CHAPTER 4 ECOLOGICAL CHARACTER

a. Lifeforms of the vegetation

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

Trees and Shrubs

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

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

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

Lianes

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

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

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

**Epiphytes**

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

**Perennial herbs**

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

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

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

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

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

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

Annuals

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

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

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

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

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

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

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

b. *Forms of branching*

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

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

In contrast to the above examples where each internode grows to some length there are many groups with a tendency to produce abbreviated shoots. This feature appears to me to be common in the general *Hibbertia* and *Grevillea*, and also in *Logania* (about which I shall have something to say later). Mesophytic species of *Hibbertia* (Dillen.) e.g. *H. perfoliata* and *H. amplexicaulis*, bear their foliage on long branches, while the closely related *H. potentilliflora* which grows in exposed regions (and suggests its ecological hardiness by the presence of a silky felt) carries leaves and flowers on short branches. Similar differences are met with amongst other related groups of the genus - the section
Candollea (*H. desmophylla*) the polymorphic series of *H. montana*, and in *H. Huegelii*, and its relations. A similar and instructive variation is presented in the genus *Grevillea* where the western species form an epharmonically very diverse species. Most have long leafy branches as for example in *G. oxystigma* *G. acerosa* and the beautiful *G. Candolleana*. When I followed the genus to the boundary of the Southwest Province (annual rainfall about 30 cm) I encountered in *G. uncinulata* a type characterized by distinct short branches. This points to one aspect of its general xeromorphism. (Fig. 38) *G. uncinulata* is more common in drier areas but it has also been found in higher rainfall regions.

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

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

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

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

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

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

A remarkable peculiarity of many plants which grow in sandy areas of south Western Australia lies in the great production of cork at localised places on the axes. Sometimes it is at the axis of the inflorescence as in several Myrtaceae (*Calothamnus* and *Melaleuca* spp.). It is, however, much more common at the base of the shoot at soil level, i.e. at the junction of the root and shoot. Histological details would take us too far here - suffice it to state that the result is always the same, a more or less thick mantle of large-celled cork at the zone of contact between plant and ground. This feature is very wide-spread amongst the small shrubs and subshrubs of the sand heaths. I do not believe that I would be far wrong if I estimated that 75% of the species growing there whether related or not, possess such “basal-cork”. Purely to illustrate the systematic diversity of such cork formation a few excellent examples may be mentioned, eg:- *Daviesia quadrilatera* (Legum.), *Hibbertia conspicua* (Dillen.), *Verticordia grandiflora* (Myrtac.), *Calythrix brevifolia* (Myrtac.), *Logania flaviflora* (Logan.) and *Scaevola restiacea* (Gooden.). There is not the slightest doubt that the above feature is an adaptation to the environment but I do not know how to explain the circumstances. Perhaps the function of the cork may be explained on the “heating up” theory. The surface of the ground suffers enormous heating-up on the completely unprotected sand heaths where trees are lacking. The air temperature reaches a maximum of 45-46°C almost every year, and from this one may assume that the intensity of the heating up, which the loose sand undergoes by direct radiation is very high1. It is just that part of the plant between shoot and root which is subjected to this hot soil where the corky layers develop. Perhaps the corky tissue acts as an insulating device to protect the xylem bundles from overheating.

d. Leaves

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

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1 Measurements are not given. I was not so healthy on extremely hot days.
weeks of opening rain - only the herbaceous types shows any obvious vegetative growth. However, in the Irwin River district at the beginning of June I saw considerable growth activity in many shrubs. Specimens of Grevillea amplexans, the psammophyllous bushes of Acacia aureo-nitens and others, had developed a rich growth of young foliage by the 9th of the month and the young shoots of Eremophila Oldfieldii had reached a length of 10 cm. In the more southern landscapes the vegetative growth only rose to its maximum intensity in the second half of the wet season. In September and October most bushes show a strong development of new shoots. Further south again on the south coast the production of new leaves commences still later and then continues far into the dry season. In November one sees leaf growth well developed everywhere. During this month I found Hakea trifurcata for example, with new shoots about 5 cm long. By about the New Year most growths had reached their mature shape and size and with the exception of some in climatically favoured places, had entered upon the dormant summer period. By comparing the two appearances of Acacia barbinervis shown in Figure 40, one may get a good idea of the course of vegetative growth.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

| Restionaceae | Leguminosae - Acacia | Loudonia (Halorag.) |
| Corynotheca (Liliac.) | Boronia (Rutac.) | Trachymene (Umbellif.) |
| Thysanotus (Liliac.) | Tetratheca (Tremandr.) | Samolus (Primul.) |
| Casuarinaceae | Comesperma (Polygalac.) | Logania (Loganiac.) |
| Santalaceae | Calycopeplus (Euphorb.) | Anthocercis (Scrophul.) |
| Macarthuria (Phytolacc.) | Psammomoya (Celastrac.) | Opercularia (Rubiac.) |
| Conospermum (Proteac.) | Stackhousia (Stackhousiac.) | Scaevola (Gooden.) |
| Leguminosae - Podalyrieae many spp. | | Hibbertia (Dillen.) |
The degree of occurrence of aphyll in the above list is very variable. Many groups are almost entirely made up of leafless forms, eg. the Restionaceae, the Casuarinaceae, and the genera *Exocarpos* (Santal.) and *Psammomoya* (Celastr., Fig. 43). Others on the contrary consist for the most part of normal leaved species, the leafless examples being extremes which occur only once. Examples are *Hibbertia conspicua*, *Conospermum Eatoniae* and *Boronia spinescens*. There are many groups occupying intermediate positions between these two main types.

