the family has diversified on the northern heathlands, the jarrah forest and the adjacent southern coastal heathlands.

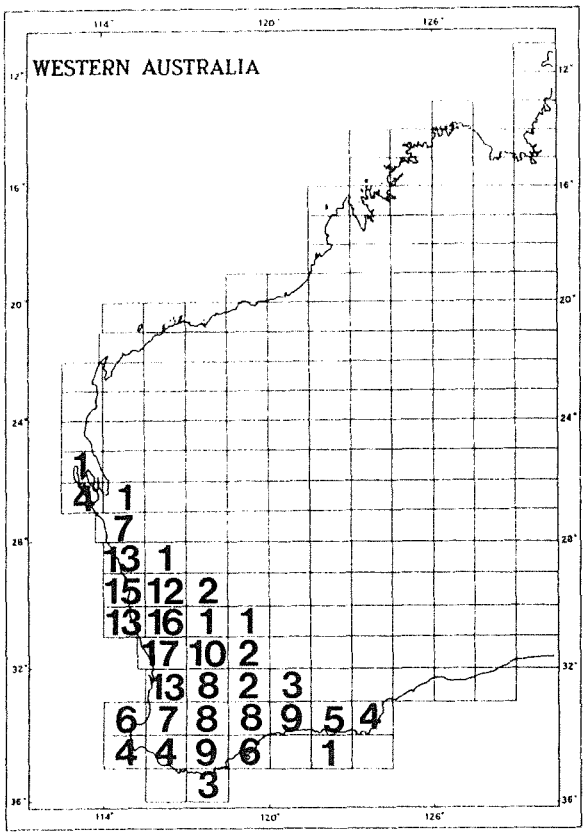


Figure 17 : Species Diversity in the genus Conostylis

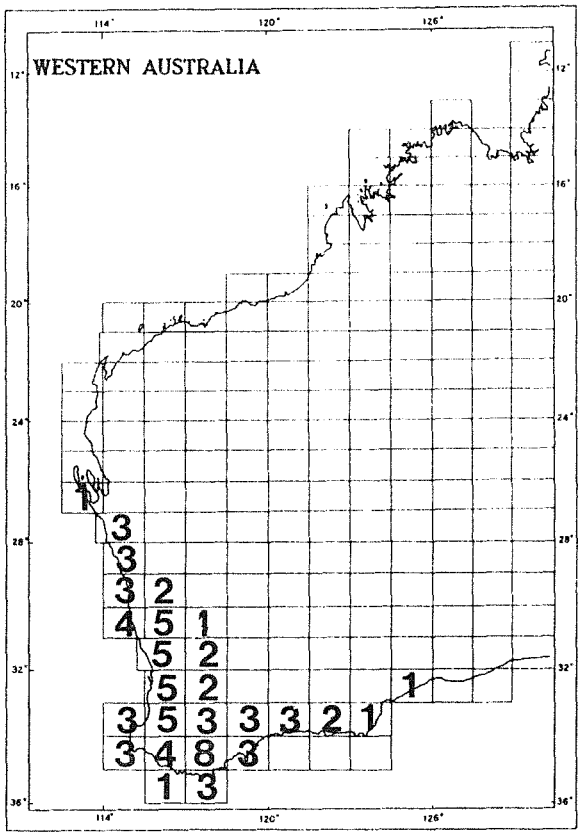


Figure 18 : Species Diversity in the genus Anigozanthos

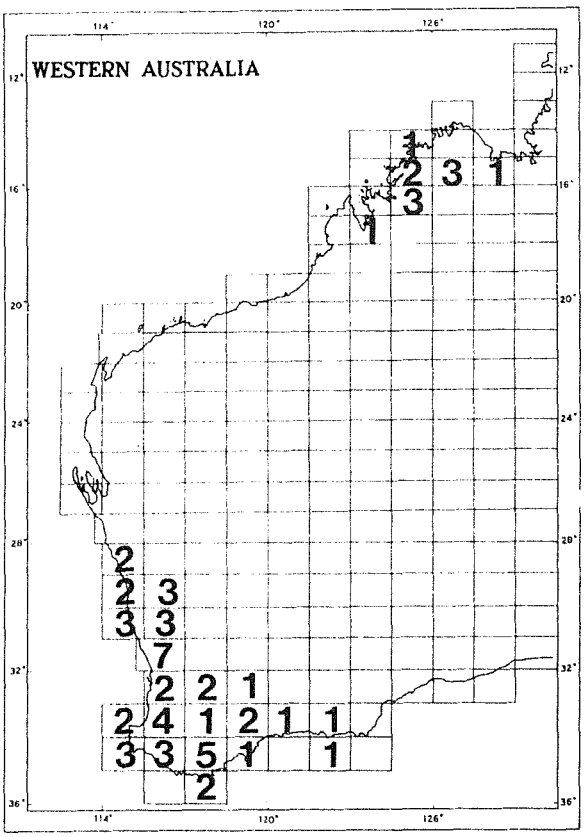


Figure 19 : Species Diversity in the genus Haemodorum

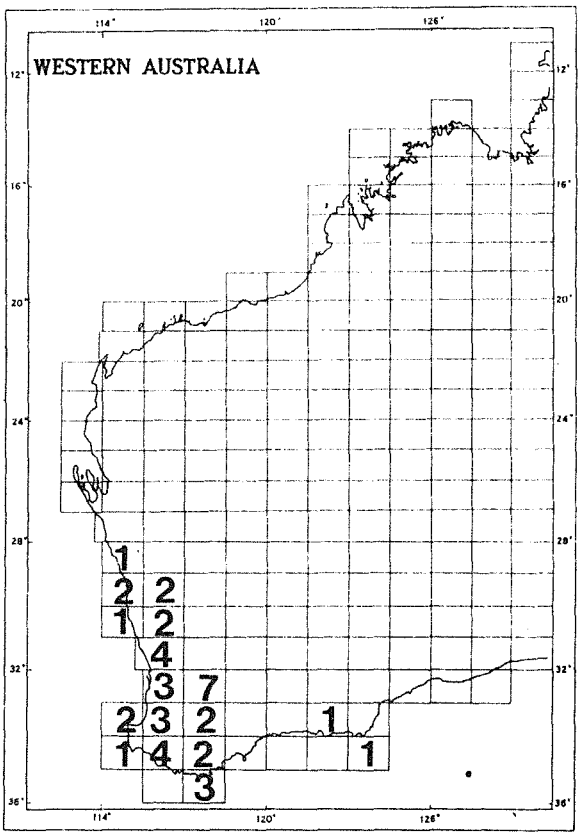
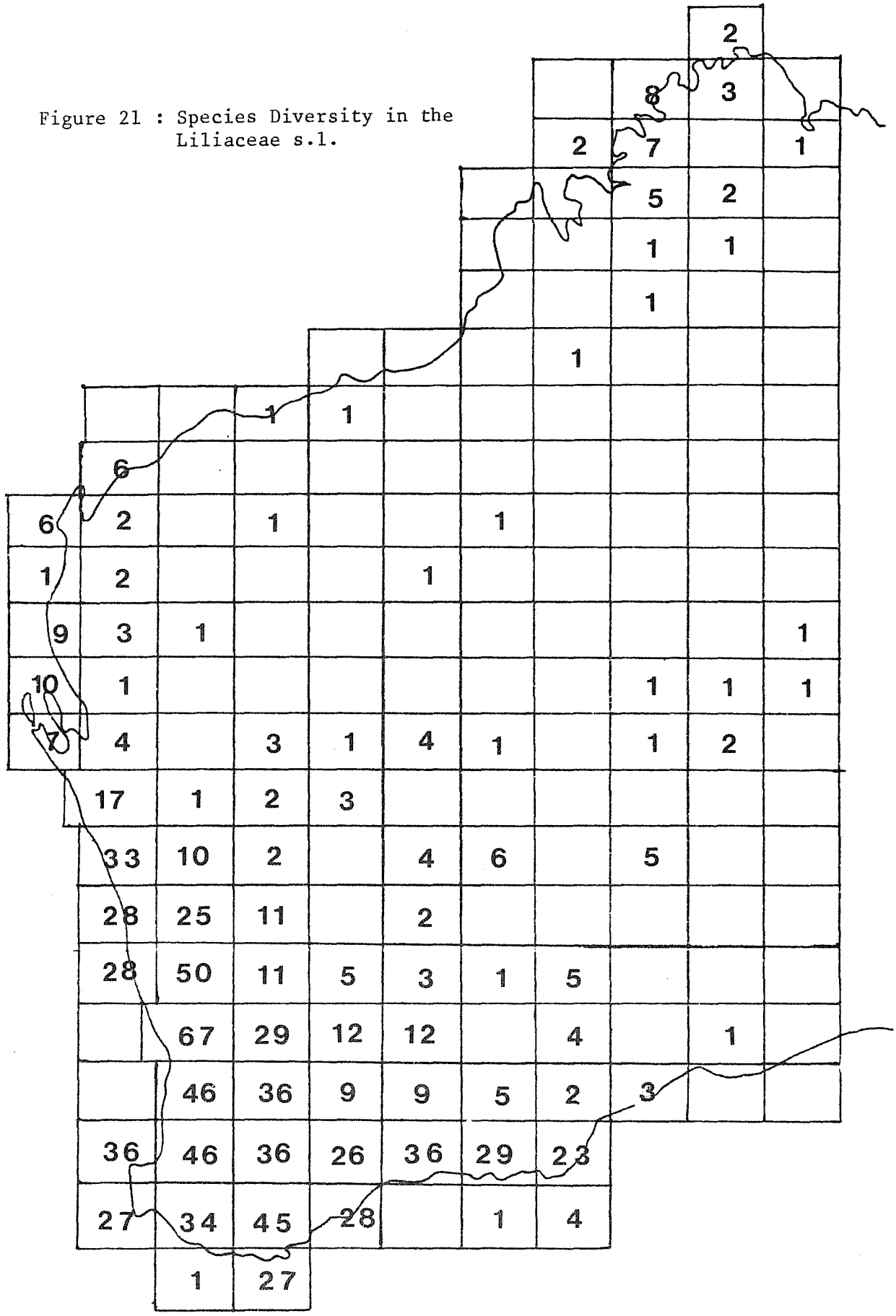


