TAXONOMIC STUDIES IN THE

GENUS CRYPTISA, Case.

(VOLUME I)

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by

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CHAPTER ONE

INTRODUCTION

The present study is but one of several treatments of the genus. However, all previous treatments have either concentrated on the genus in part, or have been part of a larger and more extensive work of either a taxonomic or phytogeographic nature. *Celmisia* has been regarded by many taxonomists as being "difficult" to classify both at the species level and at the generic. This is still true to some extent, though modern techniques of study are rapidly solving many of the problems found in genera of similar complexity.

Although computer techniques have not been used in this treatment they will probably prove useful, particularly at the subgeneric level. However, traditional techniques such as comparative morphology are still powerful tools in the hands of the taxonomist and much of this study is concerned with these methods.

1.1 TAXONOMIC HISTORY OF Celmisia

In 1817 Cassini founded the genus *Celmisia* with *C. rotundifolia* as the type. This species had been previously placed by Thunberg in *Arnica* as *A. tabularis*. It is endemic to the southern portion of Africa and recent taxonomists have placed it in the Seneconae. In 1825 Cassini included in his genus a plant collected by Gaudebout from the eastern coast of Australia. He described this as *Celmisia longifolia*. This addition required a redefinition of the genus since *C. longifolia* was found to have greater affinities with the Asteraceae than with the Seneconae.
In 1836 de Candolle took Cassini’s 1825 definition of the genus, with
C. longifolia as the type species, and regarded this as representing the
genus, placing it, however, in the Eupatoriaceae. C. rotundifolia was
placed in his new genus, Alcione. This treatment was adopted by most
nineteenth century botanists including Bentham and Hooker, although the
latter transferred Celmisia to the Asteraeae. In 1913 Robinson pointed
cut that the genus should be based on Cassini’s 1817 definition with
C. rotundifolia as the type. Accordingly, he adopted the earlier
definition with Celmisia tubularis (Thunb.) Robinson as the type and
restricted the genus to this species and one other, C. tomentosa. The
Australian plant was made the type of a new genus, Eleaemia (an anagram
of Celmisia) and the necessary new combinations published. Since this
move caused considerable confusion, the generic name Celmisia was con-
served with de Candolle’s usage being retained and the genus being based
on the Australian Celmisia longifolia.

The first specimens now included in the genus were collected by
Banks and Solander at Admiralty Bay, New Zealand. They were described
in manuscript as Aster gracilentus but the description was never validly
published (Solander, 18.) George Forster in 1786 described two further
species as Aster, these being A. coriaceus and A. holosericeus. Later,
both were transferred to Celmisia by Hooker.

In 1844 J.D. Hooker summarised the genus as it was then known,
including within it a total of four species of which three were placed
in the Eucelmisia and one (C. vernicosa) in section Ionopsis. By 1853
the number of species had risen to twelve, including one described by
Racil in 1844. In the Handbook of the New Zealand Flora published in
1867, Hooker accepted 25 species of which thirteen were described for the first time, chiefly from collections made by Hector and Buchanan, Haast, and Sinclair. Here Hooker reduced to synonymy, under C. longifolia, his C. gracilenta which had been based upon the manuscript species of Banks and Solander. The complexity of the genus was appreciated by Hooker who wrote:

A most beautiful genus, abundant in New Zealand, and, as in all the other large genera in these islands, the species are very variable, difficult to discriminate, and intermediate forms may be expected between those here described. It is very closely allied in characters but not in habit to the large northern genus Erigeron and the minute obscure tails to the anthers is the only diagnostic mark; three South American Erigerons, indeed, have all the habits of Celmisia, they have, however, the anthers of Erigeron, in which genus Weddell has placed them. From Aster, the same characters of the anthers, and the rarely flattened achenes distinguish them. From Clearia and Pleurophyllum they differ only in habit. Two of the New Zealand species, and another are Australian; the genus is unknown elsewhere.  

(Hooker, 1864, 129)

Not until the turn of the century was a further account of the genus to appear. In 1899 Kirk’s Student’s Flora of New Zealand was published and only seven years later Choaaman published the first edition of his Manual of the New Zealand Flora. During this period of over forty years, botanists had, however, not been inactive. Kirk accepted thirty-nine species of Celmisia and Choaaman accepted forty-three.

From 1860 to 1900 there was a distinct phase in the taxonomic history of Celmisia. The period saw the emergence of the local amateur botanists well versed in a knowledge of biology and intimately familiar with plants as they occurred in the field. Although the enthusiasm for describing species and varieties sometimes overrode the caution which is necessary when describing and publishing new taxa, the general quality of their work
is seen in the number of species and varieties which have survived to the present day. Previously to this period all the descriptive work had been done by experts such as Hooker who worked in Europe from material collected by early voyagers and explorers. However the middle of the nineteenth century saw an upsurge in local interest in science with the emergence in New Zealand of the enlightened amateur researcher and institutions such as the New Zealand Institute (later to become the Royal Society of New Zealand). Probably this emergence of the amateur scientist masked any direct influence which Darwinism may have had on the taxonomic history of *Celmisia* although the interest in subspecific taxa which dates from the 1860-1870 period, probably owed its origins to the broadened horizons which evolutionary theory revealed. During this phase, Kirk, Buchanan, and Petrie were prominent in the description of new species, most of which were published in the *Transactions of the New Zealand Institute*.

By the end of the nineteenth century a change was occurring in the type of species being described. Previously many of the species had been completely new to science and were often not closely related to species already known. From the turn of the century, however, most new species of *Celmisia* were segregates split off from already well known species. An example is *Celmisia petriei* which was described by Cheeseman in 1906 but which had been included in the type suite of *C. livellii* by Hooker in 1864. One result of this was an increasing amount of synonymy, this being apparent in the major works dealing with the New Zealand flora from Kirk onwards.

One interesting aspect of the late nineteenth century work on *Celmisia* was that local botanists looked beyond New Zealand in seeking to describe the relationships between species. Buchanan (1865, 1867)
described two *Galaxia* species as *Arisarum* and Kirk commented in the introduction to his flora:

The habit is exactly that of *Aster alpinus* L., which, except for the anthora, might well be referred to *Galaxia*. Under cultivation some of the stronger-growing species frequently develop branched spikes. All the species are endemic in New Zealand except *Galaxia picta*, which extends to Australia, and the doubtful *G. leichlandii* Schl. Bip., which is restricted to Peru.

(Firk, 1899, p. 279)

Another trend which was noticeable by the turn of the century was the realization of the complexity of the genus at the species level and the lack of good diagnostic characters. Cheeseman, in introducing the genus, made remarks similar to those made by Becker in 1894, but added:

... In *Galaxia* as in other large genera of the New Zealand flora, the species, such as they are, must be regarded as founded on an aggregation of several small prevalent characters rather than on conspicuous and important differences.

(Cheeseman, 1906, p. 297)

A study of the growing plant was becoming a necessity by this time and the population-oriented studies by Leonard Cockayne laid the basis for a more secure approach to the taxonomy of the genus. His study of the relationships between *Galaxia lindleyi* and Cheeseman's *Arisarum broughii* was a significant though crude example of the use of statistical methods in the field (Cockayne, 1906). Cockayne also pioneered the study of hybridization in *Galaxia* and showed that several species, including some of his own, were actually of hybrid origin.

The publication of Cheeseman's second edition of the *Manal* in 1925 saw the number of species accepted rise to 58. Even so there was considerable synonymy and several species not accepted by Cheeseman were probably quite valid and real. By this time the genus was becoming a complex of intergrading species almost requiring a specialist knowledge of the plants.
for the species to be keyed out successfully.

Work on *Calamia* which has almost passed unnoticed was done by S.A. Thomson of Dunedin. Over a period of many years (at least between 1915 and 1945) he grew and hybridised many species of *Calamia* and crossed the resulting progeny to at least the fourth generation in some cases. His basic hypothesis was that *Calamia* species had arisen by hybridisation from a small number of basic species. The results of his work were presented at the New Zealand Science Congress in 1947, and are summarized in brief in the Transactions of the Royal Society of New Zealand for 1949:

The progeny of *Calamia planchagoi* and *Calamia holocarpea* both of the Fiord Botanical District in the third generation produced plants showing the tomentum both on the upper and lower surfaces, with musk-scented leaves and viscid qualities. Another plant is a facsimile of *Calamia coriacea*. In the fourth generation, a plant appears a facsimile of *Calamia discolor* in one of its forms. Most types of tomentum found in the southern half of the South Island have been produced in this cross. As there are several species of *Calamia coriacea* and many musk-scented *Calamia* in the southern half of the South Island, this experiment is significant. There is much experimental evidence that *Calamia discolor* and the northern *Calamia planchagoi* have produced these *Calamia* in the northern half of the South Island and North Island.

(Thomson, 1949, 169)

Thomson's knowledge of at least the southern species of *Calamia* was unrivalled as for many years he combed Fiordland, searching for evidence to support his theories. Marginal notes in his personal copies of both Kirk's and cheeseman's floras attest to the detailed knowledge which he had:

The presence of teeth in *Calamia petiolata* and in *C. traversal* as seedlings is rather suspicious. Even *C. variscifolia* is said to be serrulate and not the southern *C. petiolata* is very like its northern type in many respects it seems conclusive that there is a common parent to the two types in *C. traversal*. On the bushland etc., where there is no *C. coriacea* one finds a plant a cross between *C. traversal* *petiolatia* that seems to show a great resemblance to *C. coriacea*. So far there is a
Corylacea growing on the Franklin Mts. It will be interesting
to note that is on the Stuart Mts. Possibly the great link line
is there... F4's new number 13. What can one make of
these with a queer first leaf? This may not be a Calmisia. This
viscid property is found on Calmisia. Could any Calmisia arrive
from... the F 4's. That a stir if one should turn up.

Fjordland is not, mountainous, steep and rugged, and ever
changeable. Yet, very much worth all the time and hard work
spent on it. The hard experiences of thirty years have yielded
almost twenty-one undescribed plants and the key to the origin of
possibly sixty odd at least of our Calmisias.

(S. A. Thomson, MSc.)

It is tragic that at present no coherent record is known to exist
of his work, for his detailed and accurate observations would be of
inestimable value to the taxonomist today.

During the 1930's several years of study by S. Martin culminated
in three papers published in the Transactions of the Royal Society of
New Zealand (Martin 1935, 1936, 1938). He described in detail, the species
of Calmisia occurring in Marlborough and also carried out detailed
taxonomic studies in the Calmisia discolor complex. His treatment
included the description of several new species and varieties and he paid
particular attention to subspecific variation.

Later, Simpson and Thomsen described several species and varieties,
most of which were from Otago. Though they undoubtedly recognised
several "good" taxa, their work still awaits critical evaluation.

The most recent work on the genus is that of Allan who in his
Flora of New Zealand, Volume I, published in 1961, provided the first
formal taxonomic subgeneric classification since that of Hooker in 1844.
Allan accepted 58 species and followed Chesser in many instances. The
species in Allan's scheme are grouped into three sections and nine
subsections which are based mainly on vegetative characters. It is
unfortunate, and certainly detrimental to his classification, that, apart from a very brief introduction, Allan does not discuss his system in this or any other publication. It is difficult, and only possible through inference, to gain any insight into his reasons for associating particular species in his arrangement. In discussing the genus, Allan comments:

Vegetatively the New Zealand species fall into three rather well marked groups but I have not found any correlated flower or fruit characters to justify the erection of subgenera.

(Allen, 1951, 614)

Hybrids are well dealt with by Allan, in contrast to the earlier floras, and a full treatment of putative hybrids recorded in the genus, in New Zealand, is included. This is a valuable summary of present knowledge of hybridism, though some of the recorded hybrids are highly unlikely in view of the known present-day distributions of the species concerned.

The chief fault with Allan's work on the genus as presented in the *Flora* is that it attempted too much. For obvious reasons a regional flora is not the place to launch into a major taxonomic revision and in this instance a compromise had to be reached between the amount of revision undertaken and the stringent requirements of space and time. The compromise was not entirely satisfactory and it is unfortunate that Allan's revision even as it stands was not published separately so that a fair evaluation could be made.

Only a small number of species from outside New Zealand have been placed in *Celastria*. Although the type for the genus is the Australian *Celastria longifolia*, a total of four Australian species have been published. The only recent taxonomic work has been that of Willis who in 1951 described *C. sericosiphila*. In South America, however, a more complex
FIGURE 1

DISTRIBUTION OF THE GENERA CELMIGA, PLEUROPHYLLUM AND ORITROPHIUM
situation exists. During the nineteenth century several species belonging to the Asteraceae were described as *Celmisia* species by both Fiddell and Schults Bipentius. These were not referred to by New Zealand botanists apart from an occasional reference to *C. lechleri* which Schults Bip. listed in a catalogue of New Zealand Compositae in 1856. In 1960 Golding transferred four species of *Erigonum* (belonging to section *Oritrophium*) to *Celmisia*. The following year Castles and others independently placed the same species together with several other closely related species in a new genus *Oritrophium*, having raised *Oritrophium* from sectional to generic rank. As it stands at present, the situation is confused and until the South American Asteraceae can be sorted out into reasonably well-defined and natural genera it appears best to retain the species concerned in *Oritrophium*.

1.2 THE PRESENT INVESTIGATION

The primary aim of the present investigation has been to find subgeneric divisions within the genus and on the basis of these to suggest a taxonomic hierarchy. In addition detailed study of two species complexes has been undertaken.

The regrouping of the species into subgeneric categories cannot be considered complete. Although this is the most detailed work on the taxonomy of the whole genus to date, there was insufficient time available to study in necessary detail the anatomy and vegetative morphology of the genus. Also, the presence of species belonging to the genus in Australia, and of similar plants in South America will probably require field studies in at least Australia before a complete classification can be produced. Breeding systems have not been studied. Crossings were attempted for
species of the *Celmisia grandiflora* complex but were not conclusive. Any
evidence for the type of breeding system has been drawn from field observ-
ations.

Most of the data for the subgeneric classification has been drawn
from flowering and fruiting portions of the plant. Supporting evidence
was drawn from both morphological and non-morphological sources. In
particular, the distribution of each species has been studied and the
resulting data used in the placing of taxa.

The possible phylogeny of the genus is discussed near the conclusion
of the thesis, although its consideration played no part in the classifica-
tion of the genus.

In addition, detailed studies of both *Celmisia spectabilis* and the
*C. grandiflora* complex were made. These showed that while certain characters
were apparently not significant at the subgeneric level, they could be of
value at the specific and subspecific level. Both studies showed the degree
of variation in natural populations and demonstrated the patterns of
variation which are probably common to most species in the genus.

The sections on both South American and Australian species placed
in *Celmisia* cannot be considered complete. In both areas the species
involved are imperfectly known and particularly in South America, the
taxonomic state of the whole tribe Astereae, is extremely unsatisfactory.
- o- total no. of specific & subspecific taxa described
- o- total no. of species described
- o- no. of species generally accepted as valid

FIGURE 2

NUMBER OF SPECIFIC AND SUBSPECIFIC TAXA IN CELMISIA (1810 - 1961)
CHAPTER TWO

METHODS

Since this study involved Caloedra in its entirety, it was necessary to examine as many species as possible from as many areas as convenient. Also, it became apparent at a very early stage in the study that it would be necessary to compare various attributes of the component species at different times and in different ways. Thus, a ready means of comparing data was a basic need. Collections of dried, preserved, and growing plant material were made, a slide collection of floral dissections was built up, and several hundred live specimens were grown at Lincoln and at Ilam, Christchurch. In addition, field data was collected and a card reference system summarizing the information assessed was used to store, in a retrievable form, data on many aspects of the genus and its species.

2.1 DRIED MATERIAL

Since it was possible in many instances to obtain suitable live and preserved material, dried specimens were not used to as great extent as in many comparable studies done previously. However, dried herbarium specimens were invaluable in compiling distribution lists and in checking conclusions reached on the basis of either fresh or preserved material. In a few cases it was not possible to obtain other material so that descriptions were in such cases drawn up from herbarium specimens. Usually, the parts to be examined were soaked in water and "Texpol" for about half an hour before examination, after which they could be treated in the same way as fresh material. For the study of overseas material, loan of herbarium specimens by the institutions involved is gratefully acknowledged.
2.2 PRESERVED MATERIAL

During the summers of 1965-66, 66-67, 67-68, collections of preserved plant material were made using FAA. The aim was to build up a collection including all the described species and varieties together with their principal variations. All but about ten species were collected and treated in this manner. These collections concentrated on floral material although vegetative parts were also collected, particularly for study of the leaf and stem.

Most of the floral observations made during this study of the genus were made from FAA preserved material. This method allowed quick and accurate comparisons to be made between large numbers of specimens.

2.3 GROWING MATERIAL

Several hundred plants were grown during the course of the study at both Botany Division, B.S.I.R., Lincoln and at the Botany Department, University of Canterbury, Ilam. Living collections were maintained for several reasons. Firstly, it enabled studies which required live material to be done. Such studies included cytology (done by Dr J.B. Heir, Botany Division, B.S.I.R.), and the recording of flowering and fruiting times. Secondly, it meant that material of many species was on hand at any time for any other purposes which may have required it. Thirdly, specimens which were not collected while flowering in the field could be brought on to flower under cultivation. Fourthly, a permanent reference collection was established. Lastly, by cultivating specimens under uniform environmental conditions, estimates of both genetic and environmental variation could be arrived at. This was particularly the aim with specimens belonging to both Celmisia spectabilis and the C. grandiceps complex.
The species were found to thrive in pots under light shade and at both sites mentioned above were grown in latho-constructed shade-houses. Watering was generally done twice daily. Growing in pots enabled the plants to be shifted and also tended to force the plants to flower. The pot size used varied from four inches to six inches diameter.

In a few instances plants growing in private gardens in Christchurch were used as sources of material.

2.4 EXAMINATION OF FLORAL PARTS

Dissection of the florets usually followed a set pattern. The ray florets were undischested except for the removal of the pappus and achene. The disc florets were similarly treated, after which the style was removed and the corolla split lengthwise. In some instances the stamens were removed to allow a closer look at them, though in each sample at least one floret was left with these intact.

At this stage, semi-permanent mounts were prepared so as to show the achene and pappus, entire style, stamens, outer surface of the disc floret corolla, inner surface of the disc floret corolla teeth and the entire ray floret including the inner surface of the ligule. These parts were mounted unstained in glycerine jelly and kept for future reference.

Measurements were made from both mounted and unmounted material. Drawings were also done where necessary, these later being inked and photographed.

Pollen was only examined in connection with viability studies. In this case it was mounted fresh in a mixture of phloxine and light green in glycerine jelly using Cemarzak's method.
2.5 EXAMINATION OF VEGETATIVE PARTS

Since only a very general examination was made of the vegetative morphology of *Calendula*, no elaborate methods were used in preparing and examining samples.

Stems and sepalos were sectioned by hand and examined directly using aniline sulphate, light green, or aniline blue. In a few cases temporary mounts were prepared using glycerine jelly.

Leaves were sectioned by hand to examine the internal structure. In many cases the epidermis could be removed easily by making an incision in the leaf surface and then peeling the epidermis off. This method was used for examining leaf hairs, stomata and pigmentation. The epidermal hairs were also examined by scooping off the hairs from the surface of either FAA-treated or fresh material.

2.6 PERMANENT RECORDING OF DATA

This was done in the following ways:

- **Writing up** of data onto standard reference sheets. Cyclotyped sheets were used to record floral data, the observer simply having to delete what was not applicable. Gaps were left for measurements to be added. For example, the section of the sheet on pappus hairs would read:

  "PAPPUS HAIRS up to . . . cm long, . . . in number, closely/ distantly toothed/herbaceous, tooth short/long."

- Later, additional characters were added in some instances, e.g. "pappus equal/unequal".

Permanent mounting of material, particularly floral material. Glycerine jelly mounts have been kept for up to two and a half years without any appreciable deterioration.
Card indexing. Data was card indexed where possible using 4" x 6" file cards. These covered such topics as literature, ecology, lists of available material, taxonomic history, flowering data and lists of types. Punch cards were used to build up keys in some instances and to add to the retrievability of the information stored on cards.

Photographing and drawing of points of interest has allowed many complex situations to be recorded. A permanent collection of colour slides has allowed characters such as habit to be recorded, and has been of value in identifying material brought in from the field.

Permanent collections of dried, preserved and growing material have been built up.

2.7 SAMPLING AND FIELD STUDIES

In most instances no conscious effort has been made to sample on a systematic basis except shore species are either local or are not well known. In such cases sampling was usually done as near as possible to the sites of known collections, especially the type collection. For most species a wide coverage was obtained through collections made by other interested individuals.

The areas which have been visited by the author for the specific purpose of studying *Calmia* are listed below:

Hamilton area, Volcanic Plateau, Kaweka Range, Taranaki

Range, Ruahine coast.

Galloping-horse - Cape Farewell - Moutanaw area, Cobb Valley,

Marlborough Sounds, Taihopai Valley, Kaikoura coastal area, upper Clarence Valley, Nelson Lakes National Park, Malakite Valley, Grey Valley,

Westport area, Greywash area, Lewis Pass, Jacks Pass.
Lake Taylor (upper Hurramid Valley), Arthurs Pass National Park (most portions), Porters Pass, Asheron River, Lake Coleridge, upper South Ashburton River and Mount Bonser area, Banks Peninsula, Dunse Pass, Horse Range and Shag Point, Fiaa Range, West Natsukiwi River, Old Man Range, Carrick Range, Green Range, Coronet Peak and Ben Lawrence, Rees Valley, Hector Mountains, Garvie Mountains, Dunedin area.

Harris Saddle, Thomson Range, Te Anau, Takaka Valley, Mount Larnach, Berland Burn, Green Lake, Lake McKee area (Rakiy Sound), Bluff.
CHAPTER THREE

THE DISTRIBUTION PATTERNS OF NEW ZEALAND SPECIES OF Celmisia

Two features stand out above all others when the distribution of New Zealand species of Celmisia is considered. One is that the genus is virtually confined to the South Island of New Zealand. Even within the island it is not evenly dispersed but is mainly found in subalpine and alpine zones above altitudes of from 4,000 ft in the north of the island to 2,500 ft in the south. The second feature is that extensive sympatry occurs. Up to fifteen species may occur on one mountain, and sometimes an area of only a few square yards may yield up to ten species.

These two points have an important bearing on the taxonomy of the genus, if the classification is to reflect relationships (both phenetic and phyletic) as naturally as possible. One problem is that some of the questions posed by island floras become relevant since the alpine zones in New Zealand form an archipelago with highlands being separated by lowlands (Fig. 3). This results in considerable local speciation. Another problem is that a variety of degrees of genetic isolation appear to operate and this creates difficulties in separating taxa, particularly in areas recently subject to glaciation.

In any sizeable group of plants, clustering of species is likely to occur. This is inevitable since not only will a genus have one or more centres of origin but also it will have centres of secondary development. Species will tend to be clustered about these centres. Modifying factors such as climatic and edaphic forces may further distort the original distribution patterns.
FIGURE 3

DISTRIBUTION OF LAND OVER 4000FT ALTITUDE, SOUTH ISLAND, NEW ZEALAND
In New Zealand, this clustering effect is very marked, particularly in the South Island, where Sardle (1963) and Burrows (1966, 1965) have shown that there is a concentration of species in the north and south of the island. In these areas it is possible to recognize local "Calymia-floras". In both areas three clearcut zones can be recognized and in the middle of the island Banks Peninsula forms a distinct zone.

In discussing distribution it will be frequently necessary to refer to groups of similar (and probably related) species. The groupings used are those established in Chapter 7 and shown on Appendix A. For detailed distributions of species reference should be made to the maps accompanying that chapter.

3.1 GENERAL PATTERNS OF DISTRIBUTION

The geographical distribution of Calymia species follows certain repetitive patterns. Within each of the larger groups of species there is usually one or more widespread species and a number of locally distributed ones. The latter appear to be local segregates in most instances and are usually separated from the more widespread species by only minor differences in morphology.

There are relatively few species sufficiently widespread to occupy a major portion of New Zealand. Calymia gracilenta and C. glendulosa are probably the most widely distributed, both of these ranging from the centre of the North Island to Stewart Island. Calymia spectabilis is common throughout much of the North Island high country and is abundant east of the South Island main divide from Nelson to south Canterbury. Species such as Calymia discolor and C. incana are common over wide areas but each is replaced by closely related species in other areas. Also,
though *Calaisia sessiliflora*, *C. hastil* and *C. luridifolia* are widely distributed throughout the South Island, their ecological requirements limit their abundance in many areas.

A brief survey of the species distribution in terms of taxonomic groups enables patterns to be seen. The groups are markedly disjunct and are dealt with elsewhere. Four groups consist of only one species each, with three of the species being widespread while the fourth is confined to the Subantarctic Islands. Two groups consist each of two species, in each case the distribution of one species being contiguous with that of the other and only overlapping very slightly. A further group of two species has one widespread and another undescribed species in northwest Nelson occurring entirely within the range of the first. The remaining six groups consist of species complexes in which there is one or more widespread species and a number of local endemic species.

When the groups are looked at in more detail, it can be seen that there emerges a pattern suggesting a progressive "crystallization" of species from a widespread complex. In the case of the taxa clustered about *C. petiolata*, this species itself is widely spread but in the south merges with *C. verbascifolia*. Local species are *Calaisia rutlandii* (Sounds and northern Marlborough), *C. moorei* (Banks Peninsula), *C. hookeri* (northeast Otago), and *C. rigida* (Stewart Island). *C. traversii*, which belongs to this group occurs in Nelson and southern Marlborough, and Fiordland, while the closely related *C. coriifolia* is confined to western and northern Marlborough. Similar patterns emerge in the groups of species clustered around *Calaisia discolor* and *C. incana*, *C. sessiliflora*, *C. coriifolia* and *C. lyallii*. 
where there are fewer species in a group, similar but less complex patterns occur. In the case of groups with only two species, the distributions usually suggest that the species are derived from one continuous population (for example, *Celmisia densiflora* and *C. arcuata*).

### 3.2 DISJUNCT DISTRIBUTIONS

If the whole genus is considered, it becomes apparent that large numbers of species are confined to either end of the South Island. Approximately 30% of the genus is endemic to the South Island north of the Grey and Saini Valleys. In the south, 20 to 25% is endemic to areas south of the Mackenzie Plains and the Waitaki Valley. Within these areas are further regions of endemism such as northwest Nelson (7 species), the Marlborough Sounds and northeast Marlborough mountains (5 species) and Fiordland and western Otago (6 species).