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

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

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

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

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

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

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

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

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

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

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

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

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

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economy.

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

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

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

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

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

e. Flowers

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

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

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

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

More frequently the protective scale leaves of the flower are arranged in an imbricate fashion to form a more or less completely bract-enclosed bud. In the plant kingdom this often results in a distinction being made between the general involucre and the floral involucre, although it is not unusual for both types to occur in the same group. The Proteaceae present a variety of arrangements so far as this feature is concerned. In the genera related to Petrophila the relation between the bracts of the involucre and the bracteoles of the single flowers varies from one species to another. This also holds good for other genera of the family. Similar conditions are repeated in Acacia. Thus each of the tiny flowers has its own protecting scale but there are species in which the whole inflorescence is surrounded by well developed bud scales. (e.g. A. squamata. Fig. 47A). In Acacia scirpifolia and some other species such a cover completely surrounds a young twig which bears flowers below and leaves above. The floral bud scales show a leathery consistency in many members of the Epacridaceae (eg. Andersonia and Conostephium. (Fig. 47H)). More frequently, however, they are thin, scarious, and brown in colour. The very characteristic bud scales of Hakea and Daviesia (Fig. 47D), and also those in the numerous species of Cryptandra (Rham.) and Hibbertia (Dillen.), follow this type. The flower bracts of Verticordia are hyaline in char-
acter and in many species are of considerable size. These protective leaves are frequently characterized by a covering of hair (*Hakea*, Fig. 12C-E)). In *Petrophila*, in *Hakea costata* and others the covering is to be found on both sides of the leaves so that the buds look like willow catkins.

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

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

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

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

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

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

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

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

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

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

The colours deep red and blue, which are usually regarded as being of high rank
(primary colours) occur in numerous species in Western Australia. Templetonia and
Kennedya illustrate the bright red colour among the Leguminosae. It is considered to
be of importance in relation to bird pollination. Similar colours are to be found in the
genera Banksia, Adenanthis, Lambertia, and Grevillea of the family Proteaceae, in the
genera Cosmelia and Astroloma (Epac.), in Beaufortia and Calothamnus (Myrt.) and in
the case of Leschenaultia (Gooden.). While the participation of small Meliphagidae has
been observed in the pollination of Banksia and the Epacridaceae similar information
is still lacking with regard to the other genera. It is very doubtful for instance whether
birds could take part in the pollination of flowers which are as small as those of many
species of Grevillea or Lechenaultia.

Just as widespread as the scarlet and bright red of the Western Australian flowers
mentioned above, are the blue and violet colours. Some have already been mentioned as
accompanying the bright purple. In addition to these one finds many species with bright
blue petals amongst the Pittosporaceae (Sollya, Cheiranthera, Pronaya and Marianthus, other more isolated examples occur, eg. Erodium (Geran.), Mirbelia, Hovea and Hardenbergia in the Leguminosae, together with Calytrix and Lotzkya of the Myrtaceae, Solanum, several genera of the family Liliaceae and the genus Patersonia of the Iridaceae. The series of the Campanulatae is also productive. Several annual species of Lobelia and many genera of the Goodeniaceae contribute particularly beautiful examples to this group. In these the tendency to have blue flowers is to a certain extent generically controlled. On the other hand it is unusual to meet blue flowers amongst the orchids as that colour is relatively uncommon in this group. However, there is scarcely any other flora which is richer in blue flowering orchids than that of south western Australia. This is all the more remarkable because in other respects the region has contributed practically nothing to the evolutionary development for instance of the Orchidaceae. Caladenia and Glossodia on the one hand, and Thelymitra and Epiblema on the other, highlight these peculiar colour groupings. Some of the species occur in eastern Australia, but others are exclusively western. This represents a very important fact which has significance for the floral biology of the province.

The above, of course, must be considered only as data for further investigation. I have no evidence which would enable me to establish the anthobiological peculiarities of Western Australia on a firmer foundation either geographically or systematically. We find in several genera a colour range through white, yellow and blue, without being able to recognise any determinable external factors. In Caladenia rose-red, yellow and blue coloured species occur - often close together in one and the same community. Furthermore there appears to be no law which might apply to the geographical distribution of the individual colours in the Province. The bright red Calothamnus grows in both forest and in open country. Members of the Goodeniaceae with intense highly developed blue colours are often found growing close to related species which bear inconspicuous yellow flowers. In all essential details authobiological uniformity dominates the South Western Province. There is not the slightest trace of any differentiation associated with geographical factors, such as is apparently the case in south eastern Australia. Only a certain seasonal arrangement appears to be indicated (Sect. G). There appears to be little or no information regarding relations with the insect world.

The occurrence of such bright splendid colours in the flowers of the south western flora therefore remains as an unsolved problem. One may only speculate, vaguely, that there may be some connection with the hot clear skies and the dry atmosphere of the country.