Figure 20 : Species in the genus Tribonanthes

Figure 21 : Species Diversity in the Liliaceae s.l.



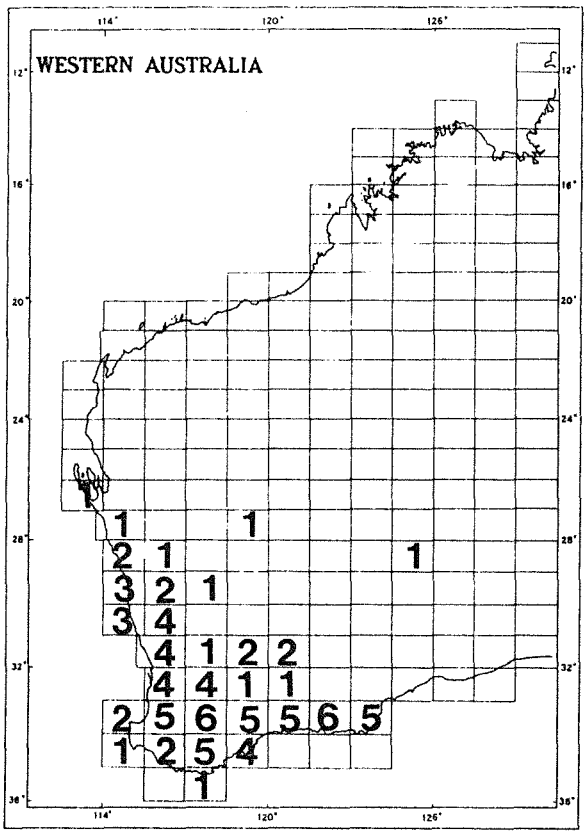


Figure 22 : Species Diversity in the genus Laxmannia

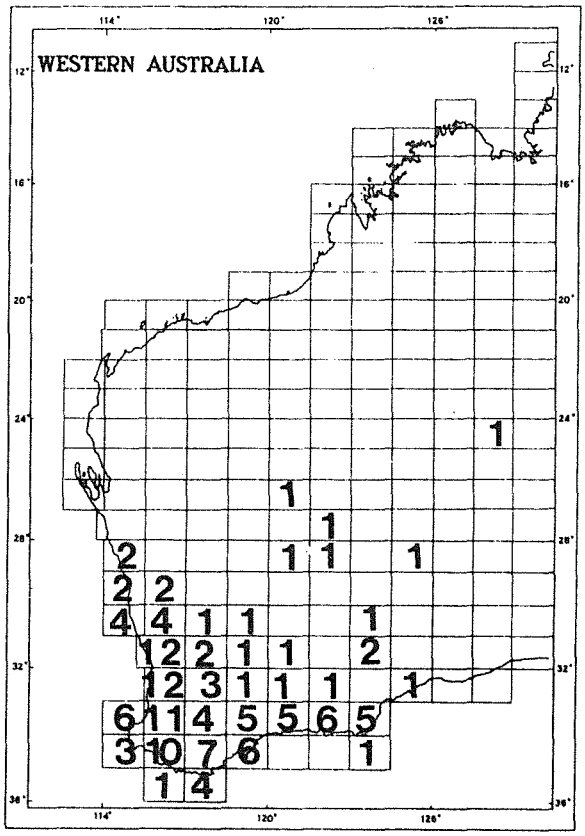


Figure 23 : Species Diversity in the genus Lomandra

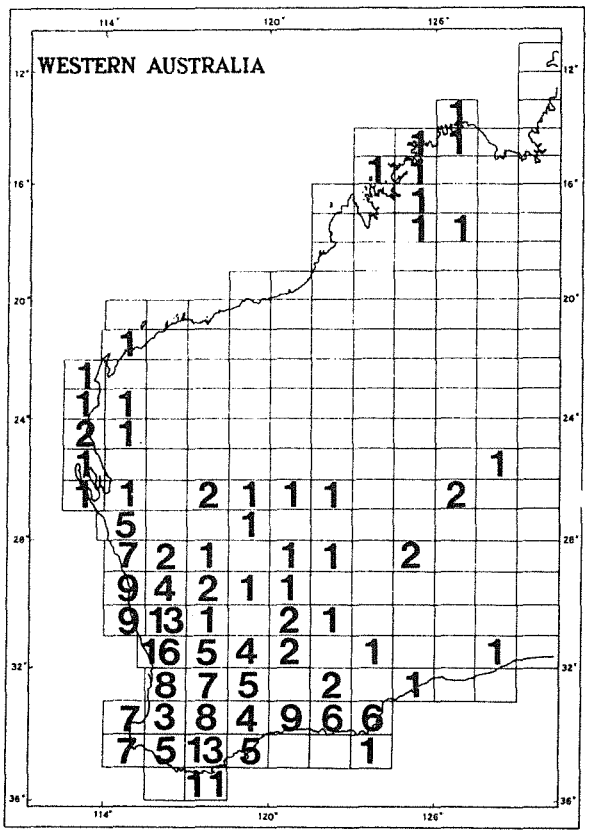


Figure 24 : Species Diversity in the genus Thysanotus

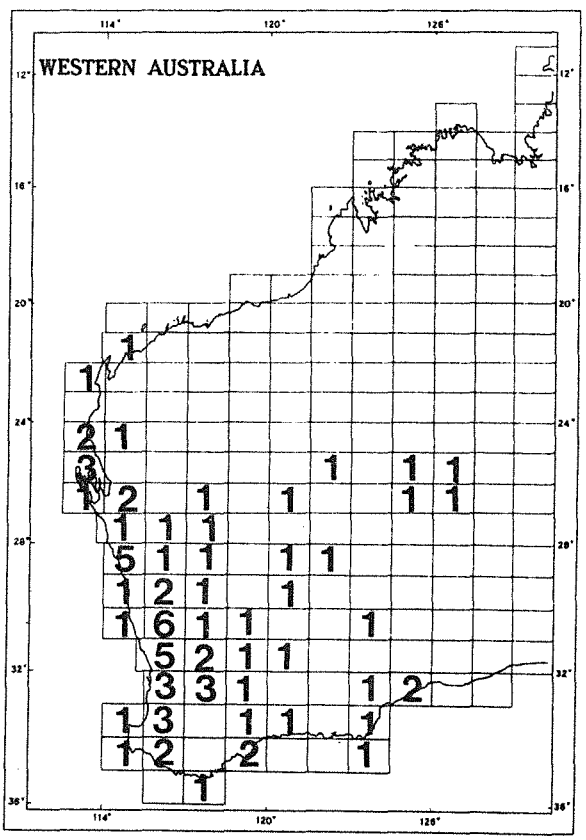


Figure 25 : Species Diversity in the genus Wurmbaea

Orchidaceae

Western Australia has 136 species (and 1 naturalized alien ; Monadenia micrantha) distributed in 26 genera. The family is largely confined to Southern Western Australia (fig. 27), where there is a high rate of specific endemism (89 species of 126 recorded for the region are endemic ; Keighery 1982,b), but only a few small genera (Drakea (4 speceies) ; Elythranthera (2 species) ; Epiblema (monotypic), Rhizanthella (monotypic) and Spiculea (monotypic)) are confined to this area. No other phytogeographical region of Western Australia has any endemic species.