As might be expected, discontinuities at the species level occur. For example, *Celmisia traversii* is found in both Nelson and Fiordland but is absent from the areas in between (Fig. 75). In other cases similar species appear at either end of the South Island but are absent from the middle portion. Examples are given by *Celmisia gibbsii*, *C. mansetria*, and *C. remulosa* (Figs. 47 and 49).

Both Barrows (1965, 1966) and Wadle (1963) in their work on glaciation and vegetation distribution in New Zealand, paid a great deal of attention to discontinuous distributions of species in various genera. Part of the evidence for glacially induced vegetation patterns depends upon the interpretation of discontinuous distributions.
It is likely that a large genus such as *Gelidia* should reflect the historical upheavals and disturbances which have affected New Zealand. Consequently, disjunctions caused by glaciation should be reflected in the distribution of the genus and in its taxonomy. Table 1 lists the instances of widespread disjunction in *Gelidia* both at and above the species level. One point which emerges is that there is only a small amount of disjunction at the species level. However, there has been considerable speciation at either end of the South Island and it is possible that past disjunctions have been obliterated through the evolution of new species.

Both of the groups of species which are markedly disjunct may be relatively primitive and their distribution patterns may date from periods of intense glaciation. However, since all members of the group of species clustered about *G. remotissima* (group 1) are alpine and tend to be high alpine, it is surprising that they do not occur on some of the high mountains in the centre of the island in a relict "mountain" pattern. At present, since the group are restricted to snow hollows and rocky slopes, distribution is limited by the ability of the species to migrate across lowland gaps such as Haast Pass. *Gelidia walkerii* (which is tentatively placed with this group of species) has a wider distribution than other members of the group but could have widened its distribution through its ability to descend to lesser levels than the other species. The other markedly disjunct group is also alpine but it is not as easy, in this case, to appreciate geographical limitations to migration along the axis of the South Island.

The two cases of species disjunction involve species which belong to relatively large groups within the genus. Of the two, *G. patriaei* appears to
<table>
<thead>
<tr>
<th>Species or section</th>
<th>Southern distribution</th>
<th>Northern distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>2 species in Fiordland and Otago</td>
<td>5 species in northwest Nelson</td>
</tr>
<tr>
<td>Group 7</td>
<td>1 species in Fiordland</td>
<td>1 species in northwest Nelson</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 species in Nelson, Marlborough and North Island</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 species in Marlborough</td>
</tr>
<tr>
<td>Geotrachel</td>
<td>Fiordland</td>
<td>Northwest Nelson to south Nelson</td>
</tr>
<tr>
<td>G. traversii</td>
<td>Eastern Fiordland</td>
<td>Northwest Nelson and Marlborough to north Canterbury</td>
</tr>
</tbody>
</table>
be linked by a closely related but undescribed species which occurs west of the main divide from the Tararimeka River south to the Haast River. The disjunct distribution of this species may not have arisen through glaciation and extinction and the species may even be polyphyletic in origin. The case of *G. traversii* is more clearly the type of disjunct distribution which could occur through a reduction in distribution area. In this case the species could now be restricted to the areas around two former refugia which existed during the height of the Pleistocene glaciation. The southern limits for the northern populations of *G. traversii* run along the Saihu and Narrui Valleys. Here, it is likely that topography is responsible for the present halting of species. South of the Saihu the only known occurrence of the northern part of the species is on Shale Peak, on the south side of the middle Saihu Valley. The southern populations are restricted to the eastern margin of Fiordland where the species ranges from Kea Summit southwards past Te Anau, through Tokeko Valley and Mount Luxmore, and by way of the Hunter Mountains to the head near Lake Hauroko (Figs. 5 and 75). One point of interest is that in Fiordland the species only occurs in a pure form on the eastern margin of the region. Further west it appears to have intergressed with *G. victoriae*.* victoriae*. It may be significant that the eastern margin of Fiordland is superficially very similar to much of the mountain country of Nelson, both climatically and topographically.

Divergence of disjunct taxa could be expected if populations were separated for long. This may have occurred in the groups discussed, although in the case of *Galeola traversii* and *G. patriciae* it can only be very slight.
3.3 SYMPATRIC DISTRIBUTION

There is a striking degree of sympatry in Celmisia which is accompanied by a conspicuous lack of extensive hybridization, except for a few instances where hybrid swarms have occurred.

If distribution is looked at in relation to the relative taxonomic position of species, it becomes apparent that only a small number of closely related species have even partially sympatric distributions. Sympatry is far commoner with species from different groups. Within a group the possible number of combinations of sympatric distributions is expressed by the formula:

\[ N = \frac{n(n-1)}{2} \]

where, \( N \) is the number of combinations
\( n \) is the number of species in the group

By dividing the actual number of cases of sympatry by \( N \) it is possible to arrive at an estimate of the actual amount of sympatry occurring. Table 2 gives the values obtained for each of the 15 groups formed in this study. Since in some cases it is not known if some species are sympatric these values are only approximate. Also, no distinction is made between species which are partially, and those which are wholly sympatric. Finally, the table only expresses sympatric distributions on a broad scale and does not take into account local allopatry caused by differing ecological preferences.

The table shows that opportunities for hybridization between closely related species are actually limited. In the field this appears to be born out by a large percentage of hybrids evidently being sterile. The table also shows that there tends to be an inverse relationship between the number of species in each group and the degree of sympatry. This is
<table>
<thead>
<tr>
<th>Groups</th>
<th>Actual number of cases of sympatry (n)</th>
<th>Theoretical maximum number of cases of sympatry (N)</th>
<th>(n/N)%</th>
<th>Number of species in group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>15</td>
<td>40</td>
<td>6</td>
</tr>
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<td>2</td>
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<td>3</td>
<td>2</td>
<td>3</td>
<td>65</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>21 - 28</td>
<td>45</td>
<td>55 - 60</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>6</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
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<td>1</td>
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<td>100</td>
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<td>8</td>
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<td>1</td>
<td>100</td>
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<td>9</td>
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<td>1</td>
<td>15</td>
<td>4</td>
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<td>10</td>
<td>5 - 6</td>
<td>15</td>
<td>55</td>
<td>6</td>
</tr>
<tr>
<td>11</td>
<td>2 - 6</td>
<td>10</td>
<td>55 - 60</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>10</td>
<td>55 - 60</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>3 - 8</td>
<td>10</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>10</td>
<td>60</td>
<td>10</td>
</tr>
</tbody>
</table>
probably related to the pattern of evolution of the genus in which species complexes appear to have "crystallised" to give numerous local and often peripheral species.

3.4 GENERAL PATTERNS OF ALTITUDBINAL DISTRIBUTION

Apart from a few species, most of which are local, the distribution of *Celmisia* is closely related to topography. Few species occur on such extensive inland areas as the Canterbury Plains and the Otago valleys, whereas the genus is abundant on the tops of adjacent mountains. The more subtle aspects of rainfall and temperature probably play a part in this distribution although the only data available at present is insufficient to determine this with certainty.

At present, little work has been done on the altitudinal variation of individual species, or even on the relative altitudinal ranges of related species. Such studies are long-term projects and require the intensive sampling of populations in several localities. However, evidence is available from two areas to show that altitudinal variation does occur in *Celmisia spectabilis*. During population studies throughout the whole range of the species, samples were taken from different areas. In two areas, on the east side of the Kawerau Range and in the watershed of the South Ashburton River, it was found that variation was climatic and could be correlated with change in altitude. Similarly, on peak 4,450 ft near Lake Hake in southeastern Fiordland, there was a gradual change from large forms of *Celmisia sessiliflora* at lower levels to *C. erecta*-like forms higher up. Probably changes of this type are not uncommon in the genus.

Differing ranges in altitude are taxonomically useful and sometimes serve to separate similar taxa. In the *Celmisia discolor* group the
### TABLE III

**ALTITUDDINAL RANGES**

<table>
<thead>
<tr>
<th>Group</th>
<th>Species</th>
<th>Lowest Altitude observed</th>
<th>Highest Altitude observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>rasulosa</td>
<td>3500ft</td>
<td></td>
</tr>
<tr>
<td></td>
<td>walkeri</td>
<td>3000ft</td>
<td>5000ft</td>
</tr>
<tr>
<td></td>
<td>gibbsii</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>rupestris</td>
<td>4500ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>lateralis</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hectori</td>
<td>4900ft</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>brevifolia</td>
<td>4000ft</td>
<td>5500ft</td>
</tr>
<tr>
<td></td>
<td>angustifolia</td>
<td>3000ft</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>argentia</td>
<td>2600ft</td>
<td>4600ft</td>
</tr>
<tr>
<td></td>
<td>sessiliflora</td>
<td>3500ft</td>
<td>6000ft</td>
</tr>
<tr>
<td></td>
<td>olavata</td>
<td>1800ft</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>incana</td>
<td>3200ft</td>
<td>5600ft</td>
</tr>
<tr>
<td></td>
<td>discolor</td>
<td>2500ft</td>
<td>5000ft</td>
</tr>
<tr>
<td></td>
<td>intermedias</td>
<td>3800ft</td>
<td>5000ft</td>
</tr>
<tr>
<td></td>
<td>durietii</td>
<td>2000ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>lindsayi</td>
<td>0ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>bonplandii</td>
<td>2800ft</td>
<td>5000ft</td>
</tr>
<tr>
<td></td>
<td>sinclairii</td>
<td>4900ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>allani</td>
<td>4000ft</td>
<td>6500ft</td>
</tr>
<tr>
<td></td>
<td>namahonii</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>viscosa</td>
<td>4000ft</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>haastii</td>
<td>4000ft</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>densiflora</td>
<td>3100ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>prorepens</td>
<td>3100ft</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>dallii</td>
<td>3800ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hieracifolia</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>holoscricea</td>
<td>100ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>cockayniana</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>glandulosa</td>
<td>3500ft</td>
<td>5000ft</td>
</tr>
<tr>
<td>9</td>
<td>bellidioideae</td>
<td>2800ft</td>
<td>5000ft</td>
</tr>
<tr>
<td>10</td>
<td>lanceolata</td>
<td>2000ft</td>
<td>5000ft</td>
</tr>
<tr>
<td>----</td>
<td>------------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>petrii</td>
<td>2000ft</td>
<td>4700ft</td>
</tr>
<tr>
<td></td>
<td>cf. petrii</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>lysallii</td>
<td>3500ft</td>
<td>5900ft</td>
</tr>
<tr>
<td></td>
<td>lancifolia</td>
<td>4000ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>armstrongii</td>
<td>4000ft</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>cordesii</td>
<td>100ft</td>
<td>5800ft</td>
</tr>
<tr>
<td></td>
<td>nonroi</td>
<td>0ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>insignia</td>
<td>1800ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>morganii</td>
<td>0ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>dubia</td>
<td>2000ft</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>spectabilis</td>
<td>1200ft</td>
<td>6000ft</td>
</tr>
<tr>
<td></td>
<td>petiolata</td>
<td>2300ft</td>
<td>4700ft</td>
</tr>
<tr>
<td></td>
<td>verbascifolia</td>
<td>3000ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>traversii</td>
<td>4000ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>cordatifolia</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>hockeri</td>
<td>0ft</td>
<td>200ft</td>
</tr>
<tr>
<td></td>
<td>rutlandii</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>loricifolia</td>
<td>3500ft</td>
<td>5400ft</td>
</tr>
<tr>
<td></td>
<td>cf. loricifolia</td>
<td>2100ft</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>gracilenta</td>
<td>0ft</td>
<td>5000ft</td>
</tr>
<tr>
<td></td>
<td>gracilifolia</td>
<td>10ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>major</td>
<td>0ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>alpina</td>
<td>100ft</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>adamsii</td>
<td>1200ft</td>
<td>1600ft</td>
</tr>
</tbody>
</table>
altitudinal ranges of the various species are not coincident. *C. durieae* and *C. leonardii* both descend into the tree zone, *C. alleni* tends to occur in alpine to high alpine zones, and *C. discolor* and *C. incurva* occupy intermediate zones. Table 3 shows the altitudinal ranges for a number of species.

3.5 SPECIES AT LOW LEVELS

Cockayne (1905) in writing on *Celmisia lindsayi* mentions several instances of species of *Celmisia* occurring at or near sea-level:

That alpine plants frequently occur at sea-level is well known, while several species of *Celmisia* also occur in the lowlands. Such are *Celmisia longifolia*, *C. articulata* var. *rigida* of Stewart Island; *C. verbascifolia*, *C. holosericea*, *C. vernicosa*, of the Southern Islands; while quite recently Mr A.R. Cockayne and also Mr H.J. Matthews have collected *C. incurva* near the sea in north-east Marlborough.

(Cockayne, 1905, 346)

In addition to these species, a number of others could be cited. Burrows (1964) writes of *C. erectabilis* and *C. erematifolia* as being often found on lowlands below high peaks in Canterbury, of *C. curvipes* and *C. holosericea* as being along stream sides and on slips in Fiordland (separated by 2,000 ft of forest from alpine populations), and of *Celmisia discolor* as being found along with other alpine and subalpine plants on the margins of some West Coast "pukihis". In northeast Otago *C. hookeri* grows at sea level near Palmerston and Moeraki and extends inland to Trotters Gorge and the lower parts of the Horse Range. On Banks Peninsula both *Celmisia praelata* and *C. beckani* grow at sea-level, the latter being restricted to a small area east of Akaroa Harbour. Near Westport *C. morandii* is endemic to a small area in the Ngakawau Valley, while further south *C. incurva* descends from the Paparoa range as variety *serratae*, to
occur at sea-level. In the North Island, both *Celmisia adamsii* and *C. major var. major* are virtually confined to coastal habitats.

From Table 4 it can be seen that the species of *Celmisia* which grow in the lowlands can be divided into three groups: those which are practically confined to coastal or lowland areas, those which are normally upland species but which occur at lower levels in limited numbers, and those which are relatively common both on uplands and lowlands.

All members of the first group are closely related to taxa occurring in alpine (or alpine and lowland) areas. For example *Celmisia major* and *C. adamsii* are both part of the widespread *C. gracilenta* complex, and *Celmisia mackauli*, *C. hookeri* and *C. rigidus* are part of the *C. petiolata-verbascifolia* group of species. Similarly, *C. marcelli* is closely related to *C. coriacea* and *C. lindseyi* to *C. bomplandii* of the *C. discolor* group.

A further point of interest is that all these coastal species are very locally distributed and exist practically as single populations. An exception is *Celmisia major* which has a supposed variety described from Mt. Egmont, 150 miles to the south of the main area of distribution of the species (see however Chapter 11).

The second group of species (those which are normally present at higher levels but which descend to lowlands in a few areas) contains seven species. These are distributed amongst five taxonomic groups and in six instances involve species which are relatively widespread.

The third group includes only two species, both of which belong to the *Celmisia gracilenta* complex. Both are widespread and found from sea-level to over 4,000 ft.

Members of the first group of species appear to be local segregates or relicts, closely related to more widespread alpine species and differing
<table>
<thead>
<tr>
<th>Species</th>
<th>Lowland distribution</th>
<th>Upland distribution</th>
</tr>
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<tbody>
<tr>
<td>major</td>
<td>Coastal cliffs Auckland</td>
<td>Variety(?) on Mt. Lidgani</td>
</tr>
<tr>
<td>adpressi</td>
<td>Coromandel Peninsula</td>
<td></td>
</tr>
<tr>
<td>rigida</td>
<td>Stewart Island</td>
<td></td>
</tr>
<tr>
<td>aequale</td>
<td>Northeast Otago coast</td>
<td>Lower part of Morris Range</td>
</tr>
<tr>
<td>maculata</td>
<td>Banks Peninsula</td>
<td></td>
</tr>
<tr>
<td>norgandi</td>
<td>Ngakawau Gorge</td>
<td></td>
</tr>
<tr>
<td>lindcavi</td>
<td>Southeast Otago coast</td>
<td></td>
</tr>
<tr>
<td>verbascifolia</td>
<td>Open sites in Fiordland</td>
<td>Abundant Fiordland alpine</td>
</tr>
<tr>
<td>coriacea</td>
<td>Westland coast in gullies</td>
<td>Up to at least 4000ft.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paparoa R.</td>
</tr>
<tr>
<td>spectabilis</td>
<td>Coastal cliffs Marlborough</td>
<td>Common Marlborough alpine</td>
</tr>
<tr>
<td></td>
<td>Descends to 1600ft in Canterbury</td>
<td>Extensive alpine species</td>
</tr>
<tr>
<td>angustifolia</td>
<td>Uncommon in Canterbury</td>
<td>Common Canterbury alpine</td>
</tr>
<tr>
<td>discolor</td>
<td>West Coast Pakihia</td>
<td>Extensive alpine</td>
</tr>
<tr>
<td>presilata</td>
<td>Locally common</td>
<td>Common throughout</td>
</tr>
<tr>
<td>grandifolia</td>
<td>Swampy areas</td>
<td>Locally common in swamp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>situations</td>
</tr>
</tbody>
</table>
from them in consistent but minor character differences only. Cookeyn
e in 1906 studied *Callicdea lindseyi* and *C. bomanndii* which previously had
been treated synonymously by most botanists. He found that though the
two species were very similar, there were consistent morphological
differences between them. Similarly, small but consistent differences
separate *Callicdea hockeri*, *C. verbascifolia*, *C. rigida* and *C. poecilata*.

The most likely explanation for the occurrence of these local
species is that they are relics from previously expanded ranges of alpine
species. In the case of *C. lindseyi* the species is now confined to open
habitats on coastal cliffs and rocks, with over 100 miles separating it
from the nearest known plants of *C. bomanndii*. Similarly, *Callicdea
mackardi* just survives at the southeast tip of Banks Peninsula in Canterbury,
its present known range covering no more than six square miles. Each
of these local coastal species exists in complete geographic isolation from
its nearest relatives. This prevents any genetic exchange and over a long
period of time would allow each population to undergo divergent evolution.
Divergence might be speeded by the probable small size of some of the
isolated populations at initial stages. In such cases drift and

canalization could come into play as evolutionary mechanisms.

It is possible that the restricted ranges of the lowland species
could be due to present day shrinking of the areas of distribution of
the species concerned and that some species are actually following a path
leading towards extinction. Within historic times areas of distribution
have been drastically reduced. Both *Callicdea hockeri* and *C. mackardi*
have suffered from the effects of stock and fire and the latter is now a
rare species.
In the second group of species a critical factor is that at low levels, sites suitable must be available for normally alpine species to grow successfully. This must involve climatic and site similarities within the tolerance of the particular species. Burrows (1964) discusses these and gives several examples. He points out that in Canterbury there are both soil and climatic similarities between mountain tops and valley floors. He suggests that the presence of open habitats at lower levels may be a critical factor and that:

They [alpine species] potentially are able to inhabit Icelandic sites but are normally confined above the tree line because they cannot compete with the trees. There are possibly few true microthecae restricted rigidly to alpine habitats.

(Burrows, 1964:127)

Although this may be generally true for many species, it does not appear to explain the situation in all cases. In Canterbury, few species of *Calamia* have descended to low levels following the destruction of the forests by fire. Most are still found occupying sites within the same or very similar altitudinal limits as they occupy in forested areas at present. Usually they are found at heights of 4,000 ft or more, even though suitable sites may exist continuously from this height downwards. Only *Calamia spectabilis* has, in Canterbury, taken full advantage of the destruction of the forests and this species is abundant in areas such as the Ashburton and Selwyn Valleys from 1,400 ft up to over 5,000 ft.

It has frequently been pointed out that there is a natural tendency in forested areas for alpine species to migrate from stream beds, across slides and avalanche chutes. Undoubtedly the presence of some alpine
species at low levels must be due to this (for example, Calamia varhassifolia and C. heliasisina in Fiordland). However, in such cases it is probable that a combination of climatic equivalence and site availability also plays a part. At alpine levels snowfall is probably a critical factor since the young growth of many species of Calamia is particularly susceptible to frost damage. It is also possible that physiological adaptation to higher altitudes could play a part particularly with respect to dormancy.

Climatic equivalence of upland and lowland sites does play a clear role in some instances of lowland occurrences of Calamia species. Two examples will be cited. The first concerns the occurrence of Calamia optiolata in the Sausalikini watershed. This species is an abundant herbfield species on and near the main divide where there is an annual precipitation in excess of 150 inches. In this area, it is normally found at heights of 4,000 ft or more. However, the species further east inhabits streambeds at low levels despite the lower rainfall of these eastern mountains where the precipitation is usually less than 100 inches per year. In the eastern ranges, plants are found at the bottoms of gorges where the general aspect is damp and gloomy. In the lower gorge of the East Golden River, Calamia optiolata is accompanied by Lomatogone grandis and several other normally alpine species despite the altitude of the stream at this point which is a little over 2,000 ft above sea-level. A second example is provided by Calamia coriacea var. semiflava which is found on the steep walls of deeply shaded gorges between Westport and Greymouth. In both these cases it appears
probable that normally alpine species can survive at lower levels because of the climatic similarities between gorge sites and alpine sites 2,000 ft higher.

A problem is posed by the occurrence of Calamia plants at low levels between Kaikoura and Blenheim. Much of the area in which this occurs is limestone and several of the plants found here show calcicophilic tendencies, e.g. Calamia asteri, Euhleboria antithecii and Hypoestis arnold).

Probably open habitats have been maintained for a very long time on the limestone, allowing a scrub and herb vegetation to develop. This could give opportunities for plants such as Calamia maguireii to exist at sea-level. A similar situation occurs in other limestone areas, e.g. Castle Hill in Canterbury. The ultrabasic magnesium-rich "Mineral Belt" of Nelson also shows floestial patterns of this type.

Only two species are common on both inland and upland sites. They are Calamia gracilenta and C. graminifolia. In this instance the species are highly specialized and both belong to a complex of ill-differentiated population groups. Members of this complex are possibly recently evolved and may represent the most successful species group in the genus.

In general, the occurrence of species of Calamia at low levels is suggested to be due to any one of three causes. These are the segregation or isolation of populations closely related to alpine species, e.g. Calamia lindseyi; a depression of a climate type found at higher altitudes, e.g. the westernmost occurrences of Calamia antithecii; and the spreading of species which are tolerant and able to invade inland sites made available by processes such as burning off. Such sites may have
edaphic characteristics similar to those found at higher altitudes, e.g., soil and moisture regimes may be similar. However, other factors such as the form of available nitrogen and competition may inhibit some species which might otherwise descend to the lowlands. In each of the above cases a reduction in the intensity of competition seems necessary. Very few species of *Calymia* seem able to compete successfully with other plants at low altitudes, without a suitable competition-free site being available for at least initial establishment.

### 3.6 CLIMATIC DISTRIBUTION

Some geographical distribution patterns are probably dependent chiefly on climatic patterns. Since factors such as climate are likely to show continuous variation (as with rainfall distribution from one side of the Southern Alps to the other) the distribution of climatically controlled species of *Calymia* tends to form a continuous pattern. However, consistent zones can be mapped, using key species, although the boundaries between such zones do not represent discontinuities but rather connect points of equivalence.

In the Arthur's Pass - Mairakairiri - Hakia area it is possible to distinguish several zones which appear to be at least partially dependent on rain and snowfall. These zones are continuous along and parallel to the axis of the Southern Alps from at least Lewis Pass to Fiordland. Fig. 4 shows the distribution of several species in detail and demonstrates the way in which certain species tend to be limited to certain zones. Table 5 lists the species occurring in high and low rainfall zones in two parts of the South Island, and Table 6 demonstrates the characteristic
| TABLE V |
| CLIMATIC ZONES IN Celmisia |

<table>
<thead>
<tr>
<th>A. CANTERBURY species</th>
<th>Western wet zone</th>
<th>Eastern wet zone</th>
<th>Dry zone</th>
</tr>
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<tbody>
<tr>
<td>spectacle</td>
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<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>lyallii</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>amastrongii</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>viscosa</td>
<td>Absent in</td>
<td>Absent in</td>
<td>Present only in gorge sites</td>
</tr>
<tr>
<td>petiolata</td>
<td>herbfield</td>
<td>herbfield</td>
<td></td>
</tr>
<tr>
<td>sp. cf. petrii</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. FIORDLAND species</th>
<th>Western wet zone</th>
<th>Marginal Zone of east Fiordland</th>
<th>Dry zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>lyallii</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>petrii</td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>lanceolata</td>
<td>Rare</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>traversii</td>
<td>Introgressed with following sp.</td>
<td>Absent</td>
<td></td>
</tr>
<tr>
<td>verbascifolia</td>
<td>Form with achenes</td>
<td>Few achenes hairs</td>
<td>Present with glabrous achenes</td>
</tr>
<tr>
<td>viscosa</td>
<td>Absent</td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>ramulosa var.</td>
<td>Present</td>
<td>Present</td>
<td>Absent</td>
</tr>
</tbody>
</table>
## Table VI

**East to West Distribution of Geranium in Otasso**

<table>
<thead>
<tr>
<th>Species</th>
<th>Lake Mike</th>
<th>Takahoe Valley</th>
<th>Lake Mike</th>
<th>Mount Lassen</th>
<th>Mount Pico</th>
<th>Densey Pass</th>
<th>Navaro Lakes</th>
</tr>
</thead>
<tbody>
<tr>
<td>helenoides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>durietzii</td>
<td>*</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sessiliflora</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>var. origina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ramulosa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>var. ramulosa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>walkeri</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>verbascifolia</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>beculandii</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lanceolata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>petrii</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cianfolosa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>traversal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>viscosa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lvalii</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>densiflora</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>brevifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
CELMISIA SPECIES

- armstrongii
- petiolata (herb-field)
- petiolata (gorge sites)
- lyallii
- viscosa

FIGURE 5
MEAN ANNUAL RAINFALL AND SPECIES DISTRIBUTION
IN THE WAINAKARIKI AND RAKAIA VALLEYS
change in species lists which occur as one moves from areas of high annual precipitation to areas of lower precipitation.

In general it is possible to distinguish dry and wet zones in the South Island, each with their own characteristic species of *Calathis*. Detailed plotting of species distribution in Canterbury has shown that the 100-120 inch isohyet appears to mark the boundary between dry zones (characterised by *Calathis viscosa* and *C. lyallii*) and wetter ones (characterised by *Calathis petioles* as a herbfield species and *Calathis armstrongii*). This is shown in Fig.5. At Green Lake, in the Hunter Mountains of western Otago, there is an overlap between the eastern *Calathis lyallii* and the western *C. petrici*. This is matched by similar overlaps in this area involving *Notharia glabra* and *H. lyallii* and species of *Chionochloa*.