Scent. Many flowers of the south western flora are distinguished by their strong scent. There is a remarkably widespread belief, however, that the flowers of Australia are almost without scent, but this is quite incorrect. In the plant world of the Southwest Province at least, a district already abounding in aromatic scented foliage, the flowers exude strong smelling substances in a lavish manner. The genus Acacia for instance brings forth such an abundance of the most different perfumes with its many species, that few genera can surpass. In many of the best known and pleasing scents such as almond, heliotrope, and others there are analogous perfumes. The same holds good for the Proteaceae. There is no species in that polymorphic company of the south-west Proteaceae whose flowers do not produce a specific perfume. Hakea recurva smells like Philadelphus, Petrophila longifolia produces a malic-acid like substance, while the banksias secrete odours reminding one of pineapple. In the characteristic genus Daviesia and in very many of the Myrtaceae the scents of the flowers carry a long way and they are always most intense when the colours of the flowers appear most dazzling. A strain of richness and diversity runs throughout the entire flower world of the south west, and the number of scented plants is another expression of it.

f. Adaptation and Morphology.

Critical examination of the elements of the flora of south western Australia shows that they fall into two large classes. The specific factors which determine these classes are
not known at the present time. The members of the first group appear to be conditioned by a limited complex of external factors. Their morphology within a limited range appears to be in equilibrium. Members of the second group exposed to the free play of the highly variable elements of the external medium develop a high degree of morphological adaptation. The first class is met with all over the world and is of little help in biogeographical studies. The second group, however, shows stronger development in some floras and less in others. It shows a particularly striking and extensive development in the flora of south western Australia. Our understanding of the biology of this flora depends to a great extent upon our ability to unravel the mystery of the tremendous variation in morphology which has occurred. All the large genera of the Western Australian flora show essentially similarly conditioned self-derived adaptations.

This is, however, very difficult to demonstrate owing to the complicated nature of the whole – i.e. the extensive subdivision in autogenous series of forms. I have, therefore chosen a relatively simple genus, *Logania*, to illustrate these principles. Similar examples could readily be chosen for most other important groups in the south western flora. The following affords us some insight into the operation of the forces which have moulded the evolution of the genera and species in this floristically rich part of the world, and which are still involved in their further evolution.

The subdivision of the genus Logania, based on its morphological adaptations. (Fig. 49, 50)

The genus *Logania* consists of two sections - Eulogania and Stomandra, which were separated by R. Brown. They differ in their floral structure in that the anthers in the Eulogania are inserted in the middle of the corolla tube, while in Stomandra they are inserted in the throat. Eulogania differs also from the hermaphrodite Stomandra in its marked tendency to be dioecious. In addition there are considerable differences in their overall vegetative structure, which results in their adaptations proceeding along very different lines. They must therefore be considered separately.

I. Eulogania DC. (Fig. 49)

In this section the flowers are mostly five-partite but occasionally four-partite flowers occur. The throat of the corolla may either be bare or bearded. These are the major differences between the flowers but they are not very important due to the lack of constancy, particularly among the more distantly related forms. The definition of the species therefore depends largely on vegetative characters. The Western Australian species may be defined as follows:-

1. *Logania vaginalis* Labill. var *laxior* Nees - Fig. 49A
   A shrub 1.5 - 2 m high without any short branches; leaf area 600 sq. mm; lamina narrow, elliptical and anatomically dorsi-ventral. Upper surface with typical palisade tissue. The under surface shows loose parenchyma with stomata on the surface of the epidermis. Its vascular bundles lack phloem fibres. It grows in shady places among the undergrowth in the Jarrah forest in a rainfall zone of 90-125 cm p.a. Distribution: south coast in the Warren and Stirling Districts.

2. *Logania vaginalis* Labill. var. *longifolia* (R.Br.) - Fig. 49B
   (*Logania longifolia* R.Br. ex Nees in Pl. Preiss I. 367; ex Benth. in Flora Austr. IV 361 p.pr.)
   Shrub 1 - 1.5 m high without any short branches; leaf area 400 sq. mm; lamina narrow, elliptical or oblong. Its anatomy agrees with that of *Logania vaginalis*. Habitat: - Shady bush in Tuart woodland or limestone. Distribution: - West coast from the Swan River southward, littoral. In a rainfall zone of 75-100 cm.

3. *Logania vaginalis* Labill. typica - Fig. 49C
A shrub 2 - 2.5 m high without any short branches; leaf area 6000 sq. mm; narrow, obovate. Anatomically it agrees with *L. vaginalis*. Found growing on sandy dunes with over limestone. Distribution: - South east coast in the Eyre district, littoral. In a rainfall zone of 60 cm.

4. **Logania latifolia** R.Br. – see Flor. Austr. IV. 361 - Fig. 49D
A shrub 0.5 - 0.8 m high without any short branches; leaf area 320 sq. mm; lamina broadly elliptical or obovate. Anatomically it agrees with *Logania vaginalis*. Habitat: - In bush on limestone soil. Distribution: - South east coast in Eyre District, probably littoral. In a rainfall zone of 60-90 cm.

5. **Logania buxifolia** F.v.M. – see Flora Austr. IV. 362 - Fig. 49E
A shrub 0.3 - 0.6 m high without any short branches; leaf area 84 sq. mm; lamina obovate or oblong. Anatomically the leaf is more isolateral than in 1 - 4 above. The walls of the upper epidermis are thicker, while the stomata are more or less sunken projections. Distribution: - South east in the Eyre district. In a rainfall zone of 50-60 cm.

6. **Logania stenophylla** F.v.M. – see Flora Austr. IV. 302 -Fig. 49C
A shrub to 0.75 m high; occasionally with short leafy shoots (dwarf shoots). Leaf area is more or less 125 sq.mm; the shape is linear and margins are revolute. Anatomically its similar to *L. vaginalis*. Habitat: - In bush on loamy sand. Distribution: South-eastern in Eyre district. In a rainfall zone of 40-50 cm.