The deserts are extremely poor in Orchids, only one species (Thelymitra sargentii R.S. Rogers) is found in a favourable microhabitat in the Great Victoria Desert at Queen Victoria Springs. Microtis unifolia (Forst. f.) Reichb. extends marginally into the desert regions, as does Pterostylis nana R.Br. and Prasophyllum nigricans R.Br. Marwick and Bates (1982) note that Pterostylis mutica extends from Western Australia to South Australia along the sandy costal stip south of the Nullabor Plain.

In the tropics, the high rainfall regions of the Western Kimberley (Mitchell Plateau has 8 species recorded) are the species rich regions for Orchidaceae. While this region is floristically the most diverse area of the tropics of Western Australia (Hopkins, et al (1983)), it is also the only area currently accessible during the "wet" when terrestial orchids flower.

In Southern Western Australia all species are perennial tuberous herbs (species of Corybas may occassionally be found on tree trunks). The family is undoubtably the best collected of any monocotyledon group, with over 100 collections recorded for some more common species. However, the family still needs systematic geographical collecting to fill the many remaining gaps (Keighery, 1982,b).

Based on current collections species diversity (fig.27) is greatest in the margins of the high rainfall zone forest regions and the transitional rainfall zone (Perth - 86 species ; Mt. Barker 77 species and Albany 78 species). While this result again displays collecting bias around Perth the family has speciated extensively on the sand heath regions, as can be seen in the larger individual genera.

Caladenia (fig. 28) has 30 species extending into the interzone region of the south west, and 14 species confined to this area. Further collecting will doubtlessly add to the levels of species diversity recorded for the inland sandheaths.

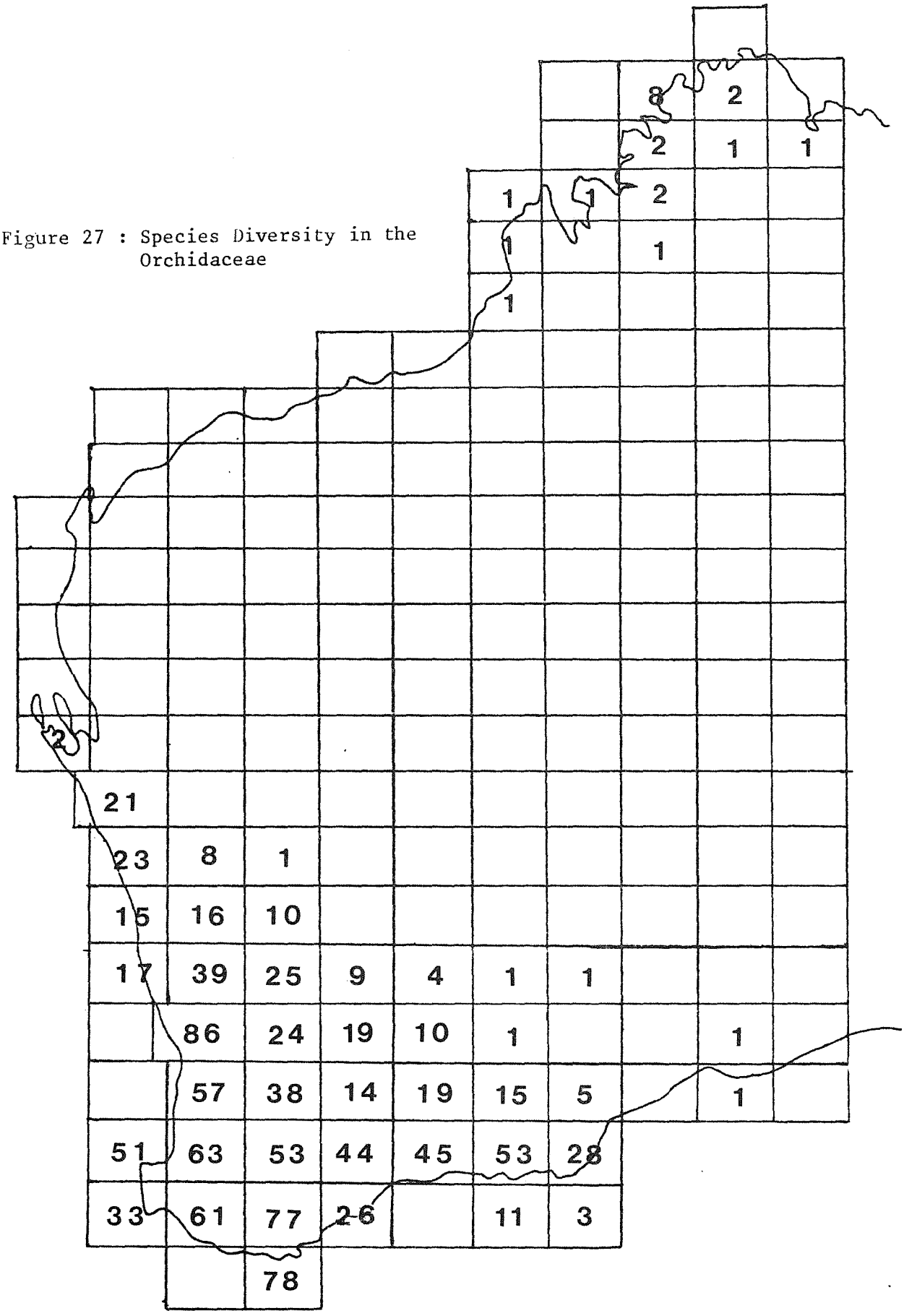
Diuris (fig. 29) has 5 species extending into the interzone region, but none are confined to this area, and specific diversity of this genus is highest in the forest zone and adjacent sandplains.

Prasophyllum (fig. 30) is taxonomically poorly known, but there are suggestions of high specific diversity in the northern jarrah forest and southern sandplains.

Pterostylis (fig. 31) and Thelymitra (fig. 32) both have high levels of specific diversity in the jarrah forest and adjacent sandplains regions.