Although the central part of the South Island has a simple pattern of climatic zones dependent apparently on precipitation, in the south part of the island the pattern is more complex. In Otago where mountain tops are notable for climatic severity (rather than for the lack of precipitation, which can be well over 100 inches per annum) a central zone can be distinguished. Table 6 shows the east-west changes which occur.

In some instances, species pairs are useful in distinguishing climatic zones since each may be abundant within its own area of distribution. *Calathis lyallii* and *C. petrici* form such a pair since though they are each abundant within particular zones, they meet in only a few localities.

### 3.7 DISPERSAL MECHANISMS AND BARRIERS

The present distribution patterns of any group of organisms reflects
the interaction of dispersal mechanisms and barriers to dispersal acting on the evolving population. In the case of *Gelidaisia* species within New Zealand, several dispersal mechanisms are possible to account for the present distribution.

The first is the effect of wind on the disseminules (including the whole plant) and particularly on the achenes. This organ has often been cited as being highly modified for carriage by wind although Good points out that in many instances the lack of a pappus has had no apparent effect on the efficiency of dispersal of Composite species (Good, 1964, 371). Obviously, in some genera the scheme is a highly successful means of using the wind to distribute plants over wide areas but in *Gelidaisia* this ability is probably not great. The achenes of *Gelidaisia* fall into the group described by Cain as "heavy soaring" seeds. They are often unable to soar in a light breeze and experiments indicated that the terminal velocity of achenes belonging to *Gelidaisia* species was in the order of from one and a half to about six miles per hour. The higher figure was found to apply to species with achenes from six to eight millimetres in length and the lower to species with a copious pappus and achenes three to four millimetres long. Thus a moderate updraft of several miles per hour would be required to keep the achenes at the same altitude while being wind-transported. Since most achenes would be collected by the wind on the windward side of a slope it is likely that many would be deposited on the lee of the ridge terminating the slope, where eddying occurs. However, the possibility of wind transport being effective over distances of a few miles cannot be discounted and may account for some isolated occurrences of
species such as Calaminia traversii which only crosses the Selwyn Valley at one point, occurring on the south side of the valley at Shale Peak. The fact that barriers such as transverse valleys appear to have stopped a number of species from effectively colonizing one side of a valley when common on the other speaks for the relative inefficiency of wind as a dispersal agent.

Some dispersal probably takes place by means of water and avalanches. The occurrence of alpine species in watercourses and on the sites of old avalanche trails is one case. However, the limitation of this means of dispersal is that it will only allow plants to disperse downhill and is probably limited to bringing species down to lowland levels.

There is, as yet, no evidence for dispersal by animals, including birds. This cannot be ruled out, however. Insufficient is known about the feeding habits and movements of alpine birds in New Zealand for the possible transport of diaspores from one range of mountains to another.

It has been demonstrated that there is a failure of correlation between dispersal mechanisms and distributions amongst the temperate mountain plants of tropical mountains (van Steenis, 1936). The same phenomena of distribution appeared to be represented in groups of plants with most divergent methods of dispersal. His conclusion was that migration was the most important dispersal mechanism. In the case of mountain flowers this will usually result from climatic change. In New Zealand it is possible that the considerably altered configuration of climatic zones during the Pleistocene enabled species to bridge gaps which would be normally impassable. Valleys which are at present forested and which carried
glaciers during the height of each glaciation would probably carry, during intervening periods, a cover of tussock, herbfield or scrub which would allow for at least a short period, the intermittent migration of alpine species. Some of the relict populations which are now isolated from main areas of distribution would have reached their present sites at this stage and been subsequently stranded with the return of warmer conditions.

Any dispersal mechanisms are useless for spreading species if the new site and conditions are unfavourable for the germination and establishment of diaspores, and for the successful growth and reproduction of the nature organism. In the case of mountain vegetation, this makes dispersal by agents such as wind and water very hazardous, particularly if seed viability is not high. Moreover, it is probably not normal but exceptional conditions which govern dispersal by such agents. Thus, an extremely strong wind occurring rarely might be all that is required to disperse achenes from one mountain range to another. If this is the case then chance must play an important part in the dispersal of alpine plant species such as Galinsoga, particularly when distribution on adjacent mountain ranges is considered.

Present topographic barriers which appear to be effective in preventing dispersal are the low hill-country between Mount Egmont and the Volcanic Plateau; Cook Strait; the transverse South Island Valleys of the Wairau, Waist and Waikato Rivers; the Canterbury Plains (which prevent species such as Galinsoga spectabilis from reaching Banks Peninsula); and the Grey Valley (which separates the northeast Nelson elements of the Paparoa Range from the Westland and Canterbury elements of the Southern
Range, the Alexander Range and the main divide). The occurrence of 
Gahnisia traversii on one peak south of the Taihu Valley suggests the 
operation of a "chance" mechanism and the establishment of an isolated 
population at this spot.

3.8 DISTRIBUTION AND TAXONOMY

The distribution of species and groups of species within New Zealand 
has been used at the subgeneric level. Although distribution has not 
been regarded as a primary character in synthesizing groups from their 
component species, it has been used to check consistency within each group 
and to gain an insight into possible evolutionary paths. An attempt 
has been made to find consistent patterns of distribution throughout the 
genus and to explain these in terms of the morphology and ecology of the 
species, as well as in terms of the geological history of New Zealand.

One major assumption which has been made is that most taxa are 
monophyletic and that under stable conditions of climate and geography each 
taxon will occupy a continuous area. None the less, this is not always 
so. In any mountainous area there will always be discontinuities even if 
the species concerned are only found on a continuous upland area, or are 
able to exist with equal ease at all altitudes. Where discontinuities 
are local the problems of dispersal are not serious. However, where a 
species is markedly disjunct, considerable problems arise. Gahnisia 
traversii is such a case. It becomes necessary to consider dispersal 
mechanisms, polyphyly, speciation by hybridisation, and geological 
history. In the example mentioned, disjunction is commonly assumed to
have resulted from the patterns of Pleistocene glaciation (e.g., Burrows, 1965).

In proposing groups to include the New Zealand species, though the groups have been created primarily on morphological grounds, distributional data has substantiated the groupings made. The basic pattern within each group is that of one or more relatively widespread species and a number of local ones separated from the major species by relatively small character differences.

Additional to the aspects of distribution mentioned, is the evidence which is offered in assessing closeness of relationship of taxa. Studies of sympathy provide evidence that closely related species tend to occupy distinct and separate areas. Also, it is evident that in several instances species have become climatic obligates and that sometimes closely related species are separated by their different climatic tolerances.

In some groups there are complex clinal patterns which produce obscure patterns of total variation. Sometimes the delimiting of taxa in such groups is (at present) an arbitrary and imperfect matter. Expediency demands that the species be classified although the reality of the taxa must remain in some cases doubtful. In such situations the relative inflexibility of the current taxonomic system becomes a hindrance, since the taxa must either be squeezed into a taxonomic strait-jacket, and at least named and given recognition, or must be described informally, in which case they are liable to receive neither. For example, the Calmias discolor group contains a number of taxa which cannot be at present satisfactorily distinguished one from the other. At present most taxonomists follow Martin (1938). However, it is becoming increasingly
evident that his work, valuable though it is, only approximately describes the situation which exists in the field and that his descriptions and concepts are being unnaturally stretched to accommodate the range of variation which has been encountered. Further research will refine the present classification and should produce a more natural system, although it is doubtful if such complexes can be accurately described in terms of the present system of taxonomy and nomenclature.

Although this study in taxonomy, several factors have prompted an interest in the detailed distributions of Calmides species and varieties. One is that the detailed distribution has often proved to be different from that which is commonly assumed. For example, some species, including Calmides spectabilis, are more limited in their distribution than is commonly supposed. This obviously affects the possibility of hybridization and also casts light on the possibly phylogeny of species groups.

Secondly, a morphological – geographical approach to the species problem is favoured with species being defined within the three dimensional framework of form, distribution, and time. Distribution assumes a new value as a character, equivalent to, but not identical with, morphological attributes. Thirdly, a study of the inter-relationships between taxa requires a knowledge of the effects of climate and topography on distribution, particularly where taxa are closely related. Lastly, a unity has been sought in distribution patterns on the assumption that each group of species will react to its environment in a similar manner, although the establishment of groupings has not been based primarily on such patterns but on morphological data.
CHAPTER FOUR

FLORAL MORPHOLOGY OF NEW ZEALAND SPECIES

The term "morphology" has been taken in its broader sense to include internal anatomy as well as external morphology. This is unavoidable since in describing the external form of many structures it is necessary to comment on the internal structures associated with it. Also, much of the description of the external morphology involves the description of cell arrangement so that there is an overlap between the studies of the external and internal morphology.

The term "floral parts" has also been interpreted broadly to include not only the actual flowers, which in Composites are reduced to florets, but also the associated structures forming the inflorescence, including the receptacular organs, involucral bracts, and the flowering stem (or scape) supporting the whole flowering structure. Since all the species being studied are normally monoeocious there is no need to describe further the type of inflorescence. Partt (1961) discusses the use of the terms "flower", "pseudanthium", and "capitulum", in relation to the Composite flowering structures and takes the view that the individual flowers in the "head" should be called such. Here, in order to avoid confusion, the individual flowers are referred to as "florets" (this being a well established term) and the term "capitulum" is used when referring to the flower-like aggregation of florets born by a single monoeocious scape.
FIGURE 6

RAY FLORET AND INFLORESCENCE OF CELMisia
(SEMI-DIAGRAMMATICO)
FIGURE 7

DISC FLORET OF CELMESTA
(SEMI-DIAGRAMMATIC)
All species of *Celmisia* are monoecephalous and thus have a simple scape. It is born laterally although in some species in which the nodes are very crowded the scape may appear to be terminal. Occasionally, branched scapes are found but these appear to be the result of injury during the development of the scape and capitulum. Figure 6 shows diagrammatically the normal arrangement of the scape and capitulum.

The anatomy of the scape has not been studied in detail but is similar in all the species studied. The vascular cylinder consists of numerous discrete bundles which may partially fuse together. These are connected by lignified tissues. Outside the cylinder is the cortex which may be slightly lignified towards its outer edge. One to three layers of regularly spaced isodiametric cells form the epidermis and the outer layer of the cortex. Epidermal hairs may be present although in many of the larger species the scapes appear to be glabrous. The pith is partially lignified in most species although in some, only the outer part is in this condition, the inner consisting of thin-walled parenchyma. In transverse section the scape varies from circular to oval in outline (Fig. 8 and 9). The larger and longer scapes of groups ten, eleven and twelve are usually flattened, especially near the base and are crescentic in transverse section, so that the scape becomes dorso-ventral. In most of the smaller species of groups one to nine, the scapes are circular in transverse section.
FIGURE 8

SCAPES IN TRANSVERSE SECTION (SEM - DIAGRAMMED)

(a) Calydisa ballistididae
(b) Calydisa helleriense
(c) Calydisa verticalis
(d) Calydisa cephaliformis
(e) Calydisa veerstra\eflig;
(f) Calydisa major
(g) Calydisa carinata
(a) *Calendula varicosa* (multi-seriate), x60.

(b) *Calendula varicosa* (multiseriate), x275.

(c) *Calendula varicosa* (cape transverse section showing hairs), x60.

(d) *Calendula truxillii* (uniseriate), x275.
In all the species examined, bracts were found to be present. Number and distribution of the bracts is valuable at specific and subspecific levels but not at the subgenetic level. However, length of the bracts, though varying with the size of the plant, can be useful since when the plant is in bud and the scape is still expanding, long bracts will tend to crowd around the bud to produce a stellate effect. This is often seen in groups eleven and twelve. Generally, long bracts are more linear than short ones, though all are basically subulate.

4.2 RECEPTACLE

The receptacle is, in the Compositae, a structure of considerable complexity bearing many individual florets. In this study only the gross aspects of the morphology of the receptacle are considered, the detailed study of the receptacle being difficult and the internal structure involving many questions still open to debate.

One feature which is discussed by Solbrig in his comparison of New Zealand and South American Asteraceae (Solbrig, 1962), is the nature of the surface of the receptacle. This surface, upon which the florets are fixed, is slightly convex in Calendula, and the margins of the depressions where the florets are attached are produced into a thin minute membrane so that the receptacle surface is alveolate. This state is similar to that encountered in the South American species.

 Differences exist in the general shape of the receptacle in
FIGURE 10

CAPITULUM SHAPE

(a) Globose form (*Celmisia allanii*).
(b) Campanulate form (*Celmisia gracilenta*).
Celmisia. Two basic shapes can be distinguished when the
receptacle is examined in vertical section. Species in groups
one to nine (except group three) tend towards a broad receptacle,
particularly in groups four and six where it may be globose
(Fig. 10a). Species in groups eleven to fifteen tend to have
oblong to capsule-shaped receptacles (Fig. 10b).

4.3 INVOLUCRAL BRACTS

Within the Astersaceae, involucral bracts tend to be uniform,
are usually herbaceous or somewhat woody, and are imbricate
(Selberg, 1960). The bracts of Celmisia are arranged loosely in
two or more series and are usually subulate in outline. In many
cases the outer surface of each bract is pubescent although the
inner surface is always glabrous. Variation is usually simple with
one main vein forming a midrib and two shorter lateral veins running
parallel to this. There is considerable variation in the dimensions
of the bracts and in the morphology of the structures associated
with and forming part of them. (Figs. 12 to 17).

Flanged base on the bract

This is characteristic of species in groups one and eleven.
Most of the species in other sections have the bracts more or less
narrowed at the base. (Figs. 12 and 17).

Recurved bracts

When mature, the bracts of several groups of species may be
recurved. Although most species have at least a few recurved bracts
FIGURE 11

BUD OF CALMISIA DENISIFLORA SHOWING RECURVED GLANDULAR INVOLUCRAL BRACTS
near the base of the receptacle, only those in groups one, two, four, six, and seven, have most to all of the bracts recurved (Fig. 11).

Length of the bract

This varies considerably, though it often correlates with variation in floret number and consequently with the size of the capitulum. Species in groups ten, eleven and twelve have long erect bracts up to 25mm long, although most other species have bracts less than 13mm long. A notable exception is *C. heliosarcina* which has bracts reaching 30mm in length.

Dimorphic bracts

Species in group seven are distinguished from all others by their dimorphic bracts. The outer bracts are narrow-triangular in shape and are not recurved. The inner bracts are narrow-lanceolate and are recurved. (Fig. 14 a,b,c,e,e).

Venation of the bract

Several species have a simple pattern of reticulate venation, which is usually best developed near the base of the bract. These species are confined to groups one, seven and eleven (Figs. 12, 14 and 17). Occasionally reticulations may be developed near the tip of the bract (Fig. 12b). In all other species there is an undivided medial vein with a variable number of parallel lateral veins.
<table>
<thead>
<tr>
<th>Groups</th>
<th>Hair Types</th>
<th>Habit</th>
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<th>Venation</th>
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</table>

Numbers entered under "hair type" refer to hair type discussed in text. An * indicates presence of the particular hair type.
BRACT HAIRS

These are illustrated in Figures 18 to 21.

1. **Glandular hairs.** These are all biserrate (Fig. 18a-d). The stalk is in most instances several cells along and is capped by a multiseriate globose head. In a few cases the hairs are short and stubby, but are modelled on the same pattern as the longer hairs. Glandular hairs were found in species belonging to groups one, two, four, six, seven, eight, and ten.

2. **Elephantine biserrate hairs.** These are found in two species groups. *C. leonii* (group five) has long hairs with the stalk made up of as many as ten elongated cells. (Fig. 19a,b). Species from section twelve have very short hairs made up of a few short, wide cells (Figs. 19c, 21a).

3. **Elephantine uniseriate hairs.** These are found in most species of *Calatia* and are described under seven types.

(a) Basal portion biserrate and consisting of elongated cells with oblique cell walls. The upper part of the hair is uniseriate. This type is apparently restricted to *C. verrucosa* (Fig. 20a).

(b) Basal portion of several cuboidal to oblong cells surmounted by a long parallel-sided cell. Found in most of the "woody" species (Fig. 20a). In *C. dallii*, thick-walled modified forms of this type occur (Fig. 18a and b).

(c) Basal portion of several oblong cells, terminal cell very long, thin-walled and tapering. These are only found on *C. verrucosa* (Fig. 20b).
FIGURE 12

DIVALUCRAL BRACTS

(a) *Celmisia lateralis*, x6.
(b) *Celmisia gibbsii*, x7.5.
(c) *Celmisia rupestris*, x6.
(d) *Celmisia walkerii*, x6.
(e) *Celmisia hectori*, x6.
(f) *Celmisia argentea*, x6.
(g) *Celmisia brevifolia* (outer), x6.
(h) *Celmisia brevifolia* (inner), x6.
(i) *Celmisia laricifolia*, x9.
(j) *Celmisia sessiliflora* (outer), x6.
(k) *Celmisia sessiliflora* (inner), x6.
(l) *Celmisia angustifolia* (inner), x7.5.
(m) *Celmisia angustifolia* (outer), x7.5.
FIGURE 13

INVOHJCRAL BRACXS

(a) *Celmisia densiflora* (outer), x5.5.
(b) *Celmisia densiflora* (inner), x5.5.
(c) *Celmisia glandulosa* (outer), x5.5.
(d) *Celmisia glandulosa* (inner), x5.5.
(e) *Celmisia duriezi*., x8.
(f) *Celmisia discolor*, x5.5.
(g) *Celmisia lindsayi* (inner), x5.5.
(h) *Celmisia lindsayi* (outer), x5.5.
(i) *Celmisia viscosa* (inner), x5.5.
(j) *Celmisia viscosa* (outer), x5.5.
FIGURE 14

INvolucRAL BRACtS

(a) **Celmisia hieracifolia** (outer), x6.
(b) **Celmisia hieracifolia** (inner), x6.
(c) **Celmisia holosericea**, x6.
(d) **Celmisia bollidioides**, x9.
(e) **Celmisia dallii**, x6.
FIGURE 15

DIVINUCUAL BRACTS

(a) *Calliccia gracilenta*, x5.
(b) *Calliccia ametroncili*, x5.
(c) *Calliccia lanceolata*, x5.
(d) *Calliccia lyallii* (outer), x5.
(e) *Calliccia lyallii* (inner), x5.
(f) *Calliccia alpina*, x5.
FIGURE 16

INVOLUCRAL BRACTS

(a) *Celmisia hookeri*, x5.
(b) *Celmisia traversii*, x5.
(c) *Celmisia verbascifolia* (Mount Tennyson), x5.
(d) *Celmisia cordatifolia*, x5.
(e) *Celmisia verbascifolia* (outer), x5.
(f) *Celmisia verbascifolia* (inner), x5.
FIGURE 17

INVOlUCRAL BRACeTS

(a) Calymelia petiolata (outer), x5.
(b) Calymelia petiolata (inner), x5.
(c) Calymelia curiosa, x4-5.
(d) Calymelia macki (inner), x5.
(e) Calymelia macki (outer), x5.
(f) Calymelia vernicosa (outer), x5.
(g) Calymelia vernicosa (inner), x5.
FIGURE 18

INVolUCRAL BRACt HAIRES

(a) *Calliccia dallii* (type 3b), x360.
(b) *Calliccia dallii* (type 3b), x360.
(c) *Calliccia discolor* (type 1), x360.
(d) *Calliccia discolor* (type 1), x360.
(e) *Calliccia makani* (type 4), x60.
FIGURE 19
INVolUCRAL BRAct HALES

(a) *Calymia hastii* (type 2), x100.
(b) *Calymia hastii* (type 2), x100.
(c) *Calymia cordatifolia* (type 3f), x200.
(d) *Calymia laricifolia* (type 2), x150.
(e) *Calymia alpina* (type 3g), x200.
(f) *Calymia spectabilis* (type 3d), x200.
FIGURE 20

ENTOCRANAL BRACT HAIRS

(a) *Calendula vernicosa* (type 3a), x300.
(b) *Calendula vernicosa* (type 3a), x200.
(c) *Calendula walkeri* (type 3b), x200.
(d) *Calendula breviloba* (type 3c), x200.
FIGURE 21

INVLUCRAL BRACT HAIRS

(a) *Celmisia alpina* (type 4), x360.
(b) *Celmisia alpina* (type 4), x100.
(c) *Celmisia cordatifolia* (type 3d), x300.
(d) *Celmisia cordatifolia* (type 3d), x300.
(e) *Celmisia cordatifolia* (type 2), x300.
(f) *Celmisia cordatifolia* (type 3d), x300.
(g) *Celmisia cordatifolia* (type 3d), x300.
(d) Only one basal cell present. Terminal cell long, twisting and tapering. This form is found in groups ten to fourteen (Fig. 19f). In some species the basal cell is doubled and the base may even consist of four cells (Fig. 21d, e, f).

(e) One basal cell present (occasionally buttressed by an additional cell). The base of the terminal cell is distinctly globose and above this is a long and tapering terminal cell. These hairs are usually paired and have only been found in group two (Fig. 20d).

(f) Base of several scar or less cubical cells, the terminal cell long, tapering, thick-walled and deeply pigmented. This was only seen in group twelve (Fig. 19e).

(g) Consisting of a few cubical cells joined end to end with no appreciable differentiation into a terminal cell. This type appears to have been developed from the fibrillate hair. It was only seen on members of group fourteen (Fig. 19g).

4. Fibrillate hairs. These are present on the bracts of most species in the genus. They are eglandular and formed by an elongation of one or more marginal cells. (Figs. 19e and 21a, b.)

The involucral bracts provide many useful characters, particularly since they are not obscured or lost during the course of budding, flowering and seeding.

4.4 NUMBER OF FLOWERS IN THE CAPITULUS

The capitulum of 
Solanum consists of both female and hermaphrodite florets. Although the total numbers of each vary considerably,
FIGURE 22
RELATIONSHIP BETWEEN DISC FLORET AND RAY FLORET NUMBERS
<table>
<thead>
<tr>
<th>Group</th>
<th>Lowest numbers encountered</th>
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<td>30</td>
<td>80</td>
</tr>
</tbody>
</table>
there is an approximately linear relationship existing between the
two. Figure 22 shows this.

Several authors such as Cronquist (1954 and 1955) and Burt (1961) have commented on the significance of relative numbers of florets in the Composite capitulum. There is probably particular significance in the relationship between the number of florets and the breeding system. There is a greater ratio of hermaphrodite florets to female florets there is probably a greater chance of inbreeding by self-pollination; where there is a lesser ratio there is probably a greater chance for outbreeding.

Outbreeding is advantageous in terms of maintaining a heterozygous genetic system in the population so that it is reasonable to expect an evolutionary trend towards smaller capitula. Further, since insect damage usually affects the whole of a capitulum and is frequent, it is probably advantageous to produce a large number of small capitula than to produce a small number of large ones. Although within Compositae there may have been a trend towards smaller capitula, many species which appear on other grounds to be advanced do have large capitula. It is possible that there may have been a counter-trend leading towards large conspicuous capitula.

Table 8 gives the range in floret number found within each group of species.

4.5 ACRES

The scheme has been used frequently in the Asteraceae to delimit genera, and was used by Bentham to distinguish the two supposed lines
of development characterised by Aster and Brongniart. In most species of *Salsteinia*, the scheme is fusiform and may or may not be pubescent (Figs. 25 to 27).

**Shape of the scheme**

This varies to a small degree giving rise to three basic forms of scheme. Most species have fusiform schemes, a few have fusiform-cylindrical ones (particularly species in group one) and one species (*G. varnica*) has obconic schemes.

**Dimensions of the scheme**

Apart from variations in the ratio of length to breadth due to variations in basic shape, differences occur in the absolute values of both measurements. Length shows considerable variation from species to species, ranging from 1.5cm to over 3cm. The longest schemes are generally found in species belonging to groups ten, eleven and twelve.

**Flattening of the scheme**

This is found in a few species, although most of the schemes examined were angled.

**Ribs and venation of scheme**

In many instances the number of ribs on the scheme is five, and equal to the number of veins passing through the scheme wall. However, in some of the larger species there are twice this number of ribs.

**Achenial hairs**

These are present on approximately half of the species studied.
FIGURE 23

ACHENES

(a) *Celmisia rupestris*, x20.
(b) *Celmisia gibbsii*, x25.
(c) *Celmisia walkerii*, x20.
(d) *Celmisia lateralis var. villosa*, x25.
(e) *Celmisia ramosa*, x25.
(f) *Celmisia hectorii*, x20.
FIGURE 24

ACHEINES

(a) *Calaisia holosericea*, x20.
(b) *Calaisia hieracifolia*, x20.
(c) *Calaisia brevifolia*, x15.
(d) *Calaisia bellidioides*, x25.
(e) *Calaisia glandulosa*, x25.
(f) *Calaisia sessiliflora*, x15.
FIGURE 25

ACHENES

(a) *Celmisia lyallii*, x25.
(b) *Celmisia vernicosa*, x18.
(c) *Celmisia coriacea var. langifolia*, x10.
(d) *Celmisia densiflora*, x20.
FIGURE 26
ACHENES

(a) *Celmisia cordatifolia*, x15.
(b) *Celmisia hookeri*, x12.
(c) *Celmisia traversii*, x15.
(d) *Celmisia spectabilis*, x15.
(e) *Celmisia petiolata*, x12.
(f) *Celmisia monroii*, x12.
(a) Compound hair tip (*C. discolor*), x250.
(b) Compound hair tip (*C. discolor*), x250.
(c) Compound hair tip (*C. discolor*), x250.
(d) Compound hair tip (*C. bellidioides*), x250.
(e) Part of bifid hair showing pits (*C. vernicosa*), x600.
(f) Granular biseriate hair (*C. hierocifolia*), x300.
(g) Normal bifid hair (*C. densiflora*), x300.
and are shown in Figure 27.

1. **Normal thick-walled simple hairs.** These have two basal cells, and the apices pointed and diverging (Fig. 27 g).

2. **Compound simple hairs.** In these the lower terminal cell is divided by an oblique wall into two elongated cells. At the point where the cells join there is a small tooth. Sometimes the tip of the hair is twisted slightly. These hairs have been found in several species, particularly in *C. bellidifolia* and species of the *C. discolor* group. (Fig. 27 a, b, c, d).

3. **Uniseriate hairs.** These have been found on the achenes of some members of the *C. semirubra* group (group 3). They are restricted to the upper part of the achenes just below the pappus.

4. **Short biseriate granular hairs.** These consist of a few isodiametric cells and have been found only on the achenes of *C. hieracioides*.

Achene studies can provide not only an indication of relative taxonomic position but also of possibly phylogeny. Since it is probable that lack of achinal hairs is a secondary and not a primary character, species such as *Calymia basilii* are likely to have been derived from species with pubescent achenes or to have a common origin with such species.