7. **Logania fasciculata** R.Br. - see Flor. Austr. IV. 363 - Fig. 49F
A low shrub with numerous small-leaved short branches; leaf area 19 sq. mm; shape, linear oblong or somewhat elliptical. Anatomically similar to *L. vaginalis*. Habitat: - On the coastal cliffs. Distribution: - South-eastern in Eyre district, sublittoral. In
rainfall zone of 50 cm.

8. *Logania micrantha* Benth. - see Flor. Austr. IV. 363 – Fig 49H
   Small shrub. Leaf area 2 - 4 sq. mm. Shape, linear, margins strongly revolute; epidermis of the under surface hairy; stomata in hairy depressions. Distribution: - Inner part of the Stirling district. In a rainfall zone from 40 cm.

The adaptations in the Section Eulogania therefore consist of variations in the dimensions of the branch system and in the size of the leaf area through reduction or inrolling of margins. Such reduction sometimes affects the length of a leaf, sometimes the width. It can be compensated only to a certain extent by the correlated development of many leafy short branches. Anatomically as the leaves become more upright they develop a more isolateral character. In the xeromorphic forms the outer walls also become of increased importance. The adaptations lead from the mesophytic type of shrub through the rolled-leaf types to the ericoid dwarfs of the most depauperate nature. The distribution of these is restricted to the 40 cm rainfall zone.

II.

   Stomandra R.Br. (Fig. 50)
   The variation in floral parts is much the same as in the Section Eulogania. The circumscription of the individual is again determined by the vegetative characters.

1. *Logania serpyllifolia* R.Br. - see Flor. Austr. IV 366. -Fig. 50A
   Habit:- Semi-shrubs with horizontal prostrate branches, leaf area 170 sq. mm; shape, oval or lanceolate with hairs along the veins. Anatomy: - Dorsiventral, although the chlorenchyma is more or less homogeneous; stomata are present only on the undersurface level with the epidermis. It is found growing among the undergrowth of the Jarrah woodlands in places where humus is present. Distribution: Probably in the whole coastal area of the Southwest Province. Rainfall, 60-125 cm.

2. *Logania campanulata* R.Br. see Flor. Austr. IV. 365 -Fig. 50B
   A semi-shrub with erect branches and larger flowers than the preceding species. Leaf area, 165 sq. mm. Shape, linear-lanceolate to linear, with revolute margins, rather more pubescent than *L. serpyllifolia*. The epidermis has a more strongly developed outer wall and the cells of the chlorenchyma are more elongated. Habitat:- Bush on stony loamy soil. Distribution: - from the Darling district to the Stirling and Eyre districts area in the 40-80 cm rainfall zone.

3. *Logania callosa* F.v.M. see Flor. Austr.IV.365. - Fig. 50C
   Habit:- A small semi-shrub. Leaf area, 34 sq. mm. Shape, linear with revolute margins, more or less leafless. Epidermis with strong outer walls. Chlorenchyma cells closely packed. Habitat: - bare places on clay-sand. Distribution: - south east in Eyre district. In the 50 cm rainfall zone.

4. *Logania flaviflora* F.v.M. in Victor. Natural. V.165 - Fig. 50D
   Habit:- A semishrub to 15 - 25 cm high with leaf area 25 sq. mm. Shape, linear. In anatomy it is similar to *Logania campanulata*. Habitat: - shrubby heaths on sand. Distribution: - Inner Avon district. In the 30-40 cm rainfall zone.

5. *Logania spermacocea* F.v.M. see Flor. Austr. IV. 365 - Fig. 50E
   Habit:- A semi-shrub 20-30 cm high. Leaf area 3.6-12 sq. mm. Shape, Linear, usually strongly hairy. Photosynthesis mainly carried on by dwarf branches. These are slightly grooved, the rounded edges (usually six) with single-layered subepidermal bast fibres. Stomata level with the epidermis. Chlorenchyma richly developed. Habitat: - Slightly shrubby heath on sand. Distribution: - North part of the Avon and Irwin districts. In the 40-50 cm rainfall zone.

6. *Logania nuda* F.v.M. see Flor. Austr. IV. 365 - Fig. 50G
   A semi-shrub 20-25 cm high; leaf area zero; all photosynthesis is carried out by the grooveless cylindrical stem axes. Numerous sub-epidermal bast fibres alternate with chlorenchyma tissue. Stomata are level with the epidermis. Chlorenchyma cells are

This Stomandra Section commences with a mesophytic type. As we pass to drier regions the leaf surface undergoes marked reduction in breadth, partly offset by the development of hairiness. Photosynthesis by the stem axis becomes increasingly important owing to the reduction in leaf area and finally all assimilation goes on in the stem axes. The adaptation to drier conditions is indicated by the change from soft, broad-leaved plants to small aphyllous shrubs. The adaptational changes appear to allow the species to survive in rainfall as low as 25 cm.

We must again emphasize the fact that these adaptations seen in the two sections of Logania are thoroughly representative for the Southwest Province. It occurs repeatedly. The Eulogania type is met with again in the genus Hovea. Here we have the large-leaved Hovea elliptica occurring on the moist slopes and forests of the south west coast, while the extremely small leaved Hovea acanthoclada, with strongly developed sclerenchymatous tissue, occurs in the Eremaea. The adaptively regulated reduction in leaf area is also well shown in the genus Dryandra. Examination of Fig. 51 makes further comment on this example unnecessary. Similar examples may be found in all the groups of the Western Australian flora. This results in an abundance of morphological variations, but the principal features always remain the same.