Therefore, despite some collecting bias, the central wettest forest zones are comparitively species poor, but they do contain many relict species (eg Calochilus robertsonii) and may be important climatic refuges. Speciation

Figure 27 : Species Diversity in the Orchidaceae



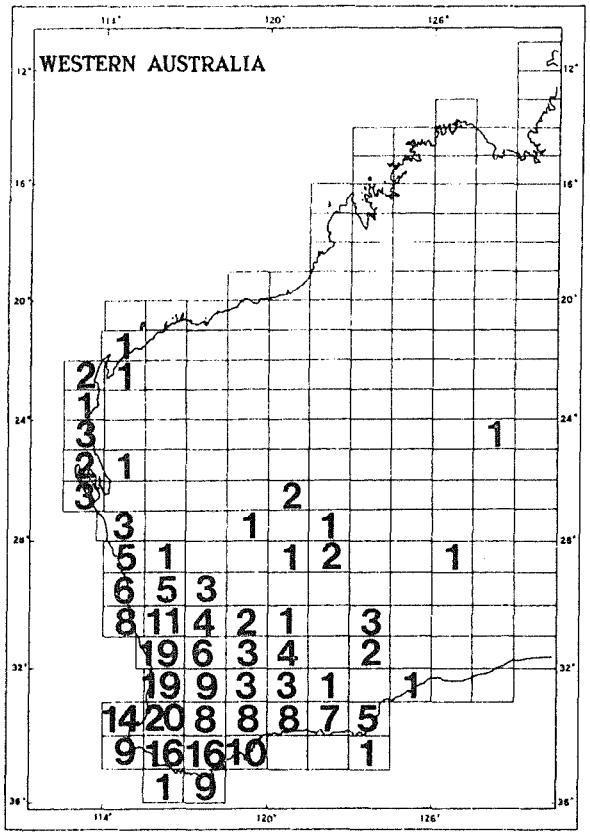


Figure 26 : Species Diversity in the Xanthorrhoeaceae

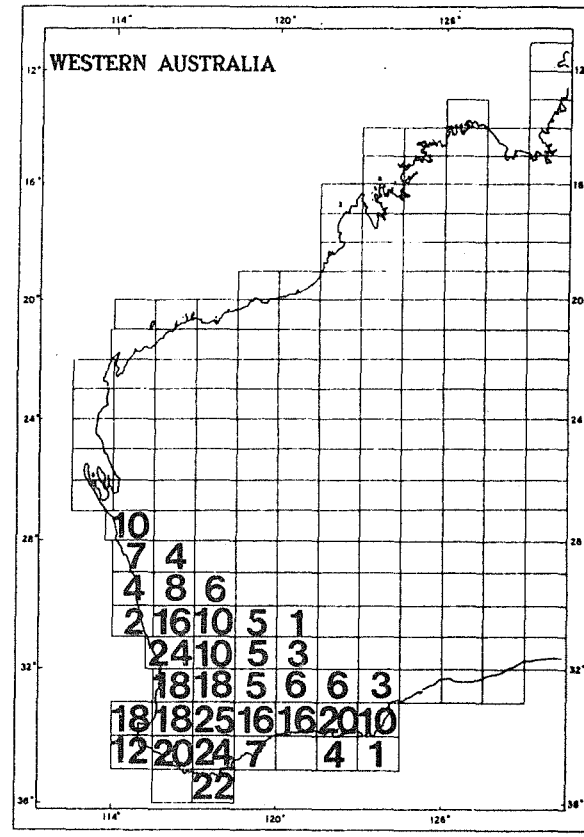


Figure 28 : Species Diversity in the genus Caladenia

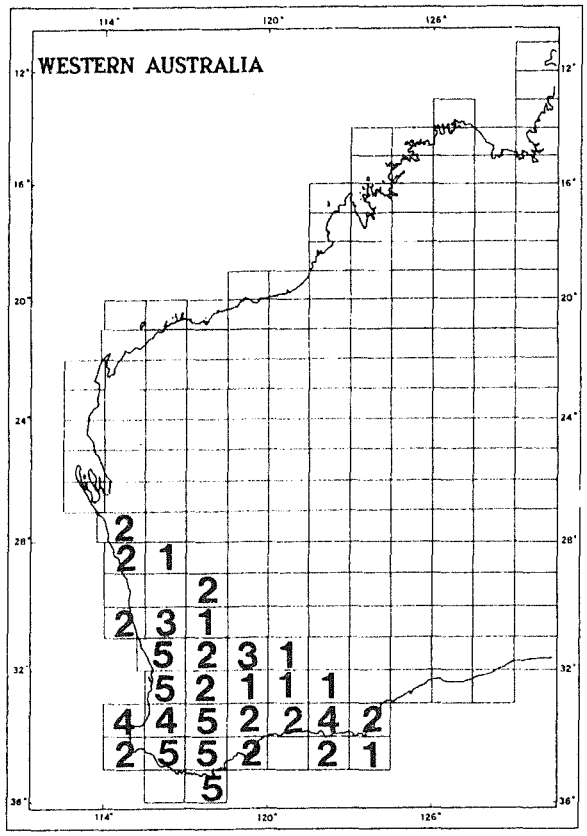


Figure 29 : Species Diversity in the genus Diuris

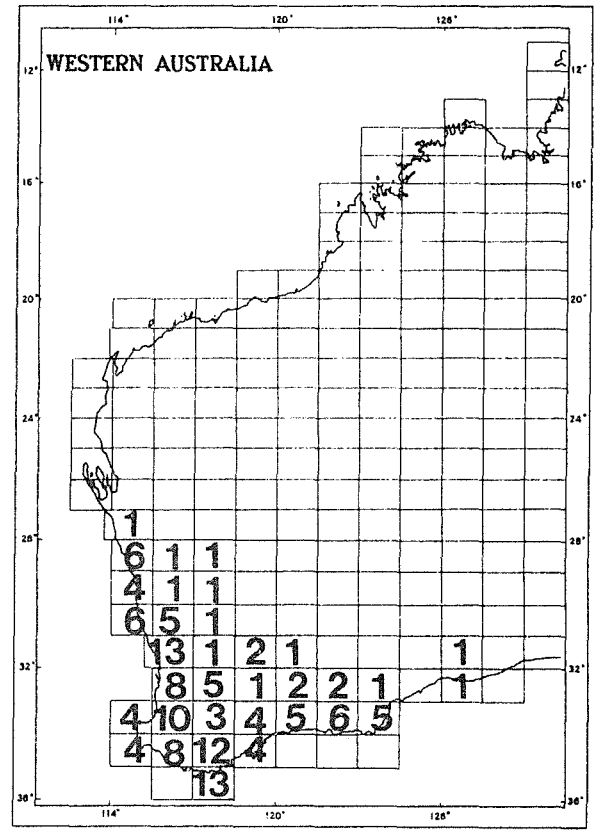


Figure 30 : Species Diversity in the genus Prasophyllum

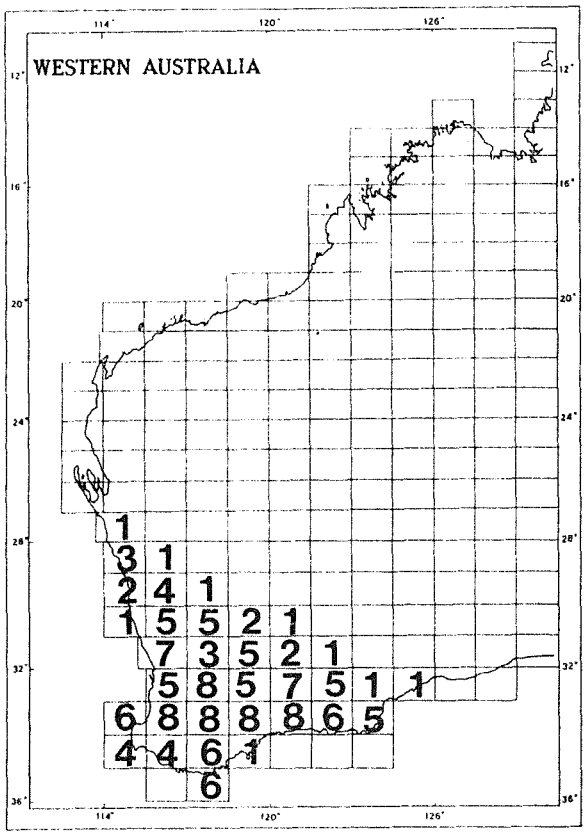


Figure 31 : Species Diversity in the genus Pterostylis

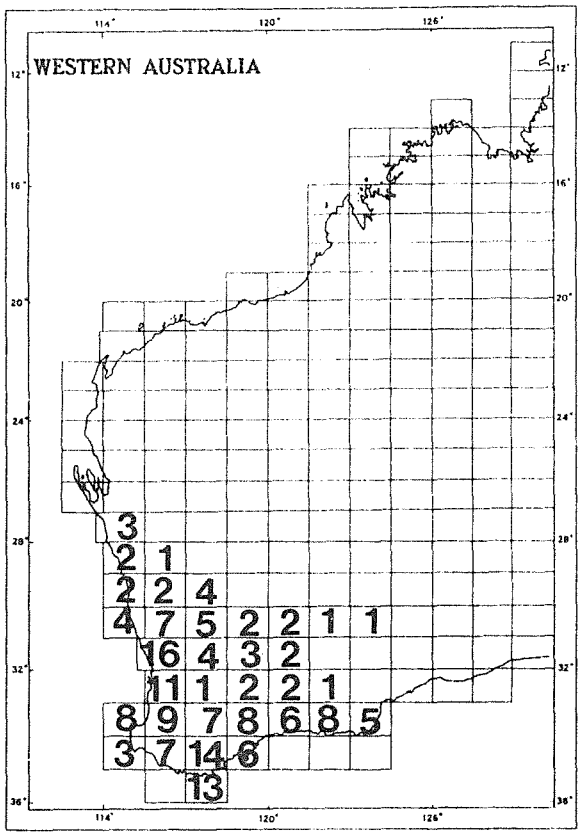


Figure 32 : Species Diversity in the genus Thelymitra

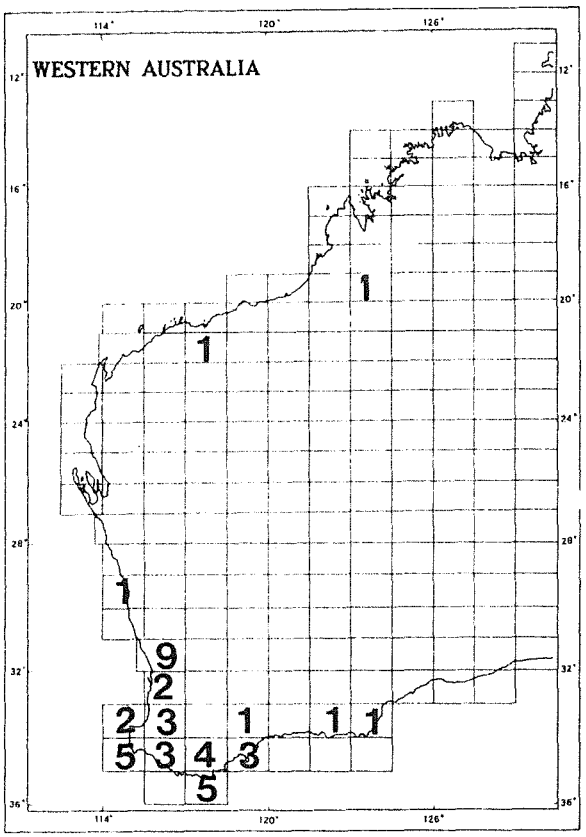


Figure 33 : Species Diversity in the genus Baumea

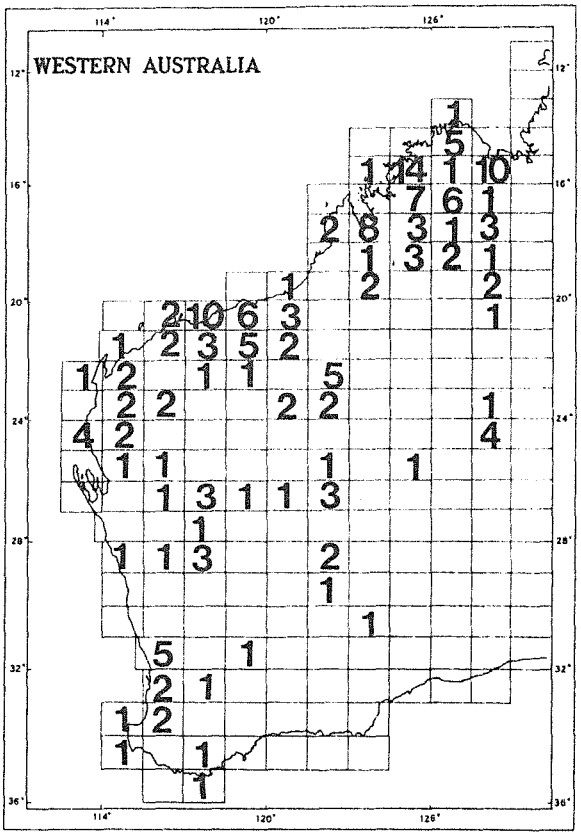


Figure 34 : Species Diversity in the genus Cyperus

has probably occurred in the transitional rainfall regions where habitat diversity (soil types) is greatest.

Cyperaceae

The Cyperaceae of Western Australia consist of ca 314 species distributed in 27 genera (Keighery, 1982,a). The family has very few endemic genera (only five) Crosslandia (1 species, in the Kimberlies). Evandra ; 2 species in the higher rainfall areas of Southern Western Australia. Mesomaelaena (5 species) which has diversified on the northern and southern heathlands (Dongara 4 (or 5 if add ssp. deflexa ; 4 on Pinjarra/Perth and 4 on Ravensthorpe sheet). Reedia; 1 species in high rainfall regions. Tricostularia ; 2 species, chiefly southern regions.

Considering the larger genera. Baumea has 9 species, 11 swamp plants, and not suprizingly most diverse in the higher rainfall areas. Several species have some remarkable outliers ; Baumea articulata at Dragon Tree Soak ($19^{o}40'S$ $123^{o}22'E$) and Baumea rubiginosa at Dales Gorge ($22^{o}30'S$ $118^{o}36'E$).