4.6 **PAPPUS**

The pappus of *Calymia* is made up of numerous toothed hairs arranged in two or more series with the outer series shorter than the inner so that the pappus is unequal. The hairs are all of the same
basic setose type. The number of hairs varies from about 20 to over 70, and the length from about 3mm to about 8mm. Generally, the hairs are from three to six cells wide for most of their length and are flattened, being toothed on one or both edges (Figs. 28 to 30). Three main forms of pappus can be distinguished (Fig. 28).

*Celmisia verrucosa* type (Fig. 28 a)

Pappus with many long narrow teeth crowded together and giving the hair a plumose appearance. Hair moderately stout. The teeth on this type are not as acute as those of the following two types.

Normal type (Fig. 28 b)

Pappus with short to moderately long teeth, often crowded though on the same hair there may be variation in spacing. Teeth usually acute and longer on one edge than on the other. Within this group there are two sub-types, (1) with short teeth, (2) with long teeth. The pappus tip is compound with three or more cells forming the tip (Fig. 30 c). This type is found in most species of *Celmisia*.

*Celmisia gracilenta* type (Fig. 28 c)

Pappus with short distant teeth. In this type, the teeth are acute with the upper edge markedly shorter than the lower. The hair tip is bifid and made up of two elongated cells lying alongside each other with one cell sometimes longer than the other (Fig. 30 a,b,d).

Other variations in the pappus occur. The number of hairs is variable within species so that its value at the subgeneric level is not great. Highest numbers are found in the *Celmisia gracilenta* complex.
FIGURE 26

BASIC PAPYRUS HAIR TYPES

(a) Plumose form (Calamia vernicosa); (b) Glossenly toothed form (Calamia discolor); (c) Distantly toothed form (Calamia gracilenta); All approx. x500.
FIGURE 29
PAPPUS HAIR TEETH

(a) *Gelmisia alpina* (showing cell arrangement).
(b) *Gelmisia major* (showing cell arrangement).
(c) *Gelmisia alpina*.
(d) *Gelmisia adonii*.
(e) *Gelmisia loricifolia*.
(f) *Gelmisia glandulosa*.
(g) *Gelmisia spectabilis*.
(h) *Gelmisia bellidioides*.
(i) *Gelmisia lyallii*.
(j) *Gelmisia cordatifolia*.
(k) *Gelmisia verrucosa* (showing cell arrangement).
(l) *Gelmisia hectori* (showing cell arrangement).
(m) *Gelmisia harrietii* (showing cell arrangement).
(n) *Gelmisia coriacea* (showing cell arrangement).
(o) *Gelmisia argentea*.
(p) *Gelmisia angustifolia*.
(q) *Gelmisia rumulosa*. 
FIGURE 30

PAPPUS HAIR TIPS

(a) *Callisia alpina*, x250.
(b) *Callisia gracilenta*, x250.
(c) *Callisia cordatifolia*, x250.
(d) *Callisia adamsii*, x250.
and lowest in groups eight, nine, eleven, twelve and fifteen. The length of the longest hairs in each species are moderately uniform throughout the genus, except for \( \text{C. vermicosa} \) which has an extremely short pappus less than three millimetres long.

Several authors have commented on the pappus as an important organ of dispersal and as an important indicator of evolutionary trends and migrational pathways, e.g. Zohary (1950). In \textit{Celmisia} the pappus appears to be limited in its function as a distributive organ, but it is probable that it aids in the proper orientation of theohene as landing so that germination may occur satisfactorily. No obvious trends are apparent within the genus, and all the pappus types described are probably derived from the normal actone type common throughout much of the Compositae. Taxonomically, the pappus is useful in separating the sub-antarctic \( \text{C. vermicosa} \), the species clustered about \( \text{C. gracilenta} \) and the remaining species in the genus.

4.7 COROLLA HAIRS

Although corolla hairs have been noted in many Compositae genera they have not been used very often at the subgeneric level for determining taxonomic groupings. A number of different hair types have been found to occur in \textit{Celmisia}. All are glandular (Figs. 31 to 34).

\textit{Biseriate extended} (Fig. 31)

In some species hairs are found in which the basal cells are isodiametric or slightly elongated and the stalk consists of several
pairs of isodiametric cells. The two terminal cells are large and often elongated with one of the pair slightly larger than the other so that the tip of the hair is oblique. The whole hair expands towards the tip so that in outline it is obcordate. This type is found on both the ray and disc florets of most of the woody species.

Biseriate non-expanded (Fig. 32 a,b,d)

These are found on many of the species not bearing expanded hairs. The hairs are basically the same but are not expanded towards the tip and the terminal cells are not appreciably wider than the stalk cells. Sometimes in hairs on the ray floret corolla the hair might be slightly wider near the top than at the base, and also one of the terminal cells may project for half its length beyond its companion. Non-expanded hairs are often longer than the corresponding expanded hairs and both the length and number of stalk cells is usually greater. The stalk cells may be either paired or alternate.

Biseriate lanceolate (Fig. 33 e)

Hairs of a third type are restricted to C. vermicosa. The basal and stalk cells are similar and elongated and expand slightly to the base of the longest terminal cell where the hair is widest. From this point the hair tapers to the tip. The terminal cells are uneven, one being often twice the length of the other. So far, this hair type has only been found on the corolla of the ray floret.

Uniseriate noncormbic (Fig. 34 b,d,e)

These hairs occur in some species on both the ray and disc
floret corollas. Each hair consists of a number of elongated cells of approximately the same shape and size. This type has only been found on species belonging to group fourteen.

**Uniseriate dimorphic (Fig. 34 a)**

A second type of uniseriate hair occurs, consisting of several stalk cells surmounted by a long tapering terminal cell. Hairs of this type found on the disc florets usually have elongated stalk cells, while those found on ray florets have isodiametric cells in the stalk. These hairs are characteristic of group twelve, though they have been found on species at present placed in group eleven and doubtfully occur in group ten.

**Uniseriate elongated (Fig. 34 a)**

Found only in *C. vermicosa*, this type consists of several greatly elongated cells, joined end to end. The terminal cell is gradually narrowed to an acute tip.

Sometimes there may be few hairs on the corolla, although few species are completely glabrous. Distribution patterns of hairs are important, most of the hairs on the disc corolla occurring basally from the point of insertion of the stamens downwards to the base of the corolla. In some species the hairs are almost entirely restricted to the insertion point of the stamens. Two other hair distribution types occur. In one, the hairs are found only at the tips of the corolla lobes on the disc corolla and are found as small bunches of hairs on the inside of the lobes (Fig. 32 c). In the other, the whole outside surface of the disc corolla may be covered
<table>
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<td>4</td>
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<tr>
<td>15</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Hair types are numbered according to the classification in the text.
(a) Biseriate expanded \( \textit{Celmisia discolor} \), x220.

(b) Biseriate expanded \( \textit{Celmisia walkerii} \), x220.

(c) Biseriate expanded \( \textit{Celmisia angustifolia} \), x220.

(d) Biseriate expanded \( \textit{Celmisia angustifolia} \), x220.

(e) Biseriate expanded \( \textit{Celmisia sinclairii} \), x220.

(f) Biseriate expanded \( \textit{Celmisia hieracifolia} \), x220.

(g) Biseriate expanded \( \textit{Celmisia glaukulusa} \), x220.
FIGURE 32
COROLLA HAIRS

(a) Biseriate non-expanded (*Celmisia coriacea*), x250.
(b) Biseriate non-expanded (*Celmisia lanceolata*), x250.
(c) Corolla hairs *in situ* on corolla lobe tip
(*Celmisia major var. brevis*), x50.
(d) Biseriate non-expanded (*Celmisia alpina*), x250.
FIGURE 33
COROLLA HAIRS

(a) Biseriate expanded (*Celmisia densiflora*), x250.

(b) Biseriate expanded, narrow form (*Celmisia prorepens*), x250.

(c) Biseriate non-expanded (*Celmisia bellidicoides*), x250.

(d) Biseriate non-expanded (*Celmisia bellidicoides*), x250.

(e) Biseriate lanceolata (*Celmisia vernicosa*), x250.
(a) Uniseriate elongated (*Celmisia vermicosa*), x250.

(b) Uniseriate monomorphic (*Celmisia gracilenta*), x250.

(c) Uniseriate dimorphic (*Celmisia spectabilis*), x220.

(d) Uniseriate monomorphic (*Celmisia major* var. *brevia*), x250.

(e) Uniseriate monomorphic (*Celmisia alpina*), x250.
irregularly with hairs.

Hair distribution on the ray floret corolla is less complex and they are usually restricted to the tube and base of the limb.

4.6 STAMENS

Stamens are restricted to the hermaphrodite disc florets, in which they are found on the inner surface of the tubular corolla. The filament of each of the five stamens fuses with the corolla midway between the base and the tip of the corolla. Considerable discussion has centred about the stamens of *Colobisis*, since they are supposed to supply one of the main diagnostic characters of the genus. This is the supposed presence of tails at the base of the anthers. In the past, *Colobisis*, *Platycaulium* and *Erioceras* sect. *Gritrophium* have been separated from other members of the Asteraceae on the basis of their tailed anthers. It appears, however, that the character is not of great value in delimiting these genera. Only a small number of New Zealand species of *Colobisis* have tailed anthers and in each of these the tail is short (Fig. 37). In most species the anthers are dorsifixed and the anther cavity extends down into the anther base leaving at the lower end of the base only a few sterile cells. The anthers are thus curviled at the most rather than tailed. In the South American species of *Erioceras* sect. *Gritrophium*, only one out of four species examined by Selbig (1960) had tailed anthers. Bentham (1873) alludes to the indefinite nature of the anther tails in Asteraceae by remarking that, "the anthers are in a very few species mucronate or almost produced into fine tails", (Bentham, 1873, 404) and that:
FIGURE 35

BASIC STAMEN TIP TYPES

(a) Obtuse form (Celmisia vernicosa); (b) Acute form (Celmisia monroi). Both approx. x300.
STAMEN TIPS (SEMI-DIAGRAMMATIC)

(a) *Celmisia verrucosa.*
(b) *Celmisia gracilenta.*
(c) *Celmisia major.*
(d) *Celmisia loricifolia.*
(e) *Celmisia bellidoides.*
(f) *Celmisia glandulosa.*
(g) *Celmisia coriacea.*
(h) *Celmisia lyallii.*
(i) *Celmisia sessiliflora.*
(j) *Celmisia rumulosa.*
(k) *Celmisia discolor.*
(l) *Celmisia angustifolia.*
FIGURE 37

ANTHRAC BASKS (SEMIDIAGRAMATIC)

(a) Calmisia vernicosa.
(b) Calmisia creolina.
(c) Calmisia major.
(d) Calmisia lariolifolia.
(e) Calmisia bellidifolia.
(f) Calmisia glandulosa.
(g) Calmisia coriacea.
(h) Calmisia lvalii.
(i) Calmisia sessiliflora.
(j) Calmisia remollsae.
(k) Calmisia discolor.
(l) Calmisia amustifolia.
There is also an occasional tendency to extreme acuteness or even fine points to the antheros of the anthers, never observable in any true Aster but traceable sometimes in another Antarctic or Australasian genus, *Galaysia*.

(Bentham, 1873, 164.)

The stamen tip is made up of a lobe of sterile tissue joining the distal ends of the anthers and extending beyond them. Most species of *Galaysia* have this sterile tissue elongated and gradually narrowing to an acute or narrowly rounded tip. However, in *Galaysia venenosa* the tip is shorter, and is broad and blunt (Fig. 35).

The filament collar is cylindrical in all the species examined with no significant variation in cell size.

Although there is some variation in the point of insertion of the filaments, no taxonomic significance has been found in such variation. Usually the filaments are inserted near the middle of the corolla although insertion is lower down in some species.

4.9 DISC FLOWER STYLE

The style in *Galaysia* conforms to the general type found throughout the Asteraceae. According to Bentham:

The Asteroid style with flattened branches, the marginal abaxial series very prominent but not reaching the extremity, which consists of a so-called appendage, long or short, broad or narrow, acute or obtuse, and papillose or shortly hisset all over, is very prevalent in the tribe as now limited.

(Bentham, 1873, 190)

*Galaysia* conforms to Bentham's Asteroid type in its style or morphology, though within the genus there are considerable variations on the basic pattern (Fig. 38).

Each branch or appendage is itself divided into two parts,
the branch or style-arm proper, and the style-arm tip which is morphologically and functionally differentiated from the rest of the arm. The style arm (excluding the tip) is papillose on the margin and provides the receptive surface upon which suitable pollen can germinate. At maturity the arms resurse so as to expose the receptive surfaces which until then have been closely pressed together. The tip on the other hand bears large swollen hairs on the margin and back which may be termed collecting hairs since their function is to sweep the pollen from the anthers as the style elongates and exposes it at the mouth of the corolla. In the male florets of the outer whorls of the capitulum there is no such differentiation of the branches of the style since the absence of functional stamina obviates the need for collecting hairs. It can be seen that the style serves as a pollinating organ both in the male and the female role of the disc floret. The importance of the style as a source of taxonomic characters is bound up with its function, since variations in function will be reflected in changes in morphology. Such morphological changes are clearcut and allow deductions to be made regarding the probable evolutionary stage of a particular group of species or genera.

Three forms of disc floret style can be distinguished amongst those of the New Zealand species of *Selinia* (Fig. 38).

**Normal type (Fig. 38 a)**

Style arms parallel-sided with several rows of papillae along
<table>
<thead>
<tr>
<th>Group</th>
<th>Stamen tip</th>
<th>Style branch type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Elongate, acute</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Intermediate between 1 and 2</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>1</td>
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<tr>
<td>6</td>
<td></td>
<td>1</td>
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<tr>
<td>7</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Intermediate between 1 and 2</td>
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<tr>
<td>9</td>
<td></td>
<td>Intermediate between 1 and 2</td>
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<tr>
<td>13</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>Shorter, blunt</td>
<td>3</td>
</tr>
</tbody>
</table>
each margin. The tip short and triangular with collecting hairs short and rounded, and appressed over the outer surface of the tip.

Calymnia gracilenta type (Fig. 38 d)

Style arms parallel-sided with papillae along the inside of each margin. Tip attenuate with long clavate collecting hairs distributed evenly over the outer surface of the tip.

Calymnia ramosa type (Fig. 38 c)

Style arm (apart from the tip) very reduced in length so that it is equal to or shorter than the tip. Papillae forming a thick margin of several rows on the arm. Collecting hairs moderately long and distributed over the outer surface of the tip, sometimes forming several parallel rows which run down the length of the style arm.

In addition several species have styles which are difficult to classify in this scheme. In C. baldicinidae the arms are lanceolate rather than parallel-sided and the tip is slightly elongated (Fig. 39 b). In group three the style-arm tips are slightly attenuate and intermediate between those of type one and type two (Fig. 39 i). The phylogenetic significance of this is discussed elsewhere.

In addition to the variations discussed above, there is further variation in the collecting hairs and papillae within the three types listed. These differences are sometimes significant at the species level. Length of the style at maturity is a further character which
FIGURE 38

BASIC DISC FLORET STYLE TYPES

(a) Normal type (C. monroi); (b) gracilenta type (C. alpina);
(c) vernicosa type (C. vernicosa)
FIGURE 39

DISC FLORET STYLES (SEMI-DIAGRAMMATIC)

(a) *Celmisia vernicosa.*
(b) *Celmisia gracilenta.*
(c) *Celmisia major.*
(d) *Celmisia laricifolia.*
(e) *Celmisia bellidicoides.*
(f) *Celmisia glanulosa.*
(g) *Celmisia coriacea.*
(h) *Celmisia lyallii.*
(i) *Celmisia sessiliflora.*
(j) *Celmisia ramulosa.*
(k) *Celmisia discolor.*
(l) *Celmisia angustifolia.*
can be used since the styles (including the branches) of species in groups thirteen and fourteen are considerably longer at maturity than those of species in other groups.

Three bracted styles occasionally occur but appear to have no taxonomic importance. They have been recorded chiefly in *Calendula heliophila* and *C. grandiflora*.

4.10 RAY FLORETS

The ray florets of *Calendula* are ligulate on the basis of the definitions used by various workers such as Bentham (1873), Cronquist (1943, 1947), and Drury (1966). The florets have long ligules which are vascularised, the vascular bundles uniting near the distal end of the ligule (Fig. 6). At the base of the ligule is a short tube enclosing the style, the lower end of the tube being attached to the top of the achene. In most species in this genus four strands of vascular tissue run parallel along the length of the ligule. The outer strands consist of single vascular bundles while the inner two each contain two fused bundles. Near the tip of the ligule, the fused bundles of the middle two strands separate and curve away from the axis of the ligule to fuse with a bundle from the adjacent ray. The four strands thus terminate in three vascular arches. In the group of species centred about *C. grandiflora*, variations on this basic pattern appear. In some populations there is a predominance of the four stranded type of ligule while in others there is a reduction to only three strands and two arches. In other populations there has been an increase in the
number of strands with additional ones appearing parallel to the original strands. Normally, most of these strands are short and do not form arches, though in some populations the ligules may have more than three arches.

The number of teeth at the tip of the ligule is usually equal to the number of arches formed so that the apex of each arch lies beneath a ligule tooth. This arrangement does vary and five-stranded ligules may have either two, three, or four teeth, while three-stranded ones may have one, two, or three teeth. The predominance of four-stranded three-toothed ligules suggests that this state is the most normal for the genus.

Ligule shape is variable and most species can be grouped either as ovate— or linear—liguled. The former includes most of the woody species and the $G. \text{aristilenta}$ group, the latter being found mainly in species from groups ten, eleven, and twelve.

4411 DISK FLORETS

Most of the features of the disk florets have already been described, so that only a few additional features will be mentioned. Vascularization of the tubular corolla is constant throughout the genus, five duplex veins run from the base of the corolla to the distal toothed end of the corolla where they divide and fuse with adjacent bundles, as in the ray florets (Fig. 7). Similarly, each resulting vascular arch is associated with a tooth on the distal end of the corolla. This gives five arches and five teeth. The duplex strands running to the stamens arise midway between the
corolla base and tip, each of the five stamens being associated with one of the five duplex veins in the corolla.

Very occasionally corollas with median venation occur. These are, however, infrequent.

The teeth at the distal end of the corolla are usually distinctly papillose but the slight variation which occurs appears to be of no taxonomic significance. Thickenings sometimes occur at the corolla base but these have not been sufficiently studied for their taxonomic importance to be assessed. Shape and size of the corolla shows a small amount of variation with some groups tending towards carpelulate corollas rather than the more widespread funelliform type.
CHAPTER FIVE

VEGETATIVE MORPHOLOGY OF NEW ZEALAND SPECIES

As most of the characters used in this study are floral in nature, discussion of the vegetative characters will be brief. A full and detailed analysis of the vegetative characters was not carried out but the information which was obtained was used to supplement that resulting from a detailed examination of the floral morphology of *Celmisia*.

5.4 HABIT

Allan (1961) based his subgeneric classification of the genus chiefly upon habit, and although he implies that his distinctions are not clearcut, confusion does arise in placing species in their correct sections and series. This is probably because his main diagnostic characters were not really distinct but different states of a continuously variable set of characters. Basically all *Celmisia* species have a woody stem which may be above or below ground level. By differences in the spacing of nodes, the degree of branching and the length of time that the leaves are retained, various growth forms are produced. These forms include shrubs and sub-shrubs (Fig. 40 a), cushion-like sub-shrubs (Fig. 40 b), and creeping mat-forming types (Fig. 41). If the branches are underground and the internodes crowded, tufted forms are produced (Fig 42). The tufted form is further accentuated by the formation of a "passion-stem" consisting of closely appressed leaf sheaths. The sheaths, in this case, ascend to enclose
the shoot apex.

Allen distinguished three types of habit. These are defined by him:

1. Stems and branches definitely woody, leaves imbricate along branches, sheaths long-persistent:
   1. Living leaves not grouped together into rosulate clusters at tips of branchlets; e.g. *C. lateralis*
   2. Living leaves grouped into rosulate clusters at tips of branchlets; e.g. *C. discolor*

2. Leaves arising in dense tufts from a simple to multi-cipital somewhat woody stock. Sheaths very closely imbricate, compacted into a pseudo-stem; e.g. *C. spectabilis*
   ... a connecting group is formed by *C. bellidioides*, *C. thomasi* and some forms of *C. nervus*. Stems herboseous, much-branched, with many branchlets terminated by the living leaves in rosulate tufts.

(Allen, 1961, 611)

In addition to the growth-forms described by Allen, the following are also encountered:

**Stoloniferous or rhizomatous forms** (Fig. 84)

Some members of the *Calopsea gracilenta* complex are able to form a turf by these two methods of vegetative spreading. This habit is often associated with a bag or short grassland habitat. *Calopsea glanshosa* also spreads by this means and *C. bellidioides* is able to form an extensive system of stolones. Probably many species have the capacity to form stolones and/or rhizomes. *Calopsea holosericea* can be propagated by layering (R. Wilson, pers. comm.) and is potentially stoloniferous.

**Cushion forms** (Fig. 85a)

Some species, particularly those of group three, are able to form a compact cushion under certain conditions. That this is often
in answer to particular ecological pressures is highly likely since the species concerned are also able to adopt a mat-like form on occasions. In a detailed study on *Celmisia montabilis* Nurse (1940) commented that this species was able to form a cushion rather than the mat which is usual for that species. She described two cases where cushions were formed and ascribed this to different growth rates at the centre and periphery of the clump. However, in the case of group three the cushion habit is typical rather than the exception, although within each species there can be variation. For example, *C. annuliflora* in Nelson forms a flat cushion while in central Otago it forms a hemispherical one.

Even within Allan's framework there are considerable variations. The first group of woody species can be divided, for example, into species which are erect sub-shrubs, e.g. *C. acuminata*, and those which are woody, but prostrate and scrambling, e.g. *C. pygmaea*.

The "pseudo-stem" is an interesting development since it allows the plant to achieve maximum protection of the shoot apex and also makes use of the dead-leaf sheaths for accumulating moisture. The structure is described in detail by Nurse:

The rotting leaf sheaths are more bulky than the living ones which they surround, these dead ones being still attached to the living stem. The dead leaf sheaths hold a vast amount of water and if stripped off a freshly uprooted plant, drops of water can be squeezed out... The living leaf sheaths are attached to the top third of the stem, while below this the dead ones are attached. The top of the leaf sheaths (i.e. the base of the leaf) is in a considerable height above the stem tip. (Nurse, 1940, 23-24)
FIGURE 40

REPRESENTATIVES OF THE PREDOMINANTLY WOODY GROUPS
OF CELMISIA

(a) Sub-shrub form (Celmisia angustifolia);
(b) Cushion form (Celmisia argentea).
HABIT OF CELMISIA BELLIDIOIDES, A CREEPING MAT-FORMING SPECIES
FIGURE 4.2

CELMISIA MONTI, REPRESENTATIVE OF THE PREDOMINANTLY TUFTED SPECIES
<table>
<thead>
<tr>
<th>Group</th>
<th>Habit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Woody sub-shrubs, sometimes scrambling with branchlet tips erect, sometimes wholly erect.</td>
</tr>
<tr>
<td>2</td>
<td>Scrambling mat-forming sub-shrubs.</td>
</tr>
<tr>
<td>3</td>
<td>Cushion sub-shrubs.</td>
</tr>
<tr>
<td>4</td>
<td>Woody mat-forming sub-shrubs.</td>
</tr>
<tr>
<td>5</td>
<td>Woody mat-forming sub-shrub.</td>
</tr>
<tr>
<td>6</td>
<td>Woody mat-forming sub-shrub with long slender stems and leaves tufted at the branchlet tips.</td>
</tr>
<tr>
<td>7</td>
<td>Woody mat-forming or tufted plants.</td>
</tr>
<tr>
<td>8</td>
<td>Creeping stoloniferous woody-based herb.</td>
</tr>
<tr>
<td>9</td>
<td>Creeping mat-forming stoloniferous herb.</td>
</tr>
<tr>
<td>10</td>
<td>Tufted woody-based herbs.</td>
</tr>
<tr>
<td>11</td>
<td>Tufted woody-based herbs.</td>
</tr>
<tr>
<td>12</td>
<td>Tufted woody-based herbs.</td>
</tr>
<tr>
<td>13</td>
<td>Mat-forming or tufted woody-based sub-shrubs.</td>
</tr>
<tr>
<td>14</td>
<td>Tufted or turf-forming herbs arising from rhizomes or from woody-based stocks.</td>
</tr>
<tr>
<td>15</td>
<td>Stoloniferous woody-based herb.</td>
</tr>
</tbody>
</table>
5.2 STEM ANATOMY

The stem anatomy of *Calendula* is similar to that of most members of the Compositae. (Netolice and Chalk, 1950). A detailed description of the stem anatomy of *Calendula spectabilis*, *C. novae-zealandiae* (*C. aquantifolia*), and *C. discolor* is given by Nurse (1940). A brief examination of an additional ten species indicates that there is not a great deal of variation in the stem anatomy of the various species in the genus. The epidermis is thin-walled in the young part of the shoot but cork is formed in the older parts of the stem. The cortex consists of parenchyma and collenchyma and in some species contains scattered bundles of sclerenchyma. The vascular tissue is normal for the Compositae. Discrete bundles are formed at first but these later join in most species to form a continuous cylinder. In *C. hastata* at least, the cylinder is broken up into discrete segments separated by parenchyma. The pith is parenchymatous but becomes thickened in many species. Nurse suggests that this is a structural arrangement, "favourable to the pushing of the stems forward over and amongst the numerous rock fragments present in the soil" (Nurse, 1940). Pericyclic fibres are found just outside the phloem. These vary in number from a few up to about 20, the usual number being about 15 to 20. Sclereidoid cells are found between the cortical parenchyma and the vascular bundle, and stand out in cross-sections of the stem as a single layer of dark cells.

5.3 SHEATH

Although the sheath has not been dealt with in detail, it is apparent that taxonomically significant differences between species do
FIGURE 43

STEMS IN TRANSVERSE SECTION (SEMI-DIAGRAMMATIC)

(a) *Celmisia rupestris*.
(b) *Celmisia bellidicoides*.
(c) *Celmisia sessiliflora*.
(d) *Celmisia laricifolia*.
(e) *Celmisia haastii*.
(f) *Celmisia Sinclairii*. 
occur. Woody subshrubby species tend to have green sheaths with (usually) short hairs on the margins and either cobwebby or papilllose hairs on the surface. The number of veins in the sheath in these species is generally large but drops to low numbers in the first three groups and also in Galmania bellidifolia and G. glaucescens. On the other hand, the more tufted species such as Galmania morifolia and G. spectabilis tend to have either green or purple sheaths, short to long marginal hairs, long white hairs on the surface, and many veins in the sheath. The remaining species (the Galmania spectabilis complex, G. lanceifolia and G. verrucosa) can also be differentiated on the basis of sheath characters.