The same holds good for the Stomandra type. In this example a very widespread tendency is very precisely expressed. Its climax, the aphyllous condition, is not always reached, but the number of groups tending towards it is very considerable. When the condition of leaflessness is found we often discover that it represents the last stage of a long series of adaptations developed along much the same lines as the Stomandra type. We have already shown how this holds good for a large proportion of the Western Australian aphyllous plants.

The end result, the creation of new species, is common to both examples. A range of new forms has arisen in both which show very great differences. We need to have a clear picture of the situation in order to judge the effective possibilities of the gradations in

![Diagram](image-url)
climate. Too often this is treated in a very summary manner. Many authors have referred briefly to the modifying effect of the Australian climate and have attempted to correlate it with the peculiarities of the native plants. One can readily appreciate the errors into which this may lead us when the complexities underlying a single adaptative series have been investigated. The above exposition in relation to the western *Logania* provides an adequate demonstration of this.

A well-known effect of adaptation is in general the convergence of taxonomically distinct types. The morphological changes involved in the transfer to aphyllous are considerable. The frequency of occurrence of such cases in Western Australia can be seen by referring to the list of leafless plants. Less severely reduced growths also commonly occur. These also agree very closely in their vegetative forms. Species of *Daviesia* with cylindrical leaves and species of *Acacia* with their similar cylindrical phylodes are often very difficult, if not impossible to separate. *Hakea* and *Petrophila* have extraordinarily similar needle-like leaves. The general resemblance to one another of the ericoid type of plant is so striking that it was referred to at a very early date as a characteristic feature of the Australian “scrub” vegetation. Although usually the taxonomic differences can, on closer investigation, be demonstrated without difficulty, nevertheless striking cases occur in which, even after detailed examination it is still not possible to be sure. *Leucopogon gibbosus* possesses very small (2 mm long at most) arched leaves or ones of circular form, which are reflexed and appressed against the stem (Fig. 52B). Exactly the same form is met with in *Hibbertia microphylla* (Fig. 52A). As is often the case both examples grow in the same district under similar conditions.

This phenomenon of convergence occurs repeatedly in the Western Australian vegetation. It even extends to the tree growth-form. Phylodes of *Acacia* and leaves of *Eucalyptus* are often deceptively similar.

The number of adaptively flexible taxa in south west Australia is greater than in any other floral area of comparable size. To my mind there is no necessity to invoke some mystical factor, which has just begun to stimulate the Western Australian vegetation into active mutation. On the contrary the process of adaptation to the gradations of the environment has been going on for an immeasurably long time. The overall effect of this has been that the flora has largely come into adaptational equilibrium with its environment.

g. Yearly vegetation cycle.

During March and April the vegetation of almost the entire Southwest Province lies dormant under the influence of the dry period. The figures alongside the drawings give the average rainfall for the areas in which the relevant species grow. There are no flowers present on the shrubs while only one or two of the taller *Eucalyptus* species occasionally bear white blossoms on their dark-leaved twigs (*E. redunca*). The whole undergrowth seems to be lifeless so much is yellow and dead. Everything appears to show tired and discoloured tones. This is further reflected in the entire landscape when the sky is hidden by the livid mist of the oppressive east winds, and the dense smoke of bush-fires fills the air.

The increasing frequency of the cloudy skies and the constant summer lightning at night herald the change. Then by about the last week of April, dark clouds begin to gather in the north western sky and soon the break of season rains begin to fall upon the scorched earth.

In a few days life appears to awaken, and within two to three weeks the whole aspect of the country changes.

Tender green shoots spread out rapidly over the ground so that one soon forgets how such a short time ago the earth lay bare everywhere. The young seedlings sprout in crowded masses particularly where some small groove or channel has retained a little more water. Each shallow depression and each cart track is covered with a green veil. Grass and delicate herbs produce their first leaves while the bulb-bearing *Drosera* shows white flower buds close to the dark sandy soil. In sheltered places the delicate flowers of
the first tuberous orchids, *Eriochnilus dilatatus* appear.

Some of the vegetation damaged by bush fires during the last few months appears to be rejuvenated, but otherwise the leaves of the shrubs show little change. The flower buds, however, unfold from day to day as if they had only awaited the addition of a small amount of water to give them the first touch as it were of spring conditions. The first flowers of *Hibbertia hypericoides* (Dillen.) and of species of *Daviesia* (Legum.) appear, while in particular several species of Epacridaceous shrubs unfold their buds which had developed some time before. About the middle of May when *Styphelia tenuiflora* (Epacrid.) blooms in thousands, the undergrowth bears the snow-white cloak, as it were, of early spring. In the meantime some *Acacias* are well advanced in their development, and in a short time they brighten the still drab bush with their golden yellow flowers. *Acacia teretifolia* is one of the most effective of these.