Cyperus (fig. 34) with 43 species, is found almost throughout Western Australia (except for the Nullabor ; and of course in the central desert region where they are only found in rocky areas eg watercourses or pools). The genus is most diverse in tropical Western Australia (to 14 species in wetter regions), and a secondary centre is the Pilbara region of the Eremaean (6/10 species).

Eleocharis with ca 15 species is chiefly tropical, but is so confused taxonomically that a accurate analysis cannot be made.

Fimbristylis with 57 species (fig. 35) is again chiefly tropical in distribution. Cambridge Gulf square, the best known area of the Kimberlies has 29 species recorded from it. Only one species (F. velata R.Br.) occurs in temerate Western Australia. Minor concentrations of species are found the Pilbara area (6 species) of the Eremaean. Many taxa extend into the desert margins of the Kimberley (F. ammobia, F. caespitosa, F. ferruginea and F. littoralis), or to the Pilbara (F. cardiocarpa, F. neilsonii and F. oxystacha), and several (F. dichotoma, F. eremophila and F. microcarya) are confined to the desert.

Gahnia (8 species) occurs only in southern Western Australia (Keighery, 1982,a) where it has diversified on the southern coastal heathlands where up to 7 species per grid have been recorded.

Lepidosperma (fig. 36) is one of the major genera of the heathlands and shrublands of southern Western Australia. Despite, taxonomic problems and inadequate collections, it is apparent that the genus has high species diversity in both the forest zones and adjacent sandplains.

Both Scirpus and Schoenus (Isolepis) are difficult to comment on because of inadequate collecting and a confused taxonomy. However, tabulating

Table 2 : Distribution of selected Cyperaceae

	high	N.T.R.Z.	S.T.R.Z.	GEN.	T.R.Z.	ARID	N.B.P.
Schoenus	12 (24%)	7 (14%)	4 (8%)	14 (20%)	10 (20%)	3	--
Scirpus	6	3	1	10 (31%)	--	4	4