Within these broad groups many variations occur and the differences outlined can only be regarded as very generalised trends. For example, within the Galmania verticillata – cotylate – spectabilis group, individual populations may differ on the basis of sheath pigmentation as shown in the section on Galmania spectabilis.

The fusion of the main veins at the base of the sheath, when the number of veins is greater than three, supports the view that Galmania is trilacunar, and in this way similar to most of the Compositae. However, the possibility of other types of node cannot be ruled out, especially in the narrow-leaved shrubby species where unilacunar nodes might be found. As Drury (1956) has shown, a wide range of nodal types exist in the Compositae and only a fuller examination of Galmania will show if more than one type of node is present.
### TABLE XII

**SHEATH CHARACTERS**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Colour</th>
<th>Number of veins</th>
<th>Marginal tomentum</th>
<th>Surface tomentum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>green</td>
<td>3 - 5</td>
<td>short</td>
<td>cobwebby</td>
</tr>
<tr>
<td>2</td>
<td>green</td>
<td>3 - 5</td>
<td>long</td>
<td>papillose</td>
</tr>
<tr>
<td>3</td>
<td>green</td>
<td>3</td>
<td>long and fine</td>
<td>cobwebby</td>
</tr>
<tr>
<td>4</td>
<td>green</td>
<td>9 main - many</td>
<td>short</td>
<td>papillose</td>
</tr>
<tr>
<td>5</td>
<td>green</td>
<td>9 main - many</td>
<td>short</td>
<td>papillose</td>
</tr>
<tr>
<td>6</td>
<td>green</td>
<td>11 - many</td>
<td>short</td>
<td>cobwebby</td>
</tr>
<tr>
<td>7</td>
<td>green(coc. purple)</td>
<td>11 - many</td>
<td>-</td>
<td>papillose</td>
</tr>
<tr>
<td>8</td>
<td>green</td>
<td>3</td>
<td>few glandular</td>
<td>glandular</td>
</tr>
<tr>
<td>9</td>
<td>green</td>
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<td>few short</td>
<td>glabrate</td>
</tr>
<tr>
<td>10</td>
<td>green/purple</td>
<td>many</td>
<td>-</td>
<td>long white hairs</td>
</tr>
<tr>
<td>11</td>
<td>green</td>
<td>many</td>
<td>short</td>
<td>long white hairs</td>
</tr>
<tr>
<td>12</td>
<td>green/purple</td>
<td>many</td>
<td>long</td>
<td>long white/glabrate</td>
</tr>
<tr>
<td>13</td>
<td>green</td>
<td>3</td>
<td>short</td>
<td>long</td>
</tr>
<tr>
<td>14</td>
<td>green</td>
<td>3</td>
<td>short</td>
<td>cobwebby/glabrate</td>
</tr>
<tr>
<td>15</td>
<td>green</td>
<td>3</td>
<td>glabrous</td>
<td>glabrous</td>
</tr>
</tbody>
</table>
5.4 LEAF VENATION

This shows considerable variation. Most of the species have a characteristic parallel or arching venation. The types encountered can be grouped approximately as follows.

**Single vein**

A single vein runs the length of the leaf with one or more short lateral veins sometimes running parallel to the main vein. In some cases these lateral veins extend no further than the top of the sheath.

**Numerous parallel veins**

In this type the veins run most, if not all the length of the leaf lamina and are approximately parallel.

**Arching veins**

In this type there is usually one central vein forming a midrib and several lateral veins arching out from the sheath and running between the midrib and the margin of the leaf lamina. Secondary venation is reticulate.

The distribution of these types within the genus is shown in Table 13.

5.5 LEAF SHAPE

Although leaf shape is variable, even within individual species, the general patterns of leaf shape are clear enough to have taxonomic significance. As Kelville (1937, 1949), Simott (1958), Fisher (1960), and others have shown, leaves tend to grow
according to certain mathematical relationships, and formulae to
describe the shape can be calculated for individual species.

The leaf shapes encountered during this study may be grouped
as follows:

**Short, linear-lanceolate to subulate (Fig. 44 a)**

These leaves which characterize the subshrubs of groups one
and two, are recurved, stiff, and with the lamina narrowed to an
acute or sub-acute tip.

**Needle-like (Fig. 44 b)**

Short, needle-like leaves are characteristic of groups three
and thirteen.

**Grass-like (Fig. 44 c)**

Species of the *C. gracilenta* group are all characterized by
long flat leaves which may range in some species up to 30 times the
maximum width. Often the leaves are narrowed by the margins being
strongly recurved.

**Spathulate (Fig. 44 d)**

A large number of "woody" species in groups four, five, six
and seven have spatulate leaves which are in some cases recurved.

**Lance-lanceolate (Fig. 44 e)**

Several species, particularly, in group ten, have leaves which
are rigid and linear-lanceolate with the margins slightly recurved.
FIGURE 44

LEAF SHAPE

Traced from actual specimens.

(a) Linear subulate (G. walker i).
(b) Needle-like (G. sessiliflora).
(c) Grass-leaved (G. graminifolia).
(d) Spathulate (G. discolor).
(e) Long-lanceolate (G. petrici).
(f) Lanceolate (G. coriacea).
(g) Oblong-ovate (G. petiolata).
(h) Oblong-spathulate (G. bellidicoides).
Oblong-lanceolate to elliptic (Fig. 44 f and g)

Most of the "tufted" species of groups ten, eleven and twelve have leaves of this type.

Oblong-ovatulate (Fig. 44 h)

This includes several species which cannot be placed elsewhere. In this type the leaves narrow at the base of the lamina and then expand again at the upper end of the sheath.

Teeth are present on the margins of most species of Selmaia. They appear to be absent in the Selmaia gracilenta complex and reach their greatest development in groups six, seven and nine.

5.6 LEAF HAIRS

Both eglandular and glandular hairs are found on the leaves of various species of Selmaia. On most of the species with glandular involucral bracts, glandular hairs are represented by gland cells in the epidermis.

Eglundular clothing hairs (Fig. 45 a, b and Fig. 46)

These are present on the underside of the leaf in most species, but also occur on the upper side. No attempt has been made to group the eglandular hair types although certain trends were observed. The eglandular leaf hairs of most species have a single basal cell, either one or two stalk cells and a single shiplike terminal cell. In species of groups one to seven (excluding three), there are usually two stalk cells while in groups ten to twelve there is usually
only one. The cell-wall thickness in hair cells shows considerable variation, the "woody" species tending to have thinner cell-walls than do other species.

Stalked glandular hairs (Fig. 43 a, b)

These were only observed on the leaves of one species, Calaminia glandulosa. They were similar to the biseriate glandular hairs found on the involucral bracts of many species.

Epidermal gland cells

These are present in most species belonging to groups one to seven excluding three. In the field, species with gland cells (or glandular hairs) can often be recognized by the stickiness of the leaves. In surface view under a dissection microscope these species have the surface of the leaf lamina characteristically covered with blobs of a sticky substance secreted by the gland cells. In cross-section, the glands are seen as small spherical cells lying in the epidermis. Nurse (1949) records those of Calaminia squamifolia as consisting of two basal-cells with an enlarged balloon-like head. The number of basal cells could not be confirmed as two in the material studied.

The oglandular clothing hairs usually form a thick mat on the underside of the leaf and this can appear quite different in different species, giving rise to the terms "satin", "velvety", "felted", etc., which are used to describe the macroscopic appearance of the tomentum. Study of the different forms of tomentum have not been proceeded with in this account as the differences appear to be
FIGURE 45

LEAF HAIRS

(a) *Calmsia glandulosa*, x90.
(b) *Calmsia lyallii*, x270.
(c) *Calmsia spectabilis*, x90.
(d) *Calmsia spectabilis*, x80.
FIGURE 46

LEAF HAIRS

(a) *Celmisia monroii*, x60.
(b) *Celmisia holosericea*, x270.
(c) *Celmisia holosericea*, x60.
(d) *Celmisia traversii*, x60.
(e) *Celmisia traversii*, x60.
more applicable at the specific than at the subgeneric level.

5.7 LEAF ANATOMY

This has not been examined in detail. In most species the leaf lamina is divided into a clearly defined epidermis, palisade mesophyll and spongy mesophyll. In all but one of the species examined the epidermis is single-layered, the exception found being C. dallii. The palisade cells were found to vary considerably. Galaxia glandulosa, C. walkeri and C. gibba have long palisade cells while those of Galaxia meckii and C. dallii are shorter. Most species appear to have stomata only on the lower surface of the leaf, although in both Galaxia alpina and C. gibba they were on both surfaces. The leaf anatomy of Galaxia ivallii is unusual in the lack of differentiation of the mesophyll. The photosynthetic tissues are clustered about longitudinal grooves in the lower surface of the leaf lamina. Between the grooves and surrounding the vascular bundles are massive patches of collenchyma. The closely related C. petrii has a very similar structure with the exception of the longitudinal grooves which are absent. This suggests that the two species have diverged from a common ancestor, C. ivallii becoming suited to a drier climate by its development of a specialized extremely xeromorphic leaf anatomy. Similar massive development of collenchyma was also noted in Galaxia walkeri and C. brevifolia.
## Table XIII

**Leaf Shape and Venation**

<table>
<thead>
<tr>
<th>Group</th>
<th>Shape</th>
<th>Venation</th>
</tr>
</thead>
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<tr>
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<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>1</td>
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<td>4</td>
<td>3</td>
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<td>5</td>
<td>4</td>
<td>3</td>
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<td>4</td>
<td>3</td>
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<td>7</td>
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<td>3</td>
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<tr>
<td>8</td>
<td>7</td>
<td>1</td>
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<td>9</td>
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<td>2</td>
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<tr>
<td>10</td>
<td>5-6</td>
<td>2</td>
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<tr>
<td>11</td>
<td>5-6</td>
<td>2</td>
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<td>12</td>
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<td>3</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

Characters are numbered according to the classification in the text.
CHAPTER SIX

NON-MORPHOLOGICAL DATA ON NEW ZEALAND SPECIES

Non-morphological characters have been largely neglected in taxonomic studies. Exceptions are the use of chromosome studies (although this is still really an aspect of morphology) and the use of chemical tests in separating Lichen taxa. They are not dealt with in detail here, since data is still being accumulated on such aspects as flowering time and cytology.

6.1 FLOWERING TIME

Species of Calendula are summer flowering. Though there is considerable variation in the flowering times of particular species, few can be said to be predominantly spring or autumn flowering. One of the difficulties inherent in the use of flowering as a source of taxonomic data is that there can be considerable variation in flowering time from year to year in the one locality. It is likely that changes in weather conditions interacting with regular periodicity in flowering, are responsible for most of the variation encountered, although there is little data available on this aspect of the biology of Calendula. The species, for which data is recorded in Table 16, are divided into early, mid, and late-summer flowering species. Data recorded here has been obtained from field observations by the author, photographs, published records and herbarium specimens.

Possibly of more value is the recording of relative flowering
<table>
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<th>Group</th>
<th>Species</th>
<th>In bud</th>
<th>In flower</th>
<th>In seed</th>
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<tr>
<td>1</td>
<td>ranulosa</td>
<td>Jan - Feb</td>
<td>Jan -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>walteri</td>
<td>Nov - Mar</td>
<td>Jan -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>gibbsii</td>
<td>Dec - Jan</td>
<td>Jan -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>rupestris</td>
<td>Jan</td>
<td>Feb -</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lateralis</td>
<td>Dec - Mar</td>
<td>Dec -</td>
<td></td>
</tr>
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<td></td>
<td>hectori</td>
<td>Dec - Mar</td>
<td>Dec -</td>
<td></td>
</tr>
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<td>2</td>
<td>brevifolia</td>
<td>Nov - Apr</td>
<td>Nov -</td>
<td></td>
</tr>
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<td>angustifolia</td>
<td>Sept - Jan</td>
<td>Oct -</td>
<td></td>
</tr>
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<td>argentea</td>
<td>Dec - Feb</td>
<td>Mar</td>
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<td>sessiliflora</td>
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<td>Nov - Feb</td>
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<td>Nov - Feb</td>
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<td>Dec</td>
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<td>durietsii</td>
<td>Dec - Feb</td>
<td>Jan - Mar</td>
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<td>Nov</td>
<td>Apr</td>
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<td>Dec - Jan</td>
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<td>sinclairii</td>
<td>Dec</td>
<td>Feb -</td>
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</tr>
<tr>
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<td>allanii</td>
<td>Dec - Mar</td>
<td>Feb -</td>
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<td>Jan</td>
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<td>Dec - Apr</td>
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<td>Jan -</td>
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<td>Dec -</td>
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<td>Jan - Apr</td>
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<td>Dec - Apr</td>
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</tr>
<tr>
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<td>cf. petrii</td>
<td>Dec - Feb</td>
<td>Dec -</td>
<td></td>
</tr>
<tr>
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<td>lyallii</td>
<td>Dec - Feb</td>
<td>Dec - Feb</td>
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</tr>
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<td>lanacifolia</td>
<td>Dec - Feb</td>
<td>Jan -</td>
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<td>Jan -</td>
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<td>Dec - Nov</td>
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<td>Nov - Mar</td>
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<td>Nov</td>
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<td>Dec - Mar</td>
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<td>Dec - Feb</td>
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<td>traversii</td>
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<td>Dec - Jan</td>
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<td>Mar</td>
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<td>Nov - Mar</td>
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<td>Feb - Apr</td>
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<td>alpina</td>
<td>Oct - Dec</td>
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<td>adenii</td>
<td>Nov - Jun</td>
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<td>Mt. Debert 26.12.65</td>
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<td>&quot; &quot; &quot;</td>
<td>full fl.</td>
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<tr>
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<td></td>
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<td></td>
</tr>
<tr>
<td>laricifolia</td>
<td>&quot; &quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sessiliflora</td>
<td>&quot; &quot;</td>
<td>full fl.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gracillenta</td>
<td>full fl.</td>
<td>full fl.</td>
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<td></td>
</tr>
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<td>sd., several fl.</td>
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</tr>
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<td>fl. and sd.</td>
<td></td>
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</tr>
<tr>
<td>densiflora</td>
<td>&quot; &quot; &quot;</td>
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<td></td>
</tr>
<tr>
<td>haastii</td>
<td>few fl., mainly sd.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>hectori</td>
<td>just past f. fl.</td>
<td></td>
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<td></td>
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<td>lyalii</td>
<td>fl. and sd.</td>
<td></td>
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<tr>
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<td>full fl.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sinclairii</td>
<td>&quot; &quot; &quot;</td>
<td>sep fl.</td>
<td></td>
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<tr>
<td>discolor</td>
<td>&quot;</td>
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<td>durietzii</td>
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</tr>
</tbody>
</table>
times from particular areas during particular seasons. This enables the researcher to state that, "species A flowers earlier than species B, and later than species C and D which flower concurrently". Table 15 shows, in an elementary form, this type of data.

Flowering times are of value at the subspecific level. As shown in the studies on the *Celmisia gracilenta* complex, populations belonging to one species may differ considerably in their flowering times and it is at this level that the data is probably most useful.

### 6.2 Cytology

During the course of this study, observations on the cytology of *Celmisia* were undertaken by Dr. J. E. Hair of Botany Division, R.I.A., Lincoln, and with his permission the results of his work are incorporated here.

Species were examined to determine the numbers of chromosomes present in the tissues of the plants. Fresh material was used for making the counts, which were done at meiosis from either preparations. This was done in preference to root-tip preparations because of the large number of chromosomes present and their small size.

With the exception of one population belonging to the *Celmisia gracilenta* complex, all of the material examined so far has been found to have 54 chromosomes at meiosis (n = 54). If the base number for the Aster-Ligulata-Conyza group of genera is either 5 or 9, as is commonly assumed, then with respect to the related genera *Celmisia* is commonly 12-ploid. Such a high state of ploidy for a large group
of plants is unusual in the Composites, but up till the present no
lower numbers have been found in Australasian species of Calanthe.
No counts have been made yet on Australian species of Calanthe.

One count was made which shows that not all species of
Calanthe have the same chromosome number. A figure of $n = 108$ was
obtained from a population belonging to the Calanthe cancellata
complex. This population was sampled at View Hill, near Oxford in
Cantabury, and morphologically very similar populations in the
Pelitera Valley may also prove to be polyploid.

Although chromosome numbers do not provide taxonomic data
at the subgeneric level, they may be of value in determining generic
limits. Only one count from South American Calanthe-like material
is obtainable. This is an unpublished count of $2n = 16$ (R.A. Turner,
pers.com.). Unfortunately, no counts of Pseudocallunaum are
obtainable. However, a count of $n = 54$ for both Pachystachis insignis
and P. insignis var. minor, and for two Australian species of Olearia
indicates that there are high states of ploidy found in Australasian
genera apart from Calanthe.

Accessory chromosomes have been detected in several samples.
Their taxonomic significance is not clear, although they appear to
be restricted to certain species. Accessory chromosomes have been
recorded in at least eleven Composite genera (Battaglia, 1954).
Their origin is still in many respects uncertain and it has been
suggested that they can originate during speciation, stabilization
and hybridization. The effect on the plant varies from production
of sterility by only one B-chromosome in *Platycodon grandiflorum* (Palmer and Hyde, 1960) to increase productivity in *Poa pratensis* (Soemmmering, 1857), and increased seed fertility (Antishausser, 1956). In *Selacia*, B-chromosomes have been found to vary in number within species. Thus, accessory chromosomes may be useful at the specific or subspecific level rather than at the generic level.

6.3 PHYTOCHEMISTRY

No serious attempt has been made in this treatment to study the phytochemistry of *Selacia*. Some information is available, however, from the work of Cuthbert, Cain and Hoche (1951). In the course of their survey of the New Zealand flora, tests were made for alkaloids, leucoanthocyanins, saponins, triterpines and sterols. Table 16 is extracted from Table 1 of part II of their survey. From this it can be seen that over a third of the species of *Selacia* tested gave a positive reaction in the Liebermann-Burchard test for triterpines or sterols. As might be expected, a similar result was obtained for the genus *Clearea*. In *Selacia* there is a distinct bias towards a positive reaction for woody species and a negative one for the more tufted species. In the test for alkaloids, seven species gave a positive reaction. These included four woody species, one from the *C. speciosum* complex and two from a tufted but pubescent-aehemel group.

At present little significance can be drawn from the results. Some lines of affinities are indicated. However, a negative result not necessarily indicates complete absence of a chemical group.
Masking by pigments and chemical changes in dried material are greatly limiting factors in using phytochemistry in Selinsia taxonomy.
TABLE XVI

PHYTOCHEMISTRY OF GRIMESIA
(after Cambie, et al. 1961)

<table>
<thead>
<tr>
<th>Species</th>
<th>Plant part</th>
<th>Alkaloid Test</th>
<th>LA</th>
<th>Sep</th>
<th>LD</th>
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<tr>
<td></td>
<td></td>
<td>M</td>
<td>D</td>
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<td>adamsii</td>
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<td>H</td>
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</tr>
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<td>L,St</td>
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</tr>
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<td>lericifolia</td>
<td>H</td>
<td></td>
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</tr>
</tbody>
</table>

Abbreviations:  L = leaf,  St = stem,
                H = whole plant,  Fl = flowers,
                R = root.
CHAPTER SEVEN

THE SUBGENERIC GROUPING OF NEW ZEALAND SPECIES OF *Celmisia*

Although it is very tempting to divide the genus up into groups of species and to then use data to substantiate the groupings, the true nature of taxonomic categories must not be lost sight of. Categories are made up of their component species and thus the subgenera, series, or section is made up of component species. The definition of these categories should be in terms of the species which they contain. In the case of *Celmisia* the basic approach has been from the species level with these being grouped according to their phenetic relationships. It has been found possible to group the species, using a few well marked characters, by an additive process. The species have been surveyed for a small number of independent characters which have shown a high degree of correlation. As additional characters were surveyed throughout the genus, points of non-correlation were noted and the species moved about until a high degree of correlation was achieved. Apparently anomalous groupings may often be interpreted at this stage in terms of independent evolution of one or more species and in most cases have probably involved such trends as loss of adaxial hairs. One of the complexities in *Celmisia* is that definitions of taxa are based on small character differences. Most taxonomists who have worked on *Celmisia* have commented on this point which has made the erection of subgeneric taxa a task of considerable difficulty. However, this is a problem common to most Composite genera at all levels of
This chapter does not attempt to place the groups formed into any taxonomic framework. That is done in the following chapter. At this stage fifteen groups are formed, each being internally consistent yet distinct from other groups. Placing these at the same level at this stage implies no taxonomic equivalence. Also, these groupings apply only to New Zealand species (including the Subantarctic Islands) although the discussions on the taxonomy of the whole genus will include species of *Celmisia* and similar genera from both Australia and South America (see Chapters seven, twelve and thirteen).

7.1 GROUP ONE

Species included in this group are:

- *Celmisia ramulosa*  
  Rock.f.
- *C. rapestris*  
  Cheeseman
- *C. gibbii*  
  Cheeseman
- *C. lateralis*  
  Buchanan
- *C. walkerii*  
  Kirk
- *C. hectorii*  
  Rock.f.

**Distribution**

This group, as remarked upon earlier, displays a marked degree of disjunctness. Only *C. Walkerii* is widespread throughout the South Island, the remaining five species being restricted to either the north or the south of the South Island. *C. gibbii* and *C. rapestris* are restricted to northwest Nelson where they occur
locally on a few of the higher mountains in the area. *Celmisia lateralis* has a wider distribution and extends throughout Nelson and western Marlborough to at least as far south as the Spencer Mountains. *Celmisia roseolosa* is almost restricted to Fiordland but does extend in varietal form as far east as Mt. Aspiring in the Eastern Hills of South Canterbury. *Celmisia hastata* is common throughout western Otago and eastern Fiordland, and also ranges as far north along the main divide as the Mt. Cook area. *Celmisia walkeri* is a common plant in Fiordland and along the main divide to at least Arthur's Pass. In the case of two species (*Celmisia lateralis* and *C. roseolosa*) the type variety is replaced towards the eastern part of the species range by other varietal forms.

**Floral Morphology**

Many features uniting the species in this group are also common to many other subshrub species of *Celmisia*. However, the group possesses some unique features. The involucral bracts are very short, wide, and often erect or with only the outer bracts slightly recurved. Also, the glandular hairs on the scapes and bracts are squat. In common with the "woody" species of *Celmisia*, members of this group have the disc corolla hairs expanded in the upper part but unlike most species they are restricted to the tips of the corolla lobes. The limb on the ray floret is obsolete and the rays are in more than one series. The pubescent achenes range from one to three millimetres in length with the pappus hairs
ranging from two and a half to three times the length of the calyx. The species in this group are closest to the other "woody" species in the genus but differ in the erect tendancies of the involucral bracts, the small number of floral parts in most of the species, the short calyces, the short glandular hairs on the bracts, and in the distribution of the corolla hairs.

**Vegetative Morphology**

All species in this group are scrambling or sprawling sub-shrubs. Most have stiffly woody main branches although the stems of *G. lateralis* are woody but not stiff. The terminal branchlets are less woody and usually stand erect. Leaves are linear-subulate to linear-lanceolate and have a single medial vein with a variable number of lateral veins running parallel to this. The sheath is usually unpigmented.

**Notes on the species**

1. *Galatea ramulosa* J.D. Hooker Monograph N.Z. Fl. 1864, 733.

Originally collected by Hector from the Doubtful Sound area in 1863, this species is common throughout Fiordland. The specific variety is replaced east of Lake Wakatipu by var. *tuberculata*, which ranges throughout northeast Otago to the Grampian Range and the Hunters Hills (Fig. 47). All forms of the species are erect woody sub-shrubs. They are found typically growing on steep rocky slopes with the roots deeply embedded in the peaty soil of crevices and ledges.
2. **Celmisia lateralis** Buchanan in *T. E. Z. I.*, 1872, 226

This species ranges from its type locality at Lake Suyea northwards to northwest Nelson and much of inland Marlborough. It is morphologically variable, some populations being densely glandular on the leaves and stems while others are glabrate. The glandular forms have been described as variety *villosa* by Cheeseman (1906) and appear to be common in the upper Wairau and upper Buller mountains (Fig. 48). The species is alpine and erratic in its distribution. Though similar to *Celmisia ramulosa*, it differs in its lax habit with the weak branchlets sprawling or procumbent.

3. **Celmisia gibba** Cheeseman *Manu* E. E. *Fl.* 1906, 300.


These species are restricted to northwest Nelson where they are both known mainly from the Cobb Valley area (Figs. 47 and 49). Outside this district *C. gibba* has been reported from Mount Zetland and from the northern end of the Paparoa Range, and *C. rupestris* is recorded from Mount Glasgow near Seddonville. The two species differ chiefly in leaf tomentum and habit, though they are extremely similar. Both are procumbent with the tips of the branchlets ascending.—**Celmisia rupestris** is characteristically found on steep scree slopes where it forms mats held close to the ground by layering.


This western Otago and Fiordland mat-forming species is found along the main divide from Fiordland to the Mount Cook area. It is also found in the eastern areas of Fiordland. The most easterly record of the species is from Mount Tennyson in the Garvie Mountains (Fig. 49).
- *C. rupestris*
- *C. ramulosa*  
  var. *ramulosa*
- *C. ramulosa*  
  var. *tuberculata*

**Figure 1.7**

DISTRIBUTION OF *CELMISIA RAMULOSA*  
AND *C. RUPESTRIS*
- *C. gibbsii*
- *C. hectori*

**FIGURE 4.9**

**DISTRIBUTION OF CEMISIA HECTORI AND C. GIBBSII**
Usually it is found on lee slopes where snow is lying until late in the season. Mark and Burrell (1906) record the species as occurring in the Humboldt Mountains, only at heights in excess of 4,900 ft. They write, "above this *Chionochaete flavescens* and *C. crassicaulis* grassland are replaced in snow pockets by a high alpine grassland of the dwarf tussocks *C. crocophila* and *Rea colensoi* together with *Calamia baxteri*".


This is common throughout the wetter rainfall areas from Fiordland, north to Arthur's Pass (Fig 50). It is often most abundant on lee slopes where there is good drainage but a very moist substratum. Like *C. crocophila*, it can cover many square yards by layering from its procumbent branches. The species is not highly variable from population to population.