Towards the end of May the bush already displays a rich and variegated floral pattern, and in places the open ground in the woodland does not lag far behind in its bright display. It closely resembles what we know and love in our own leafy woodland in springtime at home. It takes quite an effort to absorb the abundance of new plants which are present wherever one turns. Beautiful indeed are the sides of the hills - their slopes upturned to the warm sun. Their soil now with adequate water, while gurgling streams flow over the steep granite slopes. A bright border of scented acacias (*Acacia alata*) accompanies the often hidden courses of the streams. *Olearia paucidentata* (Compos.) with its large and brilliant heads of flowers rises from the stony ground, and the young shoots of *Dioscorea hastifolia* grow strongly in sunny situations. Their delicate reddish leaves are scarcely visible among the masses of bright yellow flowers which give colour to the wide areas. The more woody shrubs on gravel and sand, e.g. *Hakea lissocarpa* and *H. marginata* with masses of white flowers and the small heath-like shrubs of *Leucopogon* (Epacrid.) covered with white bells, also reflect the moist and still warm conditions.

Amongst the taller shrubs many species of *Banksia* (Prot.) will be well in flower by
June. One often sees near Perth the play of colour on *B. Menziesii* whose flower cones change from a dark red colour to a fresh yellow-red as the perianths become fully open. Occasionally isolated branches of *B. prionotes* are likewise often to be seen in flower in the dry wilderness of bush in the interior. These striking forms bridge the gap between the rainy seasons of the two years. When their colours finally fade and their leaves begin to roll inwards because of increasing dryness, the new life has long had command and flowers and colours decorate the fresh and active undergrowth.

To the east of the hills the rains so far will not have been very abundant. They will, however, have been sufficient to produce a similar change to that on the coastal plain. Grass will have appeared on the parched soil and droseras and bulbous plants will have commenced to flower. Amongst the taller bushes, *eg. Acacia microbotrya*, the tiny flower buds having swollen steadily for sometime before the rains came, are now beginning to flower. When in full bloom they scent the air and their pale yellow colours appear from afar as a highly decorative feature amidst the blue-green foliage.

With the passage of time rainfall increases but the temperature falls steadily. This is reflected in the progress of vegetative development which does not proceed as rapidly as during the first few weeks of the rainy season. The buds developed in summer are now all unfolded; further progress in growth is orderly. The development of the vegetative organs becomes of prime importance. The number of flowering species increases less rapidly than in the first weeks of May but does not stop. The bright flowers of the early flowering *Hakea* and *Acacia* species are still dominant but a number of new species have joined them. These include the taller growing species of *Drosera*, *eg. D. heterophylla*. The swampy land with clay and loamy soil, which has been more or less dormant up to the present, has now become sufficiently moist to support vegetation and the drab colours are replaced by the fresh tints of young shoots. Flowers also occur here and there.

Where grasses and herbs already thickly cover the richer soils in the hills, the floral development of the perennial herbs and bulbous plants is at its strongest. In such places the white flowers of *Burchardia umbellata* and *Anguillaria dioica* are so abundant that one is reminded of the beauty of the Liliflorae in the Mediterranean countries and the Cape.

By July the number of the flowering shrubs is already very high. At the foot of the Darling Ranges one can find many vantage points from which to overlook the Swan River plain. The dazzling reddish yellow flowers of the *Daviesia* (Legum.), the dark red of *Hakea myrtoides* (Prot.) and the white bells of *Cryptandra arbutiflora* (Rhamn.), which resembles an *Erica*, are all present in abundance. Among such a wealth of flowers one may easily overlook the fact that some messengers of spring, *eg. Dioscorea*. have already faded. On the south coast where the weather is colder, the unfolding of the vegetation takes place more slowly. But from the end of May under the influence of the rainy season, the vegetation is already showing considerable development. The number of plants coming to the flowering stage increases very gradually. The floral display of the new season here appears even in July to be less striking than that further north.

This is a corollary to the observation that the interruptions caused by the dry season are less severe here than in other parts of the country. In this respect the climate creates exactly the opposite condition in the landscapes of the north-west. There the rainy season reaches its height before the middle of June - the temperature, however, never falls as low as in the Swan River area and it rests again immediately after the solstice. All this results in a much more rapid development of the vegetation, particularly in the relatively warm coastal region. In the Irwin River district by the beginning of June a considerable change in the vegetation has already occurred. The bush in the valleys is green with herbs and grasses and the scented blossoms of *Xerotes effusa* (Lil.) enliven the scene together with the brightly coloured flowers of bulbous plants. The slender *Grevillea* bushes are in flower near the creeks, the *Dioscorea* and *Clematicissus* (Vitac.) with their fresh leaves twine among their branches. These are the only “rain green” lianes in the evergreen vegetation which is so typical of Western Australia.

A few weeks later the plains are at the height of their vegetative beauty and one
will rarely see anything finer than the upper Irwin or Champion Bay area at this time. At Mingenew for example, on the upper Irwin River, a small fertile plain extends eastwards to the foot of the low hills. At the end of June it is velvety with grass and delicate herbs. The Acacias grow sufficiently far apart for one to see between them and enjoy from afar the beautiful carpet of soft green. *Acacia acuminata* (Legum.) bears an abundance of yellow flowers and each small twig terminates in silky grey leafbuds which provide a delicate touch of silver to the dark green crown. Many annuals are already in flower and the bright red heads (*Helipterium, Laurencella*), often with the yellow and white tints, which adorn the meadow-like areas as with embroidery. Blue skies, mild air, the song of birds and the scent of *Acacia* make this landscape very attractive for most of the beautiful spring days. It shows how similar the picture of awakening nature is in all countries, where its pulse periodically changes.