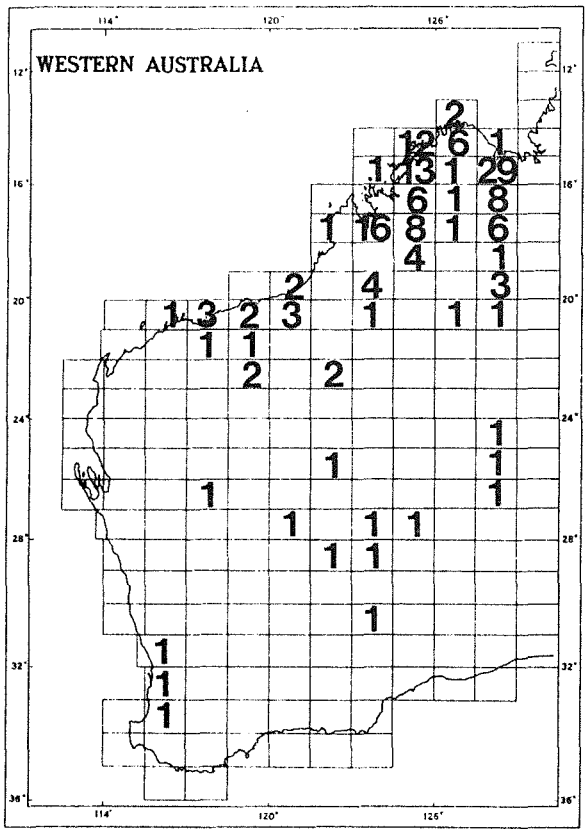


Figure 35 : Species Diversity in the genus Fimbristylis

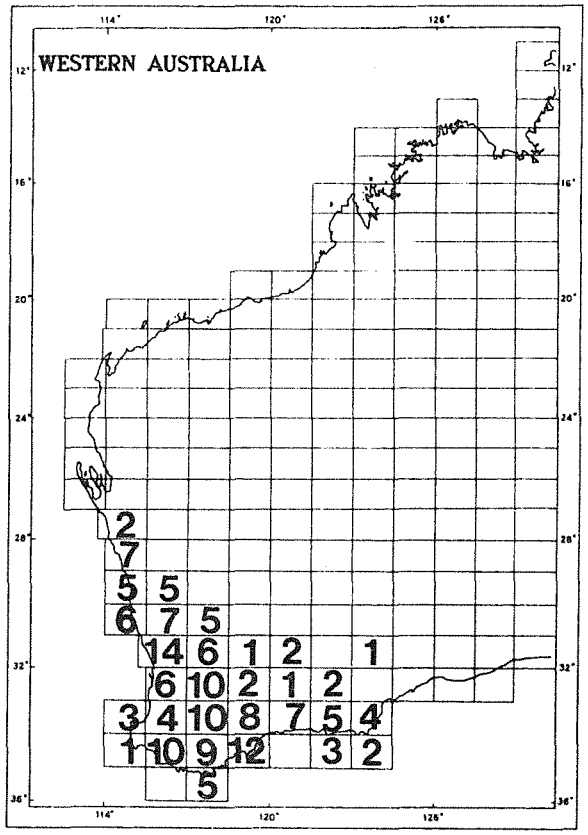


Figure 36 : Species Diversity in the genus Lepidosperma

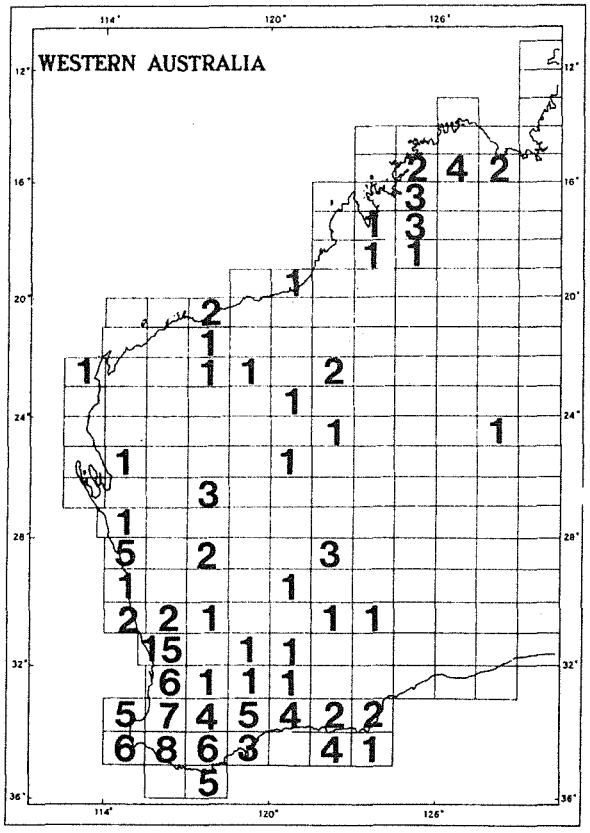


Figure 37 : Species Diversity in the genus Scirpus

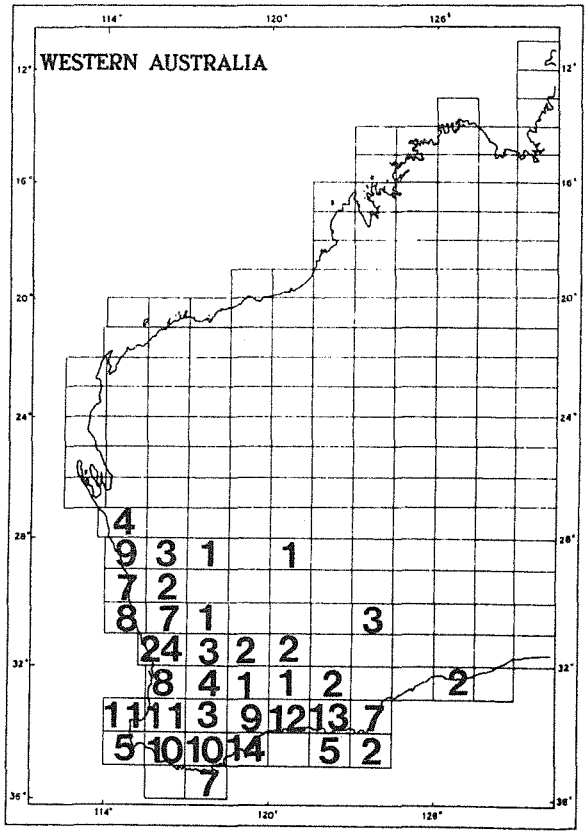
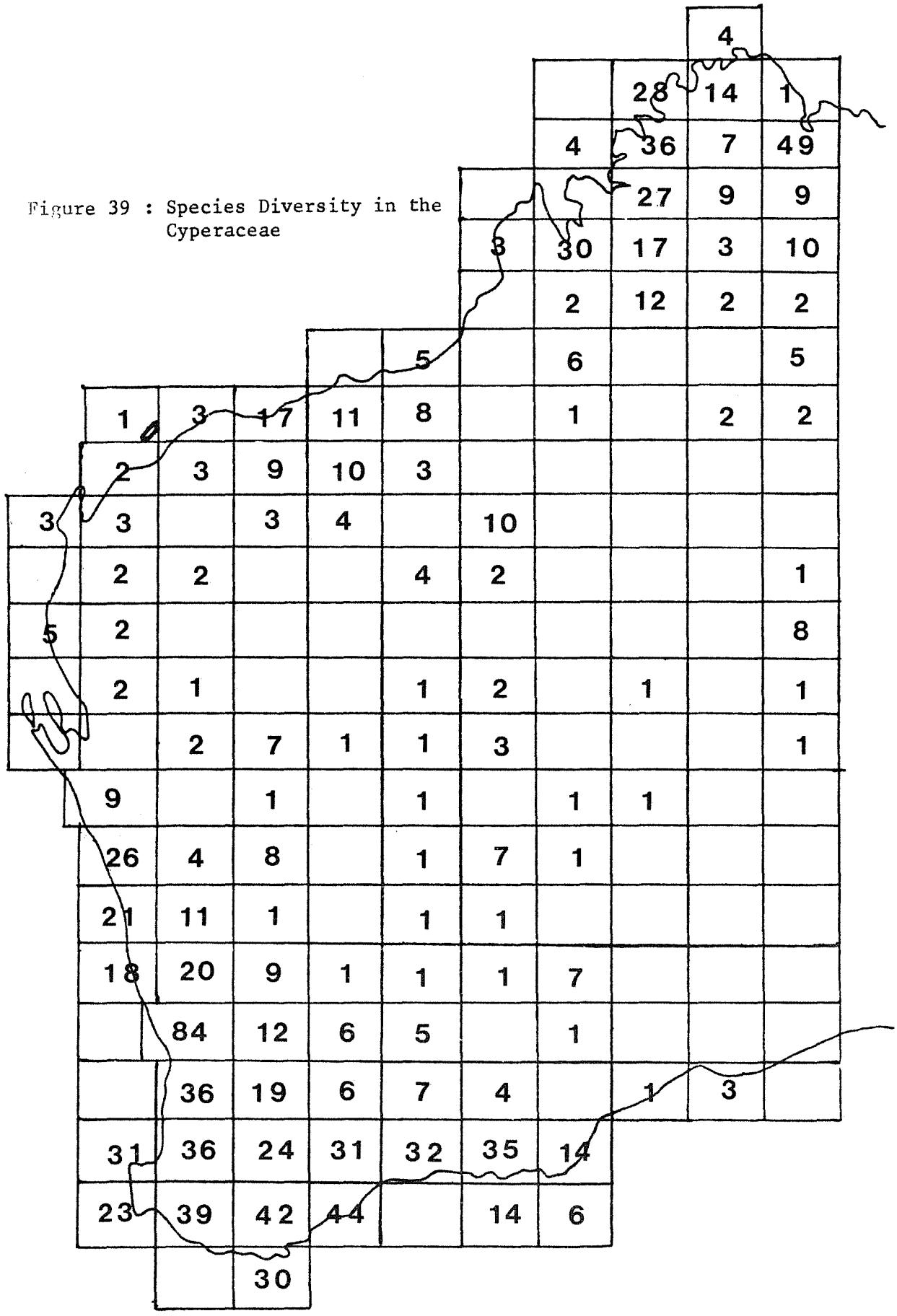