7.2 GROUP 123

Only two species are placed in this group. They are:

*Calamia angustifolia* Cockayne

*Calamia brevifolia* Cockayne

**Distribution**

These two species are complementary in their distribution with one being found north of the Waihiki Valley (*C. angustifolia*) and one to the south (*C. brevifolia*). The former species is abundant in the dry ranges east of the Canterbury section of the main divide. The latter species is common throughout the dry parts of Otago from the Garvie Mountains across the central Otago ranges to Densey Pass.
(Fig 51). In the north it reaches across to the Makatoku Valley near Waimak and ranges through the heads of Lake Hawea and Lake Ohau to reach its northern limits behind the Mackenzie Plains. In this area forms which are difficult to place in either species occur. These may be either clinal or hybrid intermediates.

**Floral Morphology**

These species are very similar in their floral morphology, and are also similar to other woody species. However, they differ from all other of these groups in their possession of very long duplex hairs on the achene, and in the possession of a distinct type of hair on the involucral bract. The involucral bracts in this group are usually recurved.

**Vegetative Morphology**

The two species in this group are vegetatively similar to the species in the previous group. They differ chiefly in the greater tendency for the living leaves to be clustered near the branchlet tip although in most populations the leaves are still found extending a short distance along the branchlet.

**Notes on the species**


Cockayne published the species in 1915 to include specimens from the eastern foothills of Canterbury. The species is known to range from just north of the Waimakariri River to the mountains north and east of the Waitaki Valley. At the southern end of the area of distribution large-leaved forms occur. These suggest that
either this species grades into _Celmisia brevifolia_ or that hybridisation between the two species takes place. Du Riets comments:

Thus the series of forms treated in Cheeseman's Manual as _C. brevifolia_ and _C. novae-elandiae_ gave me the impression of forming one very polymorphic synaneme (splendidly developed on Mount Wakefield in the Mount Cook region), probably only in some peripheral parts differentiated into pure populations of short-leaved (_C. brevifolia_) or long-leaved (_C. novae-elandiae_) forms.

(Du Riets, 1920, 384)

Although Du Riets's view, that only in some peripheral areas can the taxa be recognised, cannot be subscribed to, it is apparent that the populations in the Mount Cook area are highly polymorphic.

Throughout the whole range of _Celmisia angustifolia_ two forms occur. One is characterised by a glaucous-white bloom on the upper leaf surface and the other by the absence of this bloom. Both appear to occur mixed in natural populations and may represent a genetically balanced polymorphism.

At present, the specific epithet "angustifolia" must be retained, although many botanists have used the epithet "novae-elandiae". Buchanan used the latter in describing a northwest Nelson species of _Celmisia_ as _Erigera nova-elandiae_ in 1835. In 1925 Cheeseman transferred the species to _Celmisia_ and included in it Cockayne's species. However, other taxonomists, particularly Cockayne, came to the conclusion that the two species are not identical. Until more material of _C. novae-elandiae_ comes to hand from Nelson, it is not possible to make a fair evaluation of the situation. The only recent collection from Nelson known to the author is represented by a scrap collected from Mount Arthur and now
- C. novae-zelandiae
- C. angustifolia
- Intermediate forms
- C. brevifolia

**Figure 51**

DISTRIBUTION OF **C.** **ANGUSTIFOLIA**, **C.** **BREVIFOLIA** AND **C.** **NOVAE-ZELANDIAE**
in the herbarium of Victoria University of Wellington. It is possible that the epithet "novae-zelandiae" may have to be rejected as a homonym of "novae-zelandiae" (International Code of Botanical Nomenclature, 1965, Article 75). The latter was used as a species name by Gunther in 1918.


This replaces *G. australifolia* south of the Waitaki. It is a frequent component of dry alpine herbfield and fellfield. Web (1965) records it as being co-dominant with *Geldaria viscosa* and *G. ramosa* in the Dunstan and Old Man Ranges, the Garvie Mountains and on the summit plateau of the Rock and Pillar Range. The polymorphism of the species has not been studied but random examination of herbarium specimens indicates that there is considerable variation in leaf-colour and morphology. Martin supports this with manuscript statements that probably more than one jardinean is involved.

### 7.3 GROUP THREE

Species included here are:

- *Geldaria spinulifera* Rank.
- *G. crassenta* Kirk.
- *G. clavata* Simpson et Thomson.

**Distribution**

Although these species are included in this treatment, only two of these are recognised in Allan's *Flora of New Zealand*. Possibly the species may be best regarded as being three states of one variable species complex.
**Colusia sessiliflora** (sensu stricto) is a widespread species in the South Island and ranges from northwest Nelson to Otago and possibly to Stewart Island. Despite the wide occurrence of this species and its polymorphy, it is generally restricted to alpine habitats and within those habitats to a restricted range of community types. **Colusia argentea** is a southern species, the distribution of which is uncertain. It ranges with certainty throughout east Otago from Dunsley Pass to Moungatua. It has been recorded west of these areas in Fiordland, but most of the specimens seen from there are referable to either *C. sessiliflora* var. argentea or to *C. clavata*. **Colusia clavata** was described from Stewart Island, but probably extends to the southern part of Fiordland. Distributions are shown in Fig. 52.

**Floral Morphology**

Characteristic of the three species are the extremely short scapes with no more than two bracts. Usually the scape is sessile at flowering but elongated slightly when the plant is in fruit. The phyllaries are erect and non-glandular, which separates the group from other woody groups. The corolla is glabrous and the number of florets is small. The style tends towards that found in the *Colusia gracilenta* group, the tip being lanceolate with short collecting hairs. Unique to the group are long uniciliate hairs found at the top of the anther in many populations. Lacking glandular hairs and recurved phyllaries the group shows little affinity with the rest of Allen's woody species.
Excrescent Hemicrypts

Members of this group are, as those of the last, woody subshrubs. They are, however, characterized by the formation of closely compacted mats or cushions (Fig 40 b). In some populations hemispherical tight cushions are formed. The living leaves are distributed well along the branchlets and they are needle-like. Only a midrib is present, and this runs the full length of the leaf. Leaf tomentum has not been investigated in detail but the leaf hairs are straight, narrow and iridescent.

Notes on the species


This is one of the most widely ranging South Island species. Hooker’s specimens were collected by Travers at Discovery Peaks in Nelson. The species is highly polymorphic. Specimens from Stewart Island which have been variously placed here and under Galesia arrecta should probably be placed in the Simpson and Thomson species, G. clavata. However, belonging to G. sessiliflora sensu stricto are the following forms:

(a) G. sessiliflora var. exigua Simpson and Thomson in T.R.N.Z. 75, 1945, 169. Most of the specimens from Fiordland can be referred to Simpson and Thomson’s variety. This form is smaller than those found elsewhere. The leaves are reduced in length and floret numbers are very low. Also, plants collected from Fiordland tend to form cushions rather than the extensive mats typical of the more northern forms. On peak 4,450ft near Dusky Sound, the author
observed an apparently climatic change in morphology which could be correlated with change in altitude. The highest samples tended to be small with the tips of the branchlets rounded, and were similar to *Scleria eglanteria*. In this area it is often difficult to assign specimens to either species, and more Floriland collections are needed.

(b) Central Otago form. A distinct variant has been collected from Dunstan Pass, the Dunstan, Pisa, Old Man, Carrick and Garvie Ranges and from Coronet Peak. This form is distinguished from all others by its leaves which are unevenly thickened on the margins so as to appear ciliate to undulate. Also, plants from the areas mentioned are usually cushion-like and in extreme cases (e.g. on the Pisa Range) form hemispherical mounds from a few inches to a little over a foot in diameter and several inches high.

(c) Northern South Island. This is probably the type variety. Plants in this area form large flat mats from two to four inches thick. Cushions appear to be confined to some fellfield situations. Individual rosettes are large and the capitula are up to one and half inches across.

Variety penduliflora was described by Kirk for plants which have scapes up to \( \frac{1}{2} \) inch long. This character appears to be variable and in most cases there is at least some elongation of the scape as the achene ripens.

*Scleria sessiliflora* enters into a number of community types
as a significant member. Billings and Mark (1961) mention it in connection with the alpine tundra vegetation of the Old Man Range, as being significantly present on sites in the outer lee zones of solifluction terraces. On the Pisa Range it is a ridge top species in short tussock and tundra communities. At Green Lake (Fiordland) and on the Harper Range (Canterbury) it is a frequent fellfield species, often dominant at the margins of shingle slides. In the north of the South Island it is often on ice slopes of tussock basins forming flat mats in *Chionochloa australis* grassland.


This species was originally described as *C. sessiliflora* variety *minor* by Petrie. The type locality is Mount Haungataua near Dunedin. Away from this locality the species is not well known and records without voucher material cannot be relied upon, since many of the specimens filed in herbaria as this species are actually forms of either *C. sessiliflora*, *C. loricifolia* or *C. alpina*. If Stewart Island material is separated off as *Calandria olivacea* the range of the species includes Haungataua, the Rock and Pillar Range, Denney Pass (where it apparently reaches its northern limit) and the Old Man Range. West of here it has been recorded from several parts of Fiordland (e.g. Baylis et al., 1963), the Earnie Mountain (e.g. Allan, 1961) and the Aire Mountains. Most of the Fiordland specimens seen are referable to *Calandria sessiliflora* var. *minor*.

Because of the lack of positively identified material, the degree of polymorphy in this species is difficult to determine. The
species is apparently variable but in most cases this can be correlated with environmental factors. For example, specimens from Haungata are soft and lax with long branches, whereas some specimens from the Old Man Range have reduced branches and short stiff leaves. The former are bog-growing, and the latter are windswept forms from the tundra vegetation on the flat top of the Old Man Range. The Haungata form is shown in Figure 40 b.

Although this species does occupy a wide range of sites it is limited by water requirements and shows a definite preference for damp sites.


Little is known of this species and the comment was made by Allen (1961) that, "further study of fertile specimens is much to be desired". Collections made by J.S. Burgess since then enabled the author to examine both live and preserved material, including vegetative and floral material, from several localities on Stewart Island. It was found that in gross morphology and general appearance the species differs consistently from both *Calamia sessiliflora* and *C. acutangula*, except that it approaches some forms of *C. sessiliflora* var. *elegans*. As stated by Simpson and Thomson (1942), "its dense leafy clavate branches and its erect, rigid, closely imbricating leaves, are very distinct and not to be confused with those of any other species". In addition it differs in the size of the scheme, pappus and some parts of the floret and possibly lacks the uniciliate hairs found on the scheme of the other two species. Future field work may show that it is a subspecies of either of the other species in the
- C. sessiliflora
- C. argentea
- C. clavata

**FIGURE 52**

**Distribution of Celmisia sessiliflora, C. argentea and C. clavata**
group but at present it is best to use Simpson and Thomson's name.

7.4 GROUP FOUR

Species included in this group are:

- Calycidea discolor
- Calycidea lancea
- Calycidea sinclairii
- Calycidea allanii
- Calycidea duriifolia
- Calycidea lindsayi
- Calycidea bomaladii
- Calycidea macrhaonii
- Calycidea viscosa

Distribution

As a group, the species enumerated above are found over a wide range of territory although individually they are in some instances extremely localized (e.g. C. lindsayi). *Calycidea discolor* is common throughout the northern part of the South Island and as far south as the Rakata Valley. In the north of the South Island it overlaps with *C. lancea* which occurs also throughout much of the North Island high country from Moslem to the Tararuas Ranges. In the south *C. discolor* gives way to the similar *Calycidea bomaladii* and this ranges to southern Fiordland. A closely related species *C. lindsayi* occurs only on the southeast Otago coast. *C. duriifolia* is one of the most widespread species in the group and occurs throughout most of the wetter parts of the South Island in a variety of forms.
belonging to this species are at present filed in herbaria under several other specific names. A further complex of populations are distributed throughout the South Island. These are collectively grouped under Caladiella allanii and chiefly occur in the northern half of the South Island. Two species are restricted to relatively small areas in the northern part of the South Island. These are Caladiella alpina which is found only in the Nelson Lakes National Park, Raglan Ranges, and at the heads of the Waihopai, Clarence and Awatere Rivers, and C. magellanica which is endemic to the Sounds Nelson area. The final species, C. virosa is a common plant throughout the South Island dry ranges east of the main divide.

Floral Morphology

The species in this group are united by a number of character similarities. In common with many other "woody" species they are glandular and the involucral bracts are recurved. The glandular hairs are long and obviously globose at the tips. The corolla hairs cover the whole of the disc tube and are expanded in the upper part. The receptacle is globose. Also, the achene hairs are short (in common with many other woody species) but the achenes are longer and more similar to those of the C. spectabilis type. The group differs from others discussed so far in its species not possessing the features characterizing them rather than by any special attributes of its own.

Vegetative Morphology

The members of this group are subshrubs with woodiness developed to varying degrees. In most species there is a tendency for the living leaves to be clustered near the branchlet tips although this
appears to be partially dependent on habitat. The leaves in all but one species are spatulate with many parallel veins running along the leaf from base to tip. Tomentum is variable and may be on either the abaxial or adaxial lamina surface or on both. In one case the leaf has no tomentum on either surface. All specimens examined had either gland cells sunk into the surface of the leaf, or stalked glandular hairs. In many cases, plants are excessively viscid.

Summary of the Taxonomic History of the Group

In 1863 Hooker described two species, *Calamia discolor* and *C. insana*. By 1864, several more species in the complex had been described including, *Calamia lindseyi*, *C. viscosa* and *C. siloeirtii*. However, even at this stage *C. insana* and *C. discolor* were acquiring "portentum" status, and there is a comment by Hooker in referring to *C. insana* that it was, "generally a very distinct species . . . but I fear that it may pass into *C. discolor*". By the publication of Cheeseman's Manual (first edition) the Horsboldt Mountains specimens of *C. lindseyi* had been described as *Erigonum hordelandii*, and Kirk had described a very distinct Nelson species as *Calamia macrophoria*. Later still, species such as *C. cockburniana* and *C. angustifolia* were separated from the complex, but these are not regarded in this study as forming part of the group of species clustered about *C. discolor* and *C. insana*.

The most intensive study of the complex was undertaken in the mid-1950's by Martin who sorted out the existing nomenclature and described several new taxa. His work centred around the
redefinition of *Colobia singularii* and the description of a new species, *C. alliarii*. In the former case, he restricted the name as applying to only glabrous-leaved plants. Similar plants with tomentum previously included in *C. singularii* were referred to his new species mentioned above. This species also included populations of scaly narrow-leaved plants found in the northern parts of the South Island. In addition a number of subspecific taxa were proposed so that most of the individuals encountered in the field could be referred to a variety with reasonable confidence. One further species was segregated from the complex, this being *Colobia furcata*.

Although this has produced a certain amount of order out of chaos, the present classification is not entirely satisfactory. *Colobia incana* and *C. discolor* are still pantropical species into which anything which will not fit elsewhere is dumped. Consequently, both species, and *C. incana* in particular, are represented in hortaria by heterogeneous arrays of specimens which may belong to more than one taxon.

One additional problem is that whereas some species and varieties appear to be well defined in some districts, the distinctions used may not be reliable in other areas. Thus, though all the North Island material can be referred to *C. incana*, in the South Island there seems to be a breakdown in the discontinuities between *C. incana* and *C. discolor* on the one hand and between *C. incana* and *C. alliarii* on the other.

Table 17 summarizes the distinctions recognized by Martin within this group.
<table>
<thead>
<tr>
<th>Species</th>
<th>Upper Surface</th>
<th>Lower Surface</th>
<th>Ratio of Length to Breadth</th>
<th>Involucral Bracts</th>
<th>Leaf position and size</th>
</tr>
</thead>
<tbody>
<tr>
<td>discolor</td>
<td>thinly tomentose</td>
<td>tomentose</td>
<td>less than 2</td>
<td>not foliaceous</td>
<td>Not tufted at branch tips; small</td>
</tr>
<tr>
<td>incana</td>
<td>tomentose</td>
<td>tomentose</td>
<td>2 - 2.5</td>
<td>not foliaceous</td>
<td>tufted; larger</td>
</tr>
<tr>
<td>allantii</td>
<td>tomentose</td>
<td>tomentose</td>
<td>4 - 6</td>
<td>not foliaceous</td>
<td>tufted; larger</td>
</tr>
<tr>
<td>durietzii</td>
<td>glabrous to glabrate</td>
<td>tomentose</td>
<td>greater than 3</td>
<td>not foliaceous</td>
<td>tufted; larger</td>
</tr>
<tr>
<td>sinclairii</td>
<td>glabrous</td>
<td>glabrous</td>
<td>greater than 3</td>
<td>not foliaceous</td>
<td>tufted; larger</td>
</tr>
<tr>
<td>cockayniana</td>
<td>glabrous to glabrate</td>
<td>tomentose</td>
<td>greater than 3</td>
<td>foliaceous</td>
<td>tufted; larger</td>
</tr>
</tbody>
</table>
Notes on the species

1. *Callicola discolor* J.D. Hooker *Fl. Eu.L.* 1853: 133

This species was described by Hooker in 1853 from specimens collected by Bidwell on the Nelson mountains. As the morphological boundaries between this species and others is difficult to delineate at present, it is not possible to indicate the geographical range precisely. Specimens referable to this species have, however, been collected from most parts of the South Island north of the Rangitata River (Fig. 56). Specimens from further south usually fall into *C. bomaendii* or *C. jurietzii*.

Part of Hooker's type description reads, "foliis congestis patulis linear-ovatis oblongo-spatulis obtusis subacutis..." superne glabris subulatulis luride viridibus subtus lana crete appressa argenteis". His description in the 1854 *Handbook* reads, "leaves... from oblong spatulate to linear, the former 1 to 1½ inches long by ½ inch broad, the latter 2 inches long by ½ inch broad... opaque, glabrous or hairy above, white below, coriaceous". Although the type is at Kew, a duplicate exists in the Canterbury Museum. The leaf tomentum below is dull white, the midrib distinct and the leaf margins minutely serrulate and recurved. The lemma is oblong-spatulate and the upper surface is characteristically furrowed. Martin (1935) comments of the species that:

From *C. jurietzii* it differs mainly in the smaller size of the leaves which grow at intervals along the stem, whereas in *C. jurietzii*, *C. sinnolata*, and *C. alleni* the living leaves are normally tufted at the ends of the stems. The length to breadth ratio rarely exceeds 2 in *C. discolor* but in the case of the other it is rarely less than 3.

(Martin 1935: 75)
Plants of this type are common on the Nelson mountains and probably belong to \textit{S. discolor} sensu stricto. It is unsatisfactory, though, that the species as now interpreted is a portmanteau one.

Two varieties have been described. The first, var. \textit{ema}, was described by Allan from material collected in the upper Clarence Valley. He centres the variety on the Spencer Mountains but lists the Clyde River and Mount Aspiring as localities. This variety differs chiefly in the larger size of the leaf and in the generally viscid nature of the plant. Numerous populations falling into this variety occur in the upper Sain, Clarence and Marua Valleys but their status remains uncertain until the taxonomy of the whole group is sorted out. The second variety is var. \textit{intermedia}. This is very close in appearance to the type of \textit{S. discolor} but is consistently smaller with the leaves being usually in the order of 15 to 20 mm long. Further observations in the field might well suggest reinstatement of the variety as a valid species.

On Phillip Rock pale lemon flowered specimens of \textit{S. discolor} were collected. These are now under cultivation at B.S.I.E., Lincoln.

2. \textit{Calaisia anomala} J.D. Hooker Fl.N.Z. 1,1853,185

This species was also described in 1853, but from specimens collected by Colenso from the Rauhine Ranges. Hooker’s description was drawn up so as to include all the members of this group with soft white tomentum on both surfaces of the leaves as well as those which have the hairs of the upper surface matted in a thick silvery palisade (Fig. 53 b). Allan makes the comment that, "in herbearia a rather motley assemblage of plants is included under this name".
Martin (1935) says that:

It has been customary to include in this species all Calamiaea of fell-field having both leaf-surfaces clothed with soft-white or silvery tomentum. The North Island plants to which the name was originally given have furrowed, asperate leaves with a length-to-width ratio of from 2 to 2½, but many of the South Island jordaeanae have a ratio of from 4 to 6.

(Martin, 1935, 76)

Martin regrouped the longer-leaved plants in a new species, C. allanii. *Calamiaea incana* appears to be the only member of this group to occur in the North Island. There it is, however, most variable. On Makahu Saddle, though all the plants in the area had an oppressed adaxial tomentum, there was a range from silvery-white leaved individuals to others with green-silvery tomentum (Fig. 54a). Some of the latter could be matched with specimens from populations of *C. discolor* in Nelson, but were obviously part of a homogeneous population.

Specimens satisfying the criteria given above have been collected from the axial ranges and central volcanoes of the North Island and from the South Island, as far south as the Waitakariri Valley. Indeterminate specimens are known from Mt. Foul and the Sedley Valley. (Fig. 57)

Three varietal names are known for *Calamiaea incana*. The first, variety *articulata* was given by Kirk to material collected on Kelly's Hill near Ohira. Specimens of this variety have not been examined by the author in the field and none of Kirk's specimens have been seen. Its status remains uncertain although from the description it would appear to lie near to *C. discolor* (type variety) as suggested by Allen. The second variety is var. *mivalis*. 
FIGURE 53

SPECIES REPRESENTATIVE OF GROUPS TWO AND FOUR

(a) *Celmisia angustifolia* from Porters Pass, Canterbury.

(b) *Celmisia incana* from Kaweka Range, Hawkes Bay.
Martin applied this name in 1935 to specimens collected on the Seaward Kaikoura, Banks and Sainc mountains where it was described as being a, "common member of subalpine fellfield, rock faces and meadows.

It is distinguished from typical *S. incana* by its dense, lax, lanate tomentum clothing both leaf surfaces, the absence of obvious leaf corrugations, and by its less conspicuously reflexed involucral bracts. Martin mentions that it shows considerable variation throughout its range. Plants answering this description are common in both Harbourn and Haast. However, it seems likely that they should be referred to *Selinia allanii* if not to a separate species. The tomentum is similar to that found in *S. allanii* and though the leaves are often much shorter, the lack of leaf corrugations suggests that it might belong to that species. The combination *Selinia allanii* var.*pivallis* was used by Martin in manuscript. The third variety is var.*antarcticaeae*. This is a manuscript name only and was applied by Martin to plants from the Haast area. A manuscript drawing by Martin is labelled, "Selinia incana* var. antarcticaeae* Jollies Pesc 2/21 Col. B. M. L. Leaves gray above white below Midrib evident below pet. green". A marginal note by H.E. Allen reads, "This appears to me to be a good jordanus". The status of this form has not been investigated although similar specimens have been collected from other parts of the Haast Valley and Haast area. The situation at Haast is extremely complex with a variety of forms present in any one locality. Until the field situation is sorted out it would be unwise to erect further varieties or subspecies.

Hooker's original description of the species embraced two
distinct taxa. Until 1935, Hooker's specimens remained the only
known to have been collected. Martin, however, showed that
G. sinclairii is widespread throughout Marlborough. Having found that
Hooker had included two species in his description, Martin selected
material from Taradale as the type and placed the Dun Mountain
material in his new species, G. allanii. In doing this Martin applied
the epithet "sinclairii" to members of the group with leaves glabrous
on both surfaces.

Although not abundant the plant is a characteristic member of
fullfield communities in Marlborough.


In 1935, Martin referred Dun Mountain material included by
Hooker in Galaxia sinclairii, to a new species, G. allanii. The
type for the species was collected by Allan on Mount Tresora and
is a small-leaved plant with both surfaces of the leaf covered with
a loose grey tomentum. According to Martin specimens referable to
Galaxia allanii had been previously collected by himself, by Allan
and by Thomson in north-west Nelson, and from the Dun Mountain by Wall.
All these had been referred to G. sinclairii. Two gardeners were
described by Martin. In both, there is tomentum on both surfaces
of the leaf. However, in variety canescens when the leaf is dried,
the tomentum appears to disappear from the upper surface, whereas in
the type variety the tomentum on the upper surface is apparent in both
fresh and dried specimens. Both varieties are distinguished from
Celmisia inconea by the fewer, relatively narrower, longer leaves
and by the, "involucral bracts more conspicuously reflexed".

The species is found only in the northern part of the South
Island. Plants referable to the species have been found in northwest
Nelson and Marlborough as far south as Arthur's Pass. Variety
nemoralis appears to be restricted to the St. Arnaud, Bryant and
Richmond Ranges.

This species appears to be a valid taxon. It embraces a
variety of forms and probably contains a number of variable
populations united by common characters such as the loose tufting
on both surfaces of the leaf (Fig. 54 b). Probably Martin's
C. inconea var. nivalis belongs here as a high alpine subspecies.

Populations belonging to Celmisia allanii occur at relatively high
altitudes in the Nelson mountains ranging up to 6,500 ft.

5. Celmisia durietzii Cockayne et Allen ex Martin in T.R.E.N.Z.
65, 1936, 75.

In the comments accompanying the type description of this
species, Martin remarks that:

As their specimens clearly show, what both Kirk and Cheeseman
had in mind in their published descriptions of Celmisia allanii was
undoubtedly that plant referred to by Dr L. Cockayne in the
second edition of his Vegetation of New Zealand under the
nomen nudum of Celmisia durietzii. (Martin, 1936, 75)

He states also that all forms of this species are glabrous
or glabrate above and white below and are separated from
C. cockayniense by differences in habit and flowering breast morphology.

The distribution of this species is uncertain, but it appears
FIGURE 54

CELMISTA IHCANA AND C. ALLANTII
at
(a) Makalu Saddle, Kaweka Range, showing variation in leaf colour; (b) C. allantii from Jacks Pass, Hammer.
to range along and west of the main divide from northwest Nelson to Fiordland. It is frequently found in deep shaded situations and is one of the few species in the genus to grow in subalpine forest habitats.

It is possible that two distinct taxa may make up *Galaxia duriaei*. Most forms of the species are united in having white appressed hairs on the undersurface of the leaf (often scurfy in appearance), narrow petiolate leaves which are usually membranous and a rupestral habit. However, otherwise similar plants are sometimes found with a loose floccose tomentum on the underside of the leaf.


Hooker described this species in 1854 from specimens collected by Dr Lindsay at the Nuggets near the mouth of the Clutha River. The species is still plentiful at its type locality but is known for only a limited distance south along the coast. The upper surface of the leaf is glabrous, the lower covered with a setiny tomentum, the lamina is coriaceous and the whole plant is viscid. At the type locality the plant is robust and covers many square yards with its bright green shiny foliage.