From this low lying loamy area the land rises gently to the wide-spread sandy heaths. The vegetation still lags in development in July and the numbers of plants in flower is limited. The soil is less retentive of moisture and consequently the plants do not attain so quickly to luxurious abundance, which in the lowlands drives them so strongly to growth, blossom and maturity. In this vegetation zone each step forward is more precise, but the results are more permanent than is the case for the flora of the loamy country which after a short period of glory rapidly withers away.

Towards the end of July another important period occurs. This affects the greater part of the Southwest Province. The temperatures have reached their lowest point, rainfall is at its maximum and the sun has commenced to rise higher in the sky. At this time the pulse of the plant world also begins to beat more quickly. The hitherto smoothly rising curve of vegetative growth and flowering suddenly rises steeply. Entire plains suddenly become yellow with *Acacia* blossom and the ground in the woodland brightened by the colour of the undergrowth, is quickly converted into a colourful garden. On sandy soils, the mass of shrubs in flower forms a single gaily coloured carpet. On the open ground delicate annuals grow close to the moist soil and in the gaps between the rocks on granite bosses, the ephemeral flora now delicately but richly unfolds. In the loamy valleys the banks of small streams are green; in places the red soil is sparsely covered by patches of moss and grass, and the rosettes of ephemeral herbs. Orchids appear here and there and the first everlasting with their brightly coloured bracts begin to bloom.

In August the important woodland and heath communities show the greatest number of colourful species in flower. Swampy areas which are slow to warm up, still lag behind in flowering. Thus in the south western sector, say from the Murray River southward, where flooded areas are common, floral development is slow as compared with the better drained areas further north in the Swan River zone. The same thing applies in the forest areas of the cool southern hill country. There one may see the new green fronds of the Bracken Fern only just beginning to emerge from the tangle of the preceding season’s brown and decaying fronds.

In September the intensity and frequency of the rain diminishes markedly in the south west. However, the importance of the effects of the downpours of the preceding months now becomes apparent. The upper layers of the soil everywhere are thoroughly saturated, and consequently the vegetation almost everywhere maintains its growth much the same as in August. Both the annuals and the taller shrubs continue flowering on new shoots whilst other species also begin to blossom. It is only in the extreme north-west where, following the end of August, the rains have shown drastic reduction, that the ripening process has been initiated and fruiting becomes well advanced. The south with its slower tempo of change, however, makes up for this later.

Spring for the south west area really commences about this time. The plants have remained more or less dormant during the cold and inclement weather. This dormancy persists until September when the sun begins to shine more strongly and the temperatures become higher. The early flowering plants of the Wandoo undergrowth, eg *Hypoxis, Tribonanthes* (Amaryll.), together with other bulbous species which have long since flowered further north, now come into full bloom. For instance I have seen *Petrophila*
ericifolia (Prot.) in bloom not far from the western end of the Stirling Range at about this time, in late September. This is much later than in the more northerly coastal area.

The predominant annual vegetation in alluvial soils of the south-west also reaches its flowering peak in September. Its development is detained because of poor water absorption and slow warming up of its rooting substrate. In social groups members of the Cyperaceae, Centrolepidaceae and Restionaceae flower simultaneously and in between, the colourful flowers of Stylidium, Compositae, and other herbs occur, becoming more numerous every day.

In October a wave of falling blossoms, ripening fruit, and the wilting of some annuals, becomes evident and extends rapidly over the country, spreading down from the northwest parts. Occasionally hot days occur in the interior parts and night temperatures become mild. Ripening of the fruit proceeds rapidly particularly on the dryer loamy land. Faded patches begin to appear on the soil where shortly before all was a carpet of green. The sun shines more strongly and cloudy days become less common. Very beautiful, however, are the hundreds of flowering plants of the extensive sand-heath plains. Gradually flowers appear on species of the Myrtaceae which, up to now, have noticeably been held back in development. Soon the abundance of their flowers exceed in colour and brightness everything which flowered earlier. The late flowering Goodeniaceae also brings many new forms into view. The development of vegetative parts strongly manifests itself. Everywhere young leaves emerge, often reddish or light-green in colour. Some are still covered with long and downy hairs, which protected them in their bud stage. In eucalypts the reddish-green of young leaves contrasts with the dark green of older ones and in banksias young shoots, still covered with bronze or copper-coloured felted hairs, show on top of the last season’s branchlets. The charm which this diverse display of colour expresses, can easily deceive the observer as to the otherwise ever increasing more and more obvious signs of the decay of this season. Most of the plants have fruited by now and only species of Lobelia continue to bloom showing their fresh blue colour in November, and indicating the close of the growth phase of the annual plants. In the north by this time everything is already withered in the dried up valleys. On the sand plains Lachnostachys (Verben.) and Conospermum (Prot.) still stand out with their soft woolly white fruiting spikes. But the arrival of a windy day results in a rapid dispersion of the lightly hung fruits which are blown across the plains together with the fleeting heads of the Everlastings.

If one visits the sandy woodland of the coastal plain at the end of October, extensive bare patches may already be observed on the ground which a few weeks before was completely covered with green. Conostylis (Amaryll.) droops as if tired of bearing its heavy fruit and the panicles of Stirlingia latifolia (Prot.) are completely covered with feathery fruit. They look like Composite perennials which scatter their seeds. Inland in the Avon River region the change is most complete. The wheat is harvested and the once green areas in the Wandoo woodlands or even in the thickets where acacias and York Gums cast their light shadows. have largely disappeared. All that remains is bare ground or the remains of herbs and grasses. A few surviving rear-guard plants still keep their lonely watch here and there. Thus an Arthropodium (Lil.), its bulb nourished by the strongly developed foliage in the moist season, now bears its flowers on a bare stem. The much stronger growing and more colourful crowded ears of Trichinium species (Amaranth.) are also present. These are the plants which bring the flowering season of the year to a full toned conclusion.