Figure 38 : Species Diversity in the genus Schoenus (Isolepis)

Figure 39 : Species Diversity in the Cyperaceae



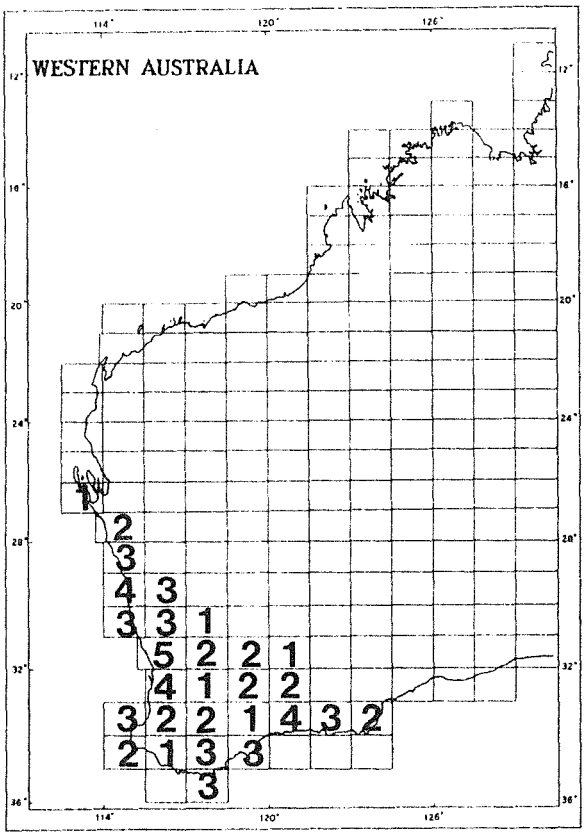


Figure 40 : Species Diversity in the genus Mesomelaena

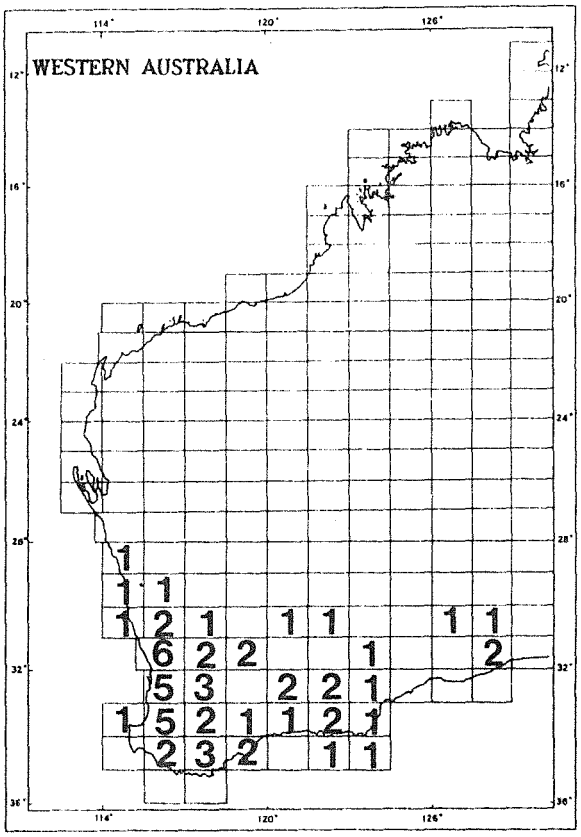


Figure 41 : Species Diversity in the genus Danthonia

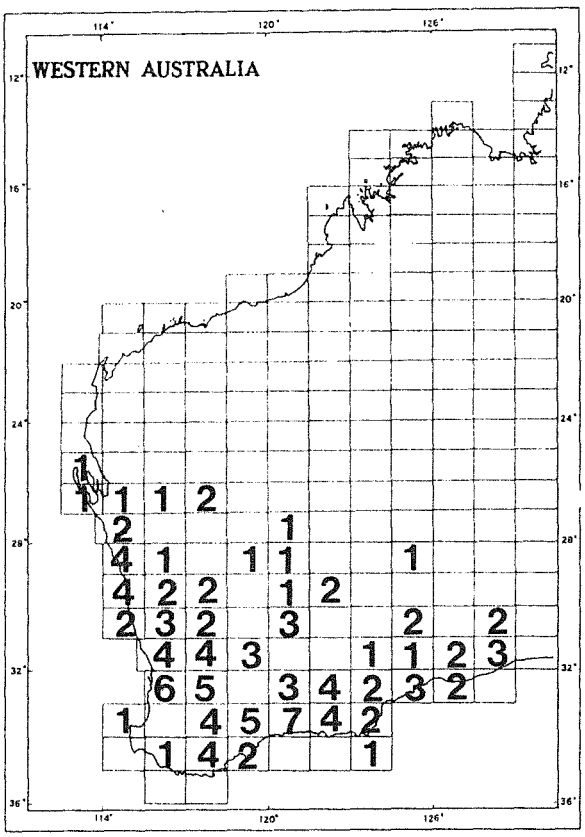


Figure 42 : Species Diversity in the genus Stipa

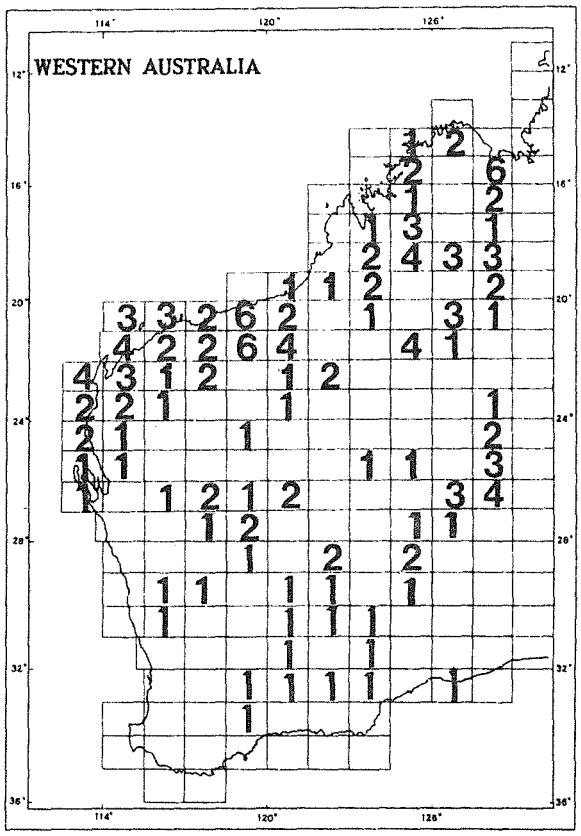


Figure 43 : Species Diversity in the genus Triodia

Mesomaelena	1	1	1	3	--	--	--
Lepidosperma	5	1	8	7	8	--	--

Key : high :
N.T.R.Z.: northern transitional rainfall zone
S.T.R.Z.: southern transitional rainfall zone
GEN. : General in south west
T.R.Z. : transitional rainfall zone
Arid : desert
N.B.P. : Northern Botanical Province

the distribution of these basically south western genera, one can immediately note that a mich greater percentage of species of Schoenus have occupied the more arid areas of the transitional rainfall zone (N.T.R.Z. ; S.T.R.Z., GEN and T.R.Z. contains 62% of Schoenus species).