This plant is probably a post glacial relict which, after becoming isolated, has managed to survive on the rocky southeast Otago coastline. It is similar to *Galaxia hornelandii* from which it is probably derived. Differences between the species are small but constant.

7. *Galaxia hornelandii* (Buchanan) Allen Fl. Z. F., 1851, 324.
          *Eriocereus hornelandii* Buchanan in Fl. Z. F., 1857, 213.
Although this species was described by Buchanan in 1867 its existence was seriously doubted for many years. Kirk and others considered that records of a *Celmisia* from Mount Boswell, which was similar to *C. lindeavii*, were erroneous and that any such material had really been collected on the coast. Cookayne (1906) showed that this was not so and that there were two valid species present.

*C. boswellii* is found throughout Fiordland and as far north as the Mount Aspiring area. It may be distinguished from *Celmisia lindeavii* by the wider leaves which are often obovate, longer stouter scapes and the more prominently denticulate leaf margins. As Cookayne comments, the species might be considered identical on morphological grounds since the differences are slight and quantitative rather than qualitative. However, he quotes Matthews as writing that, "when seen growing side by side they are dissimilar in many respects that could not be reduced to writing".

In Fiordland, this species replaces *Celmisia discolour* in herbfield and fellfield communities. Kirk and Burrell (1966) record it from all sites examined in a study of the alpine tussock grasslands of the Humboldt Mountains.


Little is known about this species. For many years it was only recorded from the type locality (Mount Stokes) but Martin subsequently showed that it was present on peaks of the Richmond Range in northwest Marlborough. He comments:
The typical form of this species is apparently restricted to Mount Stokes. It is recorded as forming "compact, silvery cushions on the steep rock faces near the summit" on Mount Stokes. Both forms of the species apparently require shade and moisture.

Like *C. alliaria*, the leaves of this species are covered with long nerved hairs. It differs in the colour of the stomata which is silvery to buff in fresh specimens and brown when dried, in the leaf shape which is narrow-oblanceolate, in the stouter and more foliaceous styles and in its habit and ecological requirements.


This species was described by Hooker in 1864 from material collected on Mount Tarlensee. It is a common species on the east side of the range from eastern Nelson to western Otago and is also reported from the Bryant Range in eastern Nelson. As discussed elsewhere it is generally only found east of the 100 to 120 inch isohyet, and within its area of distribution is part of a dry-range association characterized by such *Calista* species as *C. lyallii* and *C. angustifolia*.

This species is not highly polymorphic. However, two distinct forms do occur and most populations are made up of varying proportions of both. The first is characterized by a bloom on the upper surface of the leaves which gives plants a whitish or glaucous appearance. In the second form, this is absent and the leaves are
FIGURE 55

CELMSIA VISCOSA SHOWING TWO COLOUR FORMS GROWING TOGETHER

Plants photographed on Mount Harper, Rangitata Valley, Canterbury.
Figure 56

Distribution of Celmisia discolor, C. bonplandii, C. lindsayi and C. glabrescens
FIGURE 57

DISTRIBUTION OF CELYSIS INCANA
C. macmahonii
C. durietzii
C. sinclairii

Figure 58
DISTRIBUTION OF CELMISA DURIEZII, C. SINCLAIRII
AND C. MACMAHONII
contoured at 2000 ft
DISTRIBUTION OF GELANIST A ALLANII
FIGURE 60

DISTRIBUTION OF CELMISIA VISCOSA

countoured at 2000ft
bright green (Fig. 55). The occurrence of both forms in many populations suggests that a balanced polymorphism might be operating. Common features in all populations of G. viscosa are the linear stiff leaves with longitudinal grooves, stout scape and excessively viscid leaves, scape and stem. It is included with the group of species clustered about Galaxia dissolens and G. incana although in general appearance it appears dissimilar to most other members of the group.

Ecologically, this is a significant species. In the eastern foothills of the Southern Alps it is characteristic of ridge-tops and stable fellfield. Mark (1963) records it as being co-dominant on the summit plateaus of the Dunstan, Old Man and Garvie Ranges at 4,500ft, and as dominant on the Rock and Pillar Range. On the Old Man Range, Billings and Mark (1964) record the species as a narrow-bottom plant in the hummock and stripe tundra formation. Here it is an important species, since by growing in the lee of the hummocks it provides the catchment for wind-blown soil which builds up to form linkages between the hummocks.

7.5 GROUP FIVE

Only one species is included in this group:

Galaxia haastii Suck.f.

Distribution

The species is widely distributed throughout most of the South Island, being found from Nelson southwards along the main divide to
Fiordland. Generally, it is a plant of high rainfall areas and within its area of distribution is almost entirely restricted to the higher alpine sense.

Floral morphology

Although very similar to species belonging to group four, *C. haastii* differs from the species in that group in three respects. The achenes are glabrous although otherwise similar to those of group four. The involucral bracts are broader than is usual in that group and, thirdly, the disc corollas are only sparsely hairy.

Vegetative morphology

The general pattern is similar to that of group four. The species differs in several respects, including the broader leaves which are dark green on the upper surface, in the very thin tomentum, and in the stouter branches and scapes.

Notes on the species

*Cellisia haastii* J.R. Hooker *Handbook N.Z. Fl.* 1861, 131

Although widespread, this species is usually restricted to the high alpine vegetation zones. The species is not uncommon from southeast Nelson to Fiordland, but is not recorded from central Marlborough or eastern Otago (Fig 64). It is only known in northwest Nelson from a single collection by F. Soper in 1936 on Mt. Donett. It is apparently not common in western Fiordland.

The species is virtually confined to snow-bank communities and is a characteristic marker species. Billings and Mark (1954) found that
var. tomentosa

FIGURE 61

DISTRIBUTION OF Celmisia Haastii

contoured at 4000ft
on the Old Man Range, in a continuum in the lee of a solifluction terrace, this species was only found close to the face of the terrace.

There seems little morphological variation throughout the range of the species. All populations examined had plants with ovate- spatulate, resurred dark-green leaves with the upper surface conspicuously furrowed. The Otago variety, var. tomentosa, was described from the Rock and Pillar Range by Simpson and Thomson. Matching material from the Fisa Range appears to be of hybrid origin, the probable parentage being Calaisia viscosa x C. hastii, both of which are abundant in the area.

7.6 GROUP SIX

Species included here are:

Calaisia densiflora
C. hastii

Distribution

Both these species are southern in distribution (Fig. 62). Calaisia densiflora is found throughout most of Otago except central Otago, and extends northwards through the Hunter's Hills to south Canterbury. The northern limits of this species lie in the upper reaches of the South Ashburton River, where it was found growing in a few scattered localities on the Harper Range, by H.L. Corner and R.A. Given in 1966. The western limits of the species lie east of the high rainfall areas in western Otago and there are no known occurrences of the species west of the Thomson and Takitimu
Ganges. *Colocasia auriculata*, on the other hand, is confined to central St. George. At present it is known from the Garrick, Old Man and Rock and Pillar Ranges, and from the Blue Mountains near Tapamui. Together these species present an unusual pattern of distribution with *Colocasia densiflora* almost encircling *C. auriculata*. Despite this they come in contact in only a few places including the Blue Mountains and the Hector Mountains.

**Floral Morphology**

These two species are morphologically rather similar to the previous two groups. The main floral differences lie in the more sparsely hairy schizocarps, the very short glandular hairs on the involucral bracts, and the reduced number of hairs on the ray florets.

**Vesctative Morphology**

Both these species have conspicuously toothed leaves. The upper surface of the leaf lamina is irregularly grooved and plicated. By means of stolons plants of both species are able to occupy considerable areas of ground, although the stem structure in general is similar to that of the previous groups.

**Notes on the species**

1. *Colocasia densiflora* J.D. Hooker *Handbook* 2: Fl. 1854, 420

Hooker described this species from material collected near its northern limits at Lake Chau. Although occurring in south Canterbury it is only in St. George that it becomes a common herbfield.
C. densiflora

C. prorepens

Figure 62

Distribution of Chelcus densiflora and C. prorepens

Contoured at 2000ft
and fellfield plant. In parts of Otago it is an important contributor to certain types of community. For example, on the Hector Mountains following burning both Celmisia denseflora and C. proceraeum have become established as sub-dominant species on ridge top sites. However, the absence of these species from areas which have been continuously burnt probably indicates their inability to survive repeated burns.

*C. denseflora* does not appear to be highly polymorphic. Near the limits of its range, both in the north and in the upper reaches of the Narama River, there is a tendency for the leaves to be reduced in size.

2. *Celmisia proceraeum* Pritie in F.E.L.I. 19, 1857, 126

This species replaces the previous one in central Otago. Ecologically it is similar to *C. denseflora*. Millings and Kirk (1969) record that it occurs in mid-lee areas sheltered by solifluxion terraces on the Old Man Range although it is not dominant. As mentioned, on the Hector Range it is a "fireweed" species.

There is a small amount of variation from population to population. Specimens from the Blue Mountains are broader-leaved and coarser-toothed than are most forms of the species.

7.7 GROUP SEVEN

Four species are placed in this group, these being:

*Celmisia holosericea* (Forst.f.) Hook.f.

*C. dellii*

Bushman
Distribution

Three of the above species are distributed through the northern part of the South Island while the remaining one is southern (Figs 63 and 64). *Galecia defiliis* is confined to northwest Nelson, extending down through the Paparoa Range. *G. hieracifolia* is more widespread and is abundant in the ranges east of Nelson as well as in the Tasman Mountains of northwest Nelson. This species also extends to the North Island but is only found in the Tararua Ranges. The third species, *G. cockayniana* was only known from the type locality on Mt. Pyfe until Martin showed that it was quite a common plant in many parts of Marlborough. The known distribution ranges from the Waian southward through the Inland and Seaward Kaikoura Ranges to the Keatara Saddle between the Kaikoura and the Conway Rivers. The only southern species in the group is *Galecia helenoides* which is common throughout the wetter parts of Fiordland and which reaches its northernmost limits near the Hollyford Valley.

Floral morphology

This group may be distinguished from all others in the genus, by its dimorphic involucral bracts. The outer bracts are broader than the inner and tend to be erect. The inner bracts are narrower and are usually recurved. *Galecia hieracifolia* sometimes almost lacks the outer row of erect bracts and shows considerable
variation in this character. Other features of the floral morphology are not unlike those of group four although within the group there is considerable variation in such characters as achene length and hair density.

**Vegetative Morphology**

Species in this group are basically similar to the members of the preceding groups. They show a greater tendency towards a "tufted" appearance by a crowding of the upper nodes and are also more generally toothed on the leaf margin than are related groups (apart from group six).

**Notes on the species**


   This species was described by the Forsters as *Aster sericeus* from material collected in Dusky Sound. Since then its range has been extended to include much of Fiordland. One of the most distinct features of this species is that it commonly descends to sea-level. In many parts of Fiordland it is found abundantly on stream banks and avalanche tracks below tree-line. *G. holosericea* requires a wet environment and it is not unexpected to find it virtually restricted to western Fiordland.

   The species shows little morphological variation. It is quite distinct from the other members of this group in its size, leaf morphology and habitat. Also, it is one of the few species of *Galaxia* known to strike readily from cuttings.
2. *Calceola callida* Buchanan in J.R.I.Z., 14, 1892, 555

The description of this was made from specimens collected on the Golden (Goulain) Flows at the head of the Akaroa Valley. Since then it has been found throughout northwest Nelson and as far south as the Paparoa Range. The species is a conspicuous member of the rich herbfield encountered on many of the mountains in northwest Nelson. It is similar to *C. hiansifolia* but differs in the colour of the abaxial leaf tomentum which is always white to pale buff, in the thin rim of darker tomentum on the leaf margin and in the habit which is more tufted. Little variation has been seen in the field.

3. *Calceola hieracifolia* Hooker Fl.B.S., 1, 1853, 124.

Riddell collected this species from Nelson "on the mountains" in 1839 and provided the specimens for Hooker's type description. The plate illustrating the species in the *Flora Novae Hollandiae* suggests that the type specimen is similar to the present *C. cockayniana*. In its various forms the species occurs in the south of the North Island and throughout Nelson and northwest Marlborough.

The species is highly polymorphic (Fig. 67a). Two varieties have been described. One, var. *gouleri*, appears to occupy a definite geographical area in the upper Buller Valley. It is distinguished by the linear leaves and slender stems. The other variety, var. *oblonga*, occurs throughout the range of the species variety. It is smaller than the type variety with fewer teeth on the leaf margin. This variety may be of doubtful status since not only does it occur growing with the type variety but also
precocious flowering can take place when plants are quite small and similar in appearance to var. 

Other variant forms occur in the field. In the North Island, a very distinct form is found. The leaves are very broad and 

elliptic. The margins of the leaves are crenate rather than 

toothed. This form approaches C. cockayniana and may deserve 

subspecific recognition. In northeast Nelson a possible balanced 

polymorphism is found since in many populations both magenta 

pigmented and non-pigmented plants are found. The involucral 

bracts vary considerably, sometimes there being few leafy outer 

bracts.


For many years this species was only known from the type 
specimens collected by Cockayne on Mount Pyfe in the Seaward 

Kaikoura Ranges. Martin (1935) comments:

Strangely enough, the species is quite common and widely 
distributed in Marlborough, growing as it does on both the 

Seaward and Inland Kaikoura Ranges and parallel ranges to 

the west, as far as Mount 89 on the ridge separating the 

Tukapai River from the Aranui River.

(Martin, 1935, p. 177)

It is apparent that C. cockayniana replaces C. hieracifolia 
in eastern Marlborough. It is similar to the Tararua Ranges 

form of the latter in general appearance but differs in the longer 

leaves and more regular crenations.

7.8 SEAP HIVE

This group contains only one species which is:

Celmisia glandulosa Hook. f.
C. dallii
C. cockayniana
C. holosericea

DISTRIBUTION OF Celmisia dallii, C. cockayniana AND C. holosericea
contoured at 2000 ft

FIGURE 6b

DISTRIBUTION OF CELMISIA HERACTIFOLIA
Distribution

The species is distributed throughout most of the South Island as well as the southern half of the North Island. Within the North Island the species shows some preference for the wetter parts of the island (Fig. 65). Characteristically, U. glandulosa is found in damp situations, often in past hay associations with such plants as Calamia alpina, Drosera spp., and Pelargonium novae-caledoniae, and this limits the distribution of the species although it sometimes will occur in drier situations provided the soil does not dry out completely.

Floral Morphology

Though this species has glandular hairs and recurved involucral bracts like most of the preceding groups, it differs from them in the nature of the disc corolla hair and the style arm. The hairs on the disc corollas are of two types, both of which are bicrenate. The first type has long stalk cells surrounded by elongated terminal cells. The second type has only two stalk cells but once again has elongated terminal cells. These hair types are not found elsewhere in the genus and are unlike those of the preceding groups, most of which have the corolla hairs expanded in the upper part.

The style arms have the tip elongated whereas in all the preceding groups, except for group three the tip is shortly triangular.

The degree of elongation is, however, not as great as that found in species belonging to groups thirteen and fourteen. This species and the following group are difficult to place near any other species.
of Colnieia.

**Vegetative Morphology**

This is the only species, of those examined, which has stalked glandular hairs on the leaves. The leaf lamina is always submembranous, never coriaceous. *C. glandulosa* grows as tufts forming part of a turf on deep ground and spreading by rhizomes or by stolons.

**Notes on the species**

*Celmisia glandulosa* J. F. Hooker *Handbook III*, 2, fl. 1861, t. 136

This species was discovered by Colenso during his 1847 journey from Napier to Taupo and back to the east coast via the Ruahine Ranges. The species is widespread throughout the South Island and the central part of the North Island. Cheeseman comments on the interesting ecology of the species by pointing out that though in the South Island it is almost always found in peat bogs, in the North Island at the base of Tongariro and Ruapehu it is commonly found in situations which are dry for most of the year. The species is well adapted to peat soils in its stoloniferous habit which enables it to spread vegetatively as a turf plant.

*G. glandulosa* is highly polymorphic. Two varieties have been described in addition to that including the type. Variety *latifolia* is restricted to Mount Egmont and is characterized by large wide leaves. Variety *longissima* has slender erect scape up to 20cm long and is known at present only from Fiordland. Plants from several places have been cultivated by the author and they show
great diversity. In some cases glandular leaf hairs are restricted to the upper surface of the leaf. Pigmentation of the sheath also varies considerably. Colenso's *Grimmia umbrosa* belongs here. It has not been seen by the author. Colenso separates it from *G. limbipes* by its wider umbrosa leaves, lack of glandular leaf hairs and greater numbers of florets. Further study on this and other variants will be needed before a full evaluation can be made.

7.9 GROUP HIRI

Only one species is placed in this group. This is:

*Grimmia bellidoides* Hook.f.

**Distribution**

This species is distributed throughout the South Island where it occurs in damp and shaded sites (Fig 56). In most areas it is found both above and below the treeline and it is often found on the shaded banks of streams from 2,500 ft upwards. *G. bellidoides* is absent from most of Marlborough and from the eastern ranges of Otago and Canterbury. This is probably due to an absence of suitable sites.

**Floral Morphology**

This species is different in a number of respects from all other members of the genus. The involucral bracts are wider than usual and similar to those found in group one. They are also not recurved and are glabrate. The hairs on the disc floret corollae are unusual, being made up of cubical stalk cells amounted by a pair of
rounded terminal cells. The style branch is lanceolate and the
tip is elongated with long collecting hairs being not unlike those
found in the previous group. Finally, the number of pappus hairs
is much lower than that found in any of the previous groups,
being only about twenty per floret.

Vegetative morphology

This species is stoloniferous and able to form loose mats
of scrambling leafy stems, well suited to its habitat (Fig. 41).
The leaves are notable, in being glabrous except for a tuft of hairs
at the base. With G. venidiosa it is the only species to have
neither glandular nor eglandular hairs on the leaves or scape.

Notes on the species


This species which is considerably different from most other species
in the genus appears to require moist soil conditions and is
probably limited by these requirements to the wetter areas of the
South Island. The only Marlborough specimens known to have been
collected were found by the author at the bottom of the gorge of
the Roder River in the Inland Kaikoura Ranges where they were on
a deep bank. In areas such as this the species is probably quite
local. Little variation has been encountered throughout the
species range.

The very similar Galecia thoracita is limited in its
distribution to the Lyre Mountains. Geesaman points out that it
differs from this species in its smaller size, more compact habit,
- C. bellidioides
- C. thomsonii

Figure 66

Distribution of Geumatia Bellidioides and C. Thomsonii

Contoured at 2000'
and in the closely placed, rosulate and setulose leaves. According to Thomson and Speden (quoted by Cheeseman, 1916) it usually occurs in shaded crevices where direct rain cannot fall on the plants. It differs from \textit{G. bellidifolius} in several respects and is further discussed at the end of this chapter with other unplaced species.

7.10 GROUP TEN

This group contains six taxonomic entities, of which four are species which have been described. A further entity included in this group is a species made up of Westland specimens which have usually been placed in herbaria as \textit{G. insignis}. The sixth species is an undescribed one from northwest Nelson and including part of Cheeseman's \textit{G. coriacea} var. \textit{leptifolia}. The species included are:

- \textit{Gelidia} \textit{lyallii} Hook.f.
- \textit{Gelidia petrici} Cheeseman
- \textit{Gelidia armstrongii} Petrie
- \textit{Gelidia lanceolata} Cockayne
- \textit{Gelidia} sp. (\textit{G. coriacea} var. \textit{leptifolia} Cheeseman in part)
- \textit{Gelidia} sp. of \textit{petrici} Cheeseman

\textbf{Distribution}

This group is restricted to the South Island but is widespread throughout the island. \textit{G. lyallii} is abundant from north Canterbury south through the dry eastern ranges to Otago. It is rarely found west of the 100 inch isohyet. In higher rainfall areas this species
given way to *G. patricia* (Fig. 68). The latter species is common in northwest Nelson and in Fiordland but is absent from Westland and Canterbury. *G. lanceolata* is almost confined to Fiordland and the similar *G. armstrongii* is found in northwest Nelson and Westland at least as far south as Arthur’s Pass. It may extend to the Franz Josef and Fox Glaciers (Fig. 69). Of the remaining two taxa, one is confined to northwest Nelson, and one to Westland where it is known from a few localities between the Taramakau and Haast Rivers (Fig. 70).

**Floral Morphology**

With the following two, this group shares a number of characters which are absent from the preceding groups. Glandular hairs are absent apart from a few stubby hairs on the involucral bracts. The bracts are long and erect. The capitulum is large with very large numbers of floral parts. The receptacle is obconic rather than globose, the disc floret hairs are not widened at the tip, the pappus hairs are long and the achenes tend to be fusiform rather than cylindric. Collectively these characters ally the group with the following two and separate it from all of the preceding ones. The main basis for separating the group from these following is that the achenes are hairy and are not generally as large as those from groups eleven and twelve. Some differences are apparent within the group, e.g. the achenes of *G. torellii* are very short, but the differences are no greater than might be expected within any similar group of species.
Vegetative Morphology

All the species in this group are included in Allan's Section *Colmizia* which contains, "herbs arising from simple to branched stocks: leaves in dense tufts (rarely rosetate at tips of branchlets); sheaths usually densely compacted, forming a pseudo-stem". The herbaceous appearance of these plants arises from the contraction of the terminal branchlets so that the leaves become densely infrascabent. Since the branchlets are underground, the leaves arise in dense tufts at ground level. The enclosing sheaths of the leaves form a pseudo-stem at the base of which is the branchlet tip. Thus the flowering spases which are given off laterally appear to be terminal. There may be either a simple or a branched underground stock which may give rise to either solitary tufts or to a "tufted-like" group of tufts.

The leaves are lanceolate or linear and in some members of the group are highly modified (*e.g., Colmizia lyallii*). In all cases, glandular hairs only are found on the foliage and this in particular allies the group with those following. The abaxial surface of the leaf lamina is covered with an appressed coating of uniseriate hairs. In some species a pellicle is present on the adaxial surface, especially in *Colmizia armstrongii* and *C. lanceolata*.

Notes on the species

1. *Colmizia lyallii* J.D. Hooker Handbook H.Z.Fl. 1854, 133

   In the type description of this species Hooker cited as localities, "Dusky Bay, Hurumai (Hurumai) valleys, Ragitata, Two-thumb, and Malvern ranges, alps of the Hopkins River, Otago
Lake Districts and Lindah Pass. As Allan (1935) pointed out, all
the specimens except that from Rusa to belong to _G. Hvallisi_ as
understood by local botanists. The Rusa Sarn material belongs to
the species later described by Cheeseman as _G. patricia_, and the
description by Hooke was drawn up so as to include both species.
Allan selected a lectotype from the Mount Alta collections by
Bector (included in the Otago and Lindah Pass material) so as to
retain the current usage of specific names.

Throughout its range this species is remarkably uniform.
Most of the variations in Canterbury can be ascribed to the effects
of hybridization with _G. spectabilis_. The leaves of _G. Hvallisi_ are
well adapted to dry conditions being superficially very similar to
the leaves of some xeromorphous monocotyledonous species.

Although the species is limited to areas receiving 100 to
120 inches of rain or less it appears to tolerate poorly drained
damp sites. Thus in some areas it is absent from ridge crests but
found occupying steep spur, gully and flinty sites. Also, it is
sometimes sporadic in distribution over quite large areas. In Otago
it is abundant on the Kahurangi, Garvie and Hector Mountains but is
much less common on the Pisa, Dunstan, and Gud Wan Ranges. Its
western limits are dictated by rainfall. In Otago it is replaced
west of the 100 to 120 inch isohyet by _G. patricia_. The two species
overlap at the eastern margin of Fiordland. Mark (1965) describes
_G. Hvallisi_ as being dominant in communities on the Garvie and Hector
Mountains and locally important on the Dunstan and Harris Mountains
(Fig 67 a). In many areas it is favoured by burning, and it appears
FIGURE 67

SPECIES REPRESENTATIVE OF GROUPS SEVEN AND TEN

(a) *Celmisia hieracifolia* showing wide-leaved and narrow-leaved forms from northwest Nelson;

(b) *Celmisia lyallii* dominating tussock-herbfield on Mount Tennyson, Garvie Mountains, Otago.
to be the only species of *Celmisia* in Otago to survive repeated burning and grazing, as on the Groom and Carrick Ranges.


One of the most interesting distributions in the genus is displayed by *Celmisia retrici*. It is one of the only two disjunct northwest Nelson-Fiordland species. In both areas it is a common component of alpine grasslands and open herbfield. West of the 100 to 120 inch isohyet it replaces *C. lyallii* and occupies similar sites. It appears in better drained sites than that species and where the two occur together they are to some extent segregated by their different requirements. In their study of the vegetation of the Humboldt Mountains, Mark and Burrell (1966) found that the species was present in sites below 1,500 metres as a herbfield tussock-grassland species.


Ranging from northwest Nelson to at least a little south of latitude 43° this species is a frequent herbfield plant in the higher rainfall areas of the alps. Specimens from further south in Westland probably belong to this species but are also similar to narrow forms of *C. lanceolata*.

This species shows little variation in its morphology throughout the whole of its range. There is a tendency for plants to become reduced in size in some areas and southern forms appear to be slightly more narrow-leaved than northern forms. Like some other members of the group and like *C. coriacea*, though frequent it is rarely dominant in herbfield communities above 4,000 ft.

This species was described in 1912 from specimens collected by Rechel on the Longwood Range. Cockayne considered the species to be intermediate between *Galinsia ematriculata* and *G. coriacea* and Chessman in 1925 suggested that it might be of hybrid origin. However, the plant is widespread and common in many areas, and is a species in its own right.

It is found throughout Fiordland and appears to be a variable species. This has not been investigated but it is possible that there is a link between the bronzed form of *G. coriacea* and those of this species. *G. lanceolata* is the southern equivalent of *G. ematriculata*.

5. *Galinsia* sp. *Galinsia coriacea* var. *lancifolia* Chessman


Cockayne's *Galinsia lancifolia* from Arthur's Pass was quoted as a synonym.

Specimens from Nelson and the western margins of Marlborough appear to fall into Chessman's variety. Although Cockayne or Chessman collections of this taxon from Arthur's Pass have not been
seen, similar material observed in the field appears to be distinct from that found in Nelson. As used here the name is applied to a distinct Nelson taxon which may warrant specific status.