In December the vegetation over the whole country appears generally withered but there are still well-marked differences in the extent of this. On heavy soils practically all the vegetation has dried out. Southern areas where adequate moisture is still present provide an exception. Plants of the sandy woodland have also for the greater part entered upon their dormancy period. A few stragglers such as species of Arnochinum (Lil.), Jacksonia densiflora (Legum.), Scholtzia involucrata (Myrt.) together with other Myrtaceous genera including Calythrix and Verticordia, as well as some species of Acacia (A. Huegelli) are still evident in full flower. The beauty of the flowers persists for a remarkably long time.
on the desolate heaths, even far into the interior, hundreds of kilometres from the coast. The vegetative existence of these dry communities confirms the statement of Behr with regard to the scrub of south east Australia. “Little can wither where little sprouts”. The short-lived rainy season scarsely affects the growth cycle of these regions. Flowering sets in early (middle of May) and increases quite slowly and gradually, much more slowly in fact than in any of the other plant communities. The same pace is continued until well into the dry season. Nothing is more surprising even in January than the change which is evident when one travels from the withered landscapes of the Swan and Moore Rivers to the great girdle of sandy heaths which extends northwards up to the Murchison River. Here the bright colours of flowers of the Chamaelauciae (Myrt.), of members of the Leguminosae and Proteaceae reveal that not even the heat of the summer can rob these otherwise parched plains of their flowers and colours.

In the other communities it is the tallest growing plants which do not flower until the advent of the dry season. The tall banksias, B. attenuata, B. littoralis and B. grandis, unfold their beautiful yellow flower-cones and B. Menziesii its darker cones, only towards the end of the dry period. Christmas time is marked throughout the country by the startling vivid colour of the Christmas Tree (Nuytsia floribunda (Loranth.)) which only then begins to open its buds. The contrast between the blossoming trees and the faded undergrowth first becomes really obvious when these bright orange flowers open. At the same time the flowers of Melaleuca Presissiana (Myrt.) open to lend for a short time, to the drab and melancholy appearance of the marshy lowlands.

From the beginning of January the number of new flowers is relatively few. There are still some trees amongst them as for example, Xylomelum occidentale (Prot.), with its white inflorescences it is a stately member of the western woodland. Otherwise only a few genera take part in the production of this scantly summer flora. Loranthus is certainly the most striking of them. Being peculiar to the drab interior its bright colours render it doubly obvious there. The bright crowns of Pronaya elegans (Pittospor.), some late flowering members of the Myrtaceae, e.g. Beaufortia, Verticordia and Regelia, together with Schoenolaena with its white umbels follow in January or later. The gleaming stars of Calandrinia Lehmanni (Portulac.) which sprout without green leaves and apparently without sap, from the tile-like ground between the dried-up grass of the Wandoo zone, also surprise one by their late occurrence. Usually, however, it is a few rare isolated species of the larger genera which attract one’s attention. They seem to choose almost the hottest and driest time of the year to blossom without any relation to their sister species. Hakea ruscifolia (Prot.) and Acacia Meissneri are two of these and where they occur both are quite unmistakable, so are the flowers. Hakea ruscifolia bends under the weight of its floral burden; there are thousands of flowers upon each single branch. Acacia Meissneri presents a combination of pale blue-green foliage and deep yellow strongly scented flowers. The Acacia species are widely distributed in the Avon Valley. When one visits there on hot January days one sees little but rocks exposed on bare slopes, or dark coloured Eucalyptus tops, with withered arable land in the low-lying parts. It is only the presence of Acacia in bloom, or of a vineyard with its vivid green, which give any indication of life in the general exhaustion.

The above picture of the vegetation cycle in the south west portion of Western Australia needs to be modified because of the marked divergence from it in the most southern districts. This largely coastal area is characterized climatically by the very gradual onset of the dry season and by the fact that it is never as extreme as in any other part of the country. The monthly rainfall in November, December and March is of the order of 20 to 25 mm, which is considerably higher than in the rest of the country. This marked blurring of the periodic rainfall pattern correlates with some degree of uniformity with the biology of the vegetation. This as a consequence affects its physiognomy. There are always many plants in flower on the south coast but whatever the season they never show the same abundance or degree of crowding as they do during the peak season in other areas. It is necessary finally to look at flowering phenomena on the south coast at the beginning of the dry period. Near King George Sound towards the end of December,
for example, we may note that for the annuals in particular many are only now coming in to flower. The shrubs are, however, further advanced, being well in flower, while the swampy areas appear as if covered with snow due to the crowding together of the white flowers of the epacrid, *Lysinema*. Development continues during January reaching its peak during early February. The famed Albany Pitcher Plant, *Cephalotus follicularis* is rarely seen in flower before mid January, while the flowers of *Beaufortia sparsa* (Myrt.) are not at their best before mid-February. Other characteristic plants also show themselves to be remarkably independent of the variations in climate of this temperate coastal region. I have for instance seen *Isopogon formosus* flowering not only in February but also in July and October.