What can one note about the Cyperaceae? It is the major monocotyledon family of southern Western Australia (for example 89 species are recorded for the PERTH sheet - fig. 39). There are indications that the sandplain regions (especially the southern sandplains) are major centre of speciation for the genera Lepidosperma (fig. 36, Table 2); Mesomaelena (fig. 40, Table 2) and Schoenus (fig. 38, Table 2). The Cyperaceae are present throughout Western Australia, except on the Nullabor Plain of the Eremaean. Within the desert the highest species diversity is found within the rocky ranges edging the sandy deserts (Pilbara up to 17 species, Central Australian Ranges up to 8 species). Highest species diversities are found in the Kimberley (up to 49 species) and the south west (up to 84 species), but the large collecting bias around the major population centres makes any further analysis difficult.

Poaceae

The grasses of Western Australia are composed of 535 species distributed in 143 genera. Despite the large size, and importance of the family, the grasses are relatively poorly collected, often because they occur in remote and sparsely populated regions of the state.

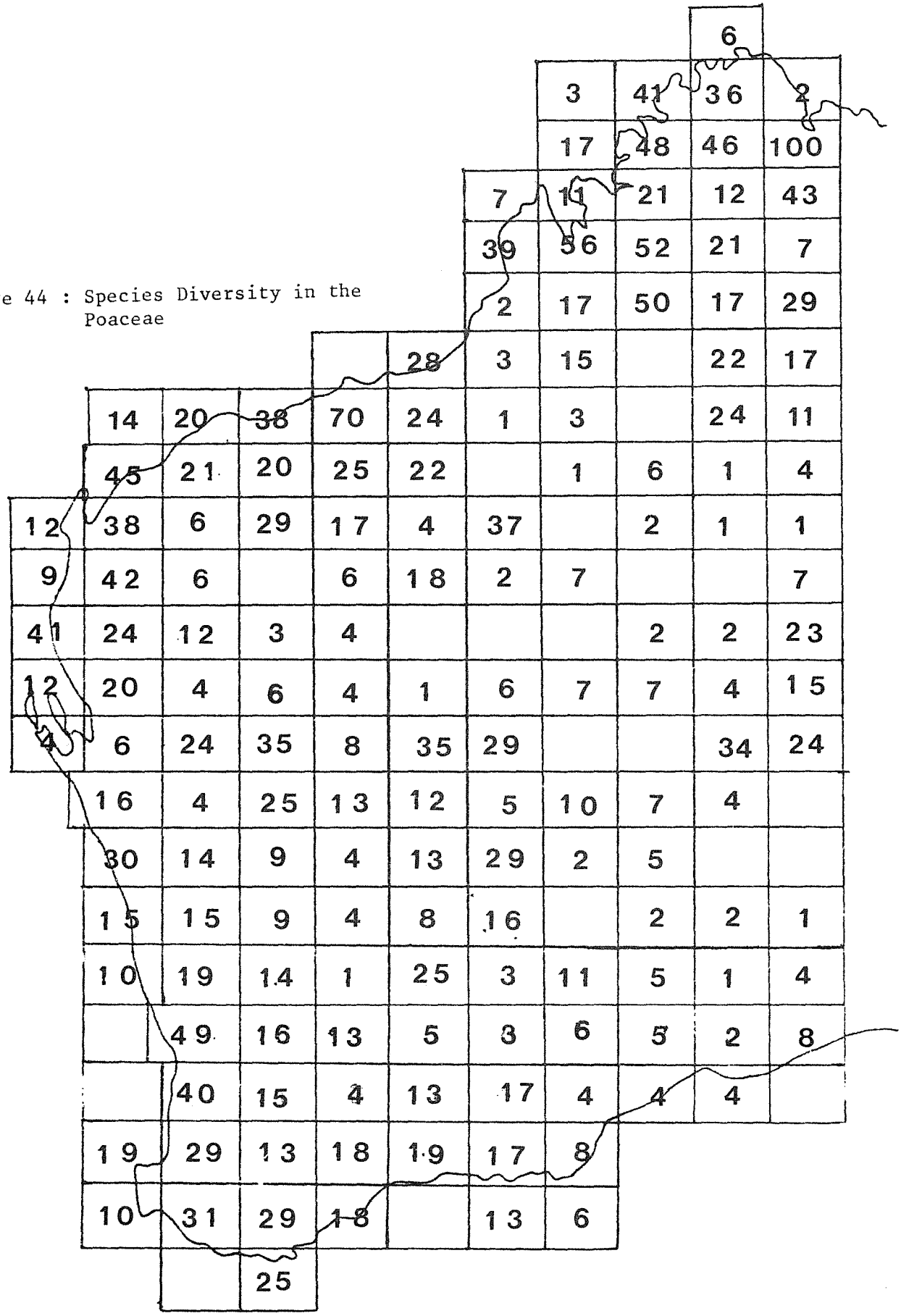
The family displays a low level of endemism compared to other major monocotyledon groups. Only 59 species are endemic to the state, and 17 of these are found in the closely related genera Triodia and Plectrachne. The only major groups of endemics from southern Western Australia are found in the genera Amphipogon (7 species) and Stipa (10).

Only a few genera are analyzed here, but notes on several more are included from Keighery (1983). Within south Western Australia the genus Amphigopon is perhaps most diverse in the northern transitional rainfall zone. Danthonia (fig. 41.) is clearly most diverse in the forest zone. Poa is most diverse in the forest zones and southern coastal heathlands. Agrostis is most diverse in the forest zone and adjacent southern sandplains. Stipa (fig. 42) is perhaps most diverse on the southern sandplains, and less so in the high rainfall zones.

Within the desert the highest species diversity is found on rocky ranges edging the sandy deserts especially the Pilbara. This is true for the genera Enneapogon, Eriachne, Eragrostis (Keighery, 1983) and Triodia (fig. 43).

On a family level (fig. 44) the grasses of Western Australia are largely tropical in distribution. The Cambridge Gulf grid cell has 100 species recorded

Figure 44 : Species Diversity in the Poaceae



from it, and this may be a reasonable baseline for the Kimberley region as this is the most accessible and best collected area. It is possible that higher numbers may eventually be recorded for parts of the western Kimberley.

The south western margin of the Kimberley edging the desert (Derby sheet : 56 species ; Lennard River : 52 and Noonkanbah : 50) appears to be species rich. This parallels the situation found in the genus Cassia (Caesalpiniaceae).

As with the Cyperaceae, the Pilbara region (Port Hedland sheet : 70 species) and the Central Australian ranges (Talbot sheet : 34 species) of the desert are the centres of specific diversity.

Within south Western Australia the highest diversity is found in the higher rainfall forest zone (Perth sheet : 49 species and Pinjarra : 40). However, as noted previously many of the larger southern genera have also diversified on the southern sandplains.

Discussion

What general trends can be noted in this survey of the distribution patterns of Western Australian monocotyledons?

Within the south west several groups have their highest specific diversity within the climatically moderate forest zones and southern sandplains (Restionaceae, Iridaceae, Juncaginaceae, Juncaceae, Xyridaceae, Hypoxidaceae and Poaceae). This is somewhat at variance with the patterns shown in many woody genera (Hopper, 1979) which are most diverse in heathland areas.

Several major families (Haemodoraceae, Liliaceae, Cyperaceae and Orchidaceae) are, however, most diverse in the heathland regions of southern Western Australia. So the pattern of species richness in these regions noted by Burbidge (1960) and Hopper (1979) is maintained in all the major monocotyledon families.

Within the desert regions significant outliers are noted in the text at Dragon Tree Soak, the Edgar ranges, Millstream and Queen Victoria Springs. Many southern species end their ranges along the sandplains at North West Cape, Dirk Hartog Island or the southern Nullabor. Fortunately the majority of these regions are currently nature reserves. The Nullabor is a major barrier for many monocotyledons, no Restionaceae, Cyperaceae, Liliaceae, Haemodoraceae or Orchidaceae are recorded from this area, for example.

The desert ranges are seen to be the areas of diversity for those families which have occupied this region (Pilbara and Central Australian Ranges), and these regions may deserve greater attention for conservation.

Most families require further study and collecting.

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