The inclusion of the variety in this group is made on the basis of similarities in the floral morphology. The most obvious one is the consistently pubescent achenes which at once distinguishes the variety from *G. coriacea*, *G. monroi* and from Cockayne's *G. flexula*. Also consistent are the pigmented sheath, long petiole and lanceolate lamina, slender scapes and generally small size.

The northern form ranges throughout northwest Nelson and is recorded as barren specimens from the upper Waiau and Clarence Valleys. In these latter localities it may overlap with *G. monroi* which it greatly resembles. It has been variously filed in herbaria as *G. monroi*, *G. abies*, *G. coriacea* or as *G. coriacea* var. *lancifolia*. From the first three it is distinguished immediately by its completely pubescent achenes. *G. monroi* usually has a green sheath and has stiffer, less lanceolate leaves with a less conspicuous petiole. *G. abies* is a much smaller plant with the upper surface of the leaf glabrous and shining; the leaves pressed to the ground and the whole plant often forming a mat of tufts. *G. coriacea* is stiffer leaved, the leaf lamina is rarely lanceolate and it is altogether a much larger plant.

6. *G. flexula* sp. of *petrii* Cheeseman, not *G. insignis* Martin.

During recent years specimens of a narrow-leaved *G. flexula* from the West Coast of the South Island have appeared in herbaria. Usually these have been filed under *G. insignis*. These specimens
C. lyallii

C. petriei

FIGURE 68

DISTRIBUTION OF CEMISIA LYALLII AND C. PETRIEI
Figure 69

Distribution of Celmisla Armstrongii
and C. lanceolata

- C. armstrongii
- C. lanceolata
- C. sp. cf. petriei
- C. sp. = var. lancifolia

**Figure 70**

Distribution of *Celmisia* sp. cf. *petriei* and C. sp. (= *Celmisia* var. *lancifolia*, in part)
appear to constitute an undescribed species. They differ from *G. insigne* sensu stricto in having pubescent achenes, in other floral differences such as achene length, pappus number and corolla hair morphology which suggest that the plants lie near *G. petriei*, and in the leaves which are shorter, stiffer, and darker in colour.

Plants belonging to this taxon have been collected in the Griffin Range, near Lake Kanori, on Mount Fox, in the Landsborough and Clarke Valleys and near Mount Aspiring. All specimens seen are morphologically very similar.

7.11 GROUP ELEVEN

This group contains the following species:

- *G. coriacea* (Forst. f.) Hook. f.
- *G. murielii* Hook. f.
- *G. insignis* Martin
- *G. obia* Cheesman
- *G. normanii* Cheesman

**Distribution**

This is chiefly a northern South Island group with all but one of the component species confined to Nelson and Marlborough. The exception is *G. coriacea* which is found throughout the South Island in both dry and wet areas (Fig. 72). *G. murielii* and *G. insignis* are restricted to Marlborough, the latter species being very local and confined to the Waihopai and Aranui Valleys and adjacent parts of the Hurama Valley. *G. obia* is confined to northwest Nelson and *G. normanii* is only found in the Ngakawau Gorge between
Westport and Lawrence. The distributions given are to some extent provisional since they are partly dependent on the result of sorting out the taxonomy of Selmisia tubla, S. nanae, and S. coriacea var. lanatula (Fig. 70 and 73).

Floral Morphology

As mentioned under the previous section, this and the preceding group are sharply differentiated from the earlier groups in several respects including a lack of glandular hairs, erect involucral bracts, capitulum shape and shape of the disc corolla hairs. It differs from the previous group in the lack of hairs on the achenes and in several features which are outlined in Table 18.

Vegetative Morphology

Vegetatively this group is very similar to the last, and, like it, differs from most of the previous groups in both habit and leaf morphology. A similar range of leaf lamina shapes is encountered and individual plants may consist of either solitary or numerous tufts. The abaxial surface of the lamina is usually covered with a velvety appressed tomentum of long unicellular eglandular hairs. The adaxial surface may be covered with a pellis of hairs.

Notes on the Species

   *Aster coriaceus* G. Forster Prodr. 1786, 56.

This species was first described by George Forster as *Aster coriaceus* from material collected at Dusky Sound. It was later found
<table>
<thead>
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<th>Characters</th>
<th>Group ten</th>
<th>Group eleven</th>
<th>Group twelve</th>
</tr>
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<tbody>
<tr>
<td>Involute bract variation</td>
<td>Simple</td>
<td>Compound</td>
<td>Simple</td>
</tr>
<tr>
<td>Involute bract base</td>
<td>Narrow</td>
<td>Wide</td>
<td>Narrow</td>
</tr>
<tr>
<td>Involute bract hairs</td>
<td>All species with one basal cell</td>
<td>All species with one basal cell</td>
<td>Some species with several basal cells</td>
</tr>
<tr>
<td>Anthoscale</td>
<td>Pubescent</td>
<td>Glabrous</td>
<td>Glabrous to glabrate</td>
</tr>
<tr>
<td>Ray floret limb</td>
<td>Narrow to wide</td>
<td>Narrow</td>
<td>Wide</td>
</tr>
<tr>
<td>Corolla hair type</td>
<td>Discinate</td>
<td>Discinate</td>
<td>Discinate and uniseriate in most sp.</td>
</tr>
<tr>
<td>Corolla hair distribution</td>
<td>Usually near base of tube</td>
<td>Usually near base of tube</td>
<td>Sometimes near corolla tip</td>
</tr>
</tbody>
</table>
to be common throughout most of the South Island. From the Buller Valley south it is frequent although records are scattered in Canterbury, northern Westland and Otago. It may be absent in parts of Nelson and Marlborough. Even when common, this species is rarely abundant. Usually it is present as isolated plants scattered throughout a community. Only between Greymouth and Westport where it reaches the coast, and in western Otago where it occurs as variety \textit{stricta}, does the species dominate certain communities.

\textit{G. coriacea} is highly polymorphic and the following forms can be recognized in the field:

(a) \textit{var. stricta}, Cockayne. This is found in western Otago and is distinguished by the conspicuous silvery pellicle on the upper surface of the leaf, by the long rigid leaves and by the large size and vigour of the plants. Cockayne comments on the occurrence of the "normal" form of \textit{G. coriacea} further west and suggests that the same relationship exists between these forms as exists between \textit{Rhabdia lymoides} and \textit{L. alpina} (Cockayne, 1913). The variety occurs on the Currie Mountains and the Tekitau Range but more mapping of it is necessary before its relationship with more westerly forms can be decided.

(b) \textit{var. semicordata}. Petrie described this as \textit{Gelsemia semicordata} from material collected at Charleston and on Buckland Peaks. An examination of "co-type" material at the University of Canterbury indicates that the Buckland Peaks specimens probably belong to the group of populations referable to Cheeseman's \textit{G. coriacea}.
var. lanceifolia. As Peters cites both localities with no indication of a holotype, either area may be selected as the type locality.

This variety is common on the coast between Westport and Greymouth. It extends inland to the Victoria Range. It appears to be variable but this may in fact be due to the inclusion of more than one taxon in the variety.

Several other varieties and species have been described.

Variety lanceifolia and Gal sia fleoida are discussed elsewhere.
G. martindii and G. coriacea var. ensata have not been studied. It appears from the description that G. martindii may be referable to either Gal sia verbascifolia or G. helosierosa.


In Marlborough, G. coriacea is replaced by this species. Away from the type area there is considerable morphological variation and in some forms the boundary between the two species is difficult to draw. G. novoi is consistently smaller in all its parts, has a silvery pellisole, has the leaves stiffly erect and tending to be narrow, and has numerous bracts on the scape.

Two varieties have been described for this species, although neither of them were recognized by Allen (1961):

(a) var. robusta. Martin described this in 1935 from specimens collected on Mount Schisa. The area of distribution mentioned by him includes Mount Patriarch, Mount 2, St. Arnaud Range, Raglan Mountains, Bounds Range and Ferns. The leaves are described as being sublanesolate, 12 - 20 cm. long and 3.5 - 5 cm. wide, with the ratio of length to breadth being 1/2 to 2/3 that of the
(b) var. *conspicua*. This coastal variety was also described by Martin in 1935. It occurs between the Clarence River and Lake Grassmere and inland to the Ur Board. Martin writes that, "the lowest bracts of the flowering scape are often four inches long and afford the best distinguishing mark between this and the previous variety".

Specimens of these varieties have not been seen by the author and Allan (1961) states that the types are apparently missing.

Other local forms of this species probably occur. Martin (1936) mentions a narrow-leaved race which was earlier referred to by Cockayne (1916) and suggests that it is probably identical to one on Ferny Gair, which may be a "good high-level jordanii".


This may be regarded as a narrow leaved form of *Celmisia novae-zealandiae* (Fig. 71). It is restricted to the ranges between the Wairau and the Awatere Rivers and has its distribution centred about the Avon and Oakea Valleys. Characteristically it is found in soil pockets and gullies on rock faces and bluffs where the soil is deep yet well-drained. West Coast specimens referred to this species belong to Group Ten. Simpson and Thomson's variety *dura* is of doubtful status. The type specimen does not appear to be related to *C. insignis* and the only known locality near the Araki Saddle is well outside the known distribution for the type variety of *C. insignis*. The possession of pubescent achene by the type specimen suggests that var. *dura* may be closer to the West Coast plants previously
**FIGURE 71**

**CELAMISIA INSIGNIS, ORIGINALLY FROM WATROPS VALLEY, MARLBOROUGH**
referred to as \textit{S. insignis}. Further collections in the vicinity of
the type locality will be necessary if the status of \textit{var. aurea} is to
be determined.


Cheeseman's original description of this species was based
on material collected at Mount Rockfort near Westport. Since
then the species has been recorded throughout most of northeast
Nelson. However, in herbaria there are, filed under this name,
several different taxa. Cheeseman admitted plants with leaves from
1\frac{1}{2} - 3 inches long and \frac{1}{2} - \frac{5}{8} inches broad, acute at both ends,
coriaceous, glabrous and furrowed above, and clothed with soft
white tomentum below. Allen (1964) admits plants with considerably
larger leaves and also allows that the upper surface can have a
distinct pellicle when young.

As already discussed, large-leaved specimens are usually
referred to \textit{Colchisia coriacea var. lancifolia}. Extraction of
specimens of this leaves an aggregate of smaller-leaved glabrous-
achene plants. Those with very small membranous leaves
(approximately 2 to 3 cm. long) may belong to \textit{S. parva}. The
remaining specimens probably constitute \textit{S. dubia}. As so formed, the
species is recognized as a small tufted species forming large patches
by branching of a multicipital stock, with the leaves glabrate and
shining on the upper surface, the lamina margins recurved slightly,
the abaxial surface clothed in a felted tomentum, and the foliage
coriaceous and stiffly appressed to the ground. In the Mount
Rockfort area this species is remarkably early flowering
FIGURE 72

DISTRIBUTION OF CELMUSIA COPACABA

var. semicordata

var. stricta

'I bronzed form
Figure 73

Distribution of Celmisia Monroi, C. Dubia, C. Morganii and C. Insignis
(C.A. Brownlie, pers. comm.), the main flowering season sometimes being as early as August or September.


On the basis of floral morphology this species is placed in this group although previously it has always been placed near *C. granitifolia*. It has not been examined in the field during the course of this study and little information is available on its ecology and variation. Allan (1961) mentions that a wide range of dimensions were noted by him when studying populations of the species. The material available in herbaria is insufficient for detailed studies to be made.

7.12 GROUP TWELVE

A large number of species are included in this group. They form a single species complex and are:

- *Celmisia spectabilis* Hook. f.
- *Celmisia retiolata* Hook. f.
- *Celmisia verbascifolia* Hook. f.
- *Celmisia hookeri* Cockayne
- *Celmisia ricida* Cockayne
- *Celmisia meckieri* Kirk
- *Celmisia rutlandii* Kirk
- *Celmisia traversii* Hook. f.
- *Celmisia cordatifolia* Buchanan

*Celmisia brownii* Chossman and *C. praestans* Allan are discussed under *C. verbascifolia*.
Distribution

As with other species complexes, this group covers a large area although in some cases the individual species are not widely distributed. *Galaxia pectabilis* is widely spread occurring throughout many of the alpine grasslands of the North Island (Fig. 76). In the South Island it is abundant throughout the northern part of the island but is absent or extremely rare south of the Waitaki River (Fig. 77). *G. petiolata* and *G. verbascifolia* are complementary in their distribution (Fig. 75). Both are main divide species which are confined to the wetter alpine areas. *Galaxia petiolata* occurs from Lewis Pass south but gives way near the Waitaki Valley to *G. verbascifolia* which is abundant in Fiordland and western Otago. *Galaxia heckerti* and *G. pectabilis* are both local species, the former being confined to northeast Otago and the latter to Stewart Island (Fig. 76). On the other hand *G. traversii* is more widely distributed being common throughout northwest Nelson, the Egland Range, Spencer Mountains and Lewis Pass. It occurs on Shale Peak just south of the Waian Valley and then not again until Fiordland is reached where it occupies a narrow strip of country on the eastern margin of that area. In the Sounds-Nelson area it is replaced by *Galaxia cordatifolia* (Fig. 77). The remaining species are very local in distribution. *Galaxia heckerti* is only known from a few localities on Banks Peninsula and *G. plectandrii* from a few localities within the same area as *G. cordatifolia* (Fig. 76). *Galaxia praestans* is a doubtful species which is included here but which is considered in this treatment to belong to the regional.
hybrid group *Calotis impressa* × *C. verbascifolia*.

**Floral Morphology**

This group is close to the preceding one. It is separated from most other groups dealt with so far by the development of the characters mentioned in the discussion on groups ten and eleven. This and the previous two groups also differ from the following groups in several important respects including the triangular style, different types of corolla hair and the larger number of floral parts. Table 18 outlines the differences in floral morphology between groups ten, eleven and twelve.

The hairs present on the corolla are variable throughout the group. In all the species examined there are bisaccate hairs. Most species also have unisaccate corolla hairs. Within species there is some variation from population to population. In almost every species the saccatae are glabrous, or at the most have only a few weak duplex hairs at the upper end of the saccatae. Western populations of *C. verbascifolia* tend to have a few duplex hairs distributed over the surface of the saccatae, while eastern populations are glabrous (Fig. 74). Only in one species, *C. nutlondii*, is the saccata properly pubescent. It is possible that this may be due to introgression by *C. semaphondii* or that the sample studied was exceptional. In the other species the glabrousity of the saccatae is a reliable character.
ACHENES OF *Celmisia verbascifolia* SHOWING PUBESCENCE IN DIFFERENT POPULATIONS

(a) Green Lake, southeast Fiordland.
(b) Routeburn Valley, northeast Fiordland.
(c) Mount Tennyson, western Otago.
(d) Mount Nalau, central western Fiordland.
(e) Lake Hike, southwest Fiordland.
Vegetative Morphology

The members of this group are vegetatively similar to the members of the previous two groups. Nevertheless, some differences do occur. Except for some forms of *Calamia spectabilis*, all have lanceolate leaves with distinctly peltate leaf bases. The leaf tuft form is more variable and may be either appressed or falcate. In the latter case the uniseriate hairs are crisped. There is also a tendency for the stock to divide and produce clumps consisting of many individual tufts belonging to one plant.

Pigmentation of the leaf sheaths is frequent. The leaf hairs and scape hairs of some species are characteristically buff, and in two species are deep brown in colour.

Notes on the Species


Hooker described this species from material collected in 1839 by Bidwell on Mount Tongariro. It is a common species throughout the alpine parts of both the North Island and the South Island except for Mount Egmont, the west coast of the South Island and Otago. *C. spectabilis* is highly polymorphic and this is discussed separately in Chapter Nine.

Although it is most abundant as a herbfield and tussock grassland species, it is also found in a variety of other habitats. Its selection of certain sites is well demonstrated in the Mount Somers area of Canterbury where it is abundant on north and west slopes but is sometimes almost completely absent from east and south
facing slopes. Wright (1963) comments on its distribution in the
Nairn catchment. Here it is apparent that *G. spectabilis* is most
common in modified communities and that with *Hedeptanthus cadifolia*
it can form an association on deteriorating sites providing erosion
is not too rapid. Elsewhere, the species has also been observed
as an indicator of modification of grassland communities on sites
affected by grazing or burning, although Nurse (1940) concluded
that burning alone does not induce the formation of a *G. spectabilis*
association, but that other factors must also operate.

The work of Nurse is an important contribution to the
understanding of this species. She concluded that it had a wide
ecological range, but that associations containing the species
became preferentially developed on sites not exposed to desiccation.
The same author showed that habit could be described either as "net
growth form" or as "hemispherical cushion growth form". The former
arose from an equal distribution of growth and was found in moister
situations while the latter was considered to be due to localized
growth in the centre and limited growth at the outer edge of the
plant and was found in drier situations. Sampling by the author
has shown similar modifications of the species morphology which can
be correlated with variations in microclimate.

Several varieties have been described. However, these are
discussed in greater detail in Chapter X of this study.

2. *Gelidista petiolata* J.D. Hooker *Handbook B.E.,* 1864, 134

Hooker's description was apparently made from a number of
specimens for the localities quoted in his type description are the
Harumui mountains, Hopkins River, Clyde Glacier, Tangitata River and Mount Brewster. The specimen which was selected as the type by Allen is that collected by Travers from the Harumui. This species is widespread and is one of the few in the genus to have its distribution centred about the Canterbury Alps. Its distribution at the south end of its range must remain uncertain until the limits between it and *C. verbascifolia* are determined. Virtually all the material examined by the author from Fiordland is referable to the latter species and the southermost specimens seen which are definitely *C. peticifolia* are from the Waihau Valley. This supports the view of Peii Neta (1930) who considered that there was a gradation from one species to the other with northern populations belonging to *C. peticifolia* and southern ones belonging to *C. verbascifolia*.

In the north, in the drainage areas of the Waitaki, Lewis and Makarau Valleys, is a variant with slender scapes, membranous leaves and smaller capitula. This has been given varietal rank by Kirk as var. *membranaceae*. Although this form is very distinct, more information on its occurrence and morphology north of Lewis Pass would be desirable. It is likely that the species will be divided into several subspecies in the future and that var. *membranaceae* is one of several local forms.

*C. peticifolia* is an important herbfield species in some areas. It is usually found on rock faces or in short tussock grassland but is able to occupy a wide range of other habitats.

This species appears to be the southern analogue of *C. weinbergii.* Throughout Fiordland it is one of the commonest species found on rocky herbfield. As understood here this species includes most of the plants placed under *C. latissima* and *C. broweri,* and inland specimens from the Garvie Mountains, placed in herbaria as *C. hockeri.* This species is highly polymorphic. There is a gradual transition from east to west with morphological changes along the line of transition. Eastern populations have glabrous achenes and copious hairs on the upper surface of the leaf. Western populations have at least a few hairs on the achenes but have few hairs on the upper leaf-surface except when the leaf is young. It is likely that *C. hockeri* was derived from this species and it is possible that relict populations will be found between the Garvie Mountains and the northeast Otage coast.

*Celmisia brownii,* which was described by Chapman from specimens collected on Mystery Pass near Manapouri, is almost certainly a synonym. The type description fits western plants of *C. verbascifolia.* *Celmisia praestans* which Allen described from specimens collected above the Langburn probably belongs to the very variable set of populations which are suggested as being the result of large-scale hybridization between *Celmisia verbascifolia* and *C. traversii.* Thus *C. praestans* would be a "hybrid species" and part of a regional swarm. Observations by the author in the summer of 1966-67 at Green Lake and Lake Hike support this view. Other possibilities are that a distinct species is represented or even
that a "good" species has been formed through stabilization of part of the hybrid swarm.

*C. verbascifolia* is a prominent species in the herbfield communities of Fiordland and extends into fellfield areas as a frequent species. In some areas near Green Lake it was found by the author to be locally dominant at the margins of stabilized scree slopes.


This species was described by Cockayne in 1915, and though no type was indicated it is probable that his material came from the eastern Horse Range-Shag Point area where it is still comparatively common. The known area of distribution extends from Shag Point and Koeraki inland through Trettars Gorge and along the Horse Range to at least Koeraki.

*C. hockeri* is very uniform throughout its range. It is obviously related to *C. verbascifolia* and differs chiefly in the large size, wider and more petiolate leaves, and the more massive capitulum with a greater number of florets than in most forms of the latter species. It is possible that relict populations may be found along the line connecting the two species. At Mid Dune aberrant specimens similar in some respects to *C. hockeri* occur. These are from the easternmost limits of *C. verbascifolia*.

Hisk and others included *C. hockeri* in *C. verbascifolia* and for some years the eastern Stage plant was known under this name while the Fiordland plants were referred to *C. hockeri.* The known distribution of the species in shrinking appreciably with burning
and grazing. It is virtually extinct at both Sting Point and Moeraki. However, it is still plentiful on sandstone bluffs at Frottores Gorge, under light forest and scrub.


Cockayne raised this to specific status. Previously it had been classified as a variety of *Celmisia patiulata*. Few specimens appear to be in herbaria and consequently not a great deal is known about its range of variation. Allan described it as, "a rather polymorphic group . . . and further study is much needed."

Vegetatively it is distinguished from similar species by its (usually) purple midrib, rigid lanceolate leaves and lustrous abaxial leaf tegument which varies from white to pale buff. It is a coastal species found on the cliffs and sandblow of the western side of Stewart Island.

Probably this species is an endemic which has evolved in isolation from the main-stream of the *Celmisia vestitifolia-patiulata* group.


This is one *Celmisia* species which is probably in danger of extinction. It was described by Racel in 1846 from material collected at Akaroa. Since then its known range has not been extended more than two or three miles from the type locality. The plant is confined to the summit areas of the peaks immediately to the east of Akaroa Harbour between the township and the harbour headland. Of the known occurrences, one at least (at the "Gbastani") no longer
exists. The plant also occurs in several inaccessible gullies facing the open sea between the east head of the harbour and Stony Bay. Dan Rogers Creek has now been made a Flora Reserve so in this locality at least the species should survive. *C. meckowi* has been recorded from Mount Herbert on the south side of Lyttelton Harbour. Although the plant is not known to occur there now the record is not unreasonable and it is possible that it may have occurred on other parts of Banks Peninsula before the destruction of suitable sites. Kirk records it from Kaikoura, but its occurrence there, though possible, is unlikely. It is a plant of rocky, damp sites and appears to yield to grazing and burning.

*C. meckowi* is similar to *C. patiulata* and differs mainly in the glabrous undersurface of the leaf lamina which is submembraneous, in the large size of the capitulum and in some details of the floral morphology. It is interpreted as being a relict species, probably post-glacially isolated from the rest of the group with which it is associated.

7. *Galaxia gutla* Kirk in *P. N. Z. L.* 27, 1895, 329

For many years this species was known only from the type locality on Mount Stokes. However, Martin (1935) has shown that it also occurs on peaks of the Richmond Range on the north side of the Wairau Valley. The species is morphologically linked to the *C. patiulata* group but differs from the rest of the species in the shape and texture of the leaf and in small details of floral morphology. The only material examined had pubescent achene. It is possible that the sample examined was not typical. If all forms
of the species are pubescent then this may indicate development of the species in isolation from the rest of the species in the group, or that it has introgressed extensively with species such as *G. macrodonii* which have pubescent achenes. According to Martin it is a plant of "shaded rocks and rock-chimneys at an elevation of between 4,000 and 5,000 ft". He applied the varietal epithet "umbrosa" to the Richmond Range specimens but later rejected the name without formally publishing it.

8. *Gelasma traversi* J.D. Hooker *Hookbook N.Z. Fl. 1864, 134.*

This species is one of the most attractive members of the genus. Hooker described it from a specimen collected by Travers on the Discovery Peaks in Nelson and commented on it as being a "very remarkable and handsome plant". It has a disjunct distribution, being found in Nelson, Marlborough and North Canterbury, as far south as the Waiau River, and also in Fiordland. In the latter area it appears to be confined to a narrow strip on the eastern margin of the region, running from Key Summit in the north to the Hump in the south.

Throughout most of its range this species is not highly polymorphic. Only in Fiordland are populations morphologically variable. Here, there is considerable variation within quite small populations as well as between populations and it is elsewhere suggested in this study that this is due to introgression by *Gelasma verbascifolia*. Only at the very eastern edge of Fiordland are populations of the pure species found. There appear to be few differences between the northern and the southern sets of
populations. Southern plants often appear to have narrower leaves, but no sampling has been done to confirm this.

_Celmisia traversii_ can be an important component of alpine herbfield. On some parts of Mount Arthur (in northwest Nelson), particularly on south-facing rocky herbfields, it is locally dominant. Further south in north Canterbury it becomes sporadic. In Fiordland it once again becomes locally abundant.


This species was first collected from Mount Starveall (Starvation) in eastern Nelson and is now known from other peaks in the Bryant and Richmond Ranges. The type material has not yet been found and Allan (1964) has suggested that until the type specimen is found, the figure accompanying the description should be treated as the type. It is desirable that an actual specimen be selected since a study of the subspecies will involve comparison of the described varieties with the type. Also, good material from the type locality is necessary for determination of the amount of morphological variation in the type populations. A specimen in the herbarium of the Auckland Institute and Museum is labelled, "All. 9792 _Celmisia cordatifolia_ Mount Starveall, J. McKay", and has an annotation by T.F. Cheeseman reading, "In Buchanan - leaves from the type specimen. If a specimen cannot be found in the Buchanan Herbarium then it is possible that the Auckland specimen may have to be selected as the type for the species. Two varieties have been described for this species. Both were described by Martin in 1935. Variety _similis_ is only known from Mount Richmond.
and is distinguished from the type variety by its more pointed leaves and in having thin silvery tomentum on the lower surface of the leaf instead of thick felted ferruginous hairs. The relationship which exists between this variety and the type is not known. A specimen in the Dominion Museum (WELT 4493) has on the one sheet a "co-type" (lectotype), leaves of all three forms of the species, and a leaf labelled as *G. cordatifolia* var. *similis*. This suggests that two forms occur on Mount Richmond and it is desirable that their relationship be sorted out. Variety *brockettii* is still only known from the type collection from Mount Bounds. Allan records the type of this as having been deposited in the herbarium of Botany Division, R.S.I.E., Lincoln, but lists it as missing. In the Dominion Museum is a specimen labelled by Martin as the co-type (WELT 4496). This is from the type locality as is a further specimen, WELT 4495. The status of var. *brockettii* is uncertain. Although not recorded from Mount Bounds, *G. traversii* is on the mountains to the west. *G. spectabilis* is present on the Bounds Range. Either of these species could have contributed to the variety by hybridisation. Alternatively the variety could be linked solely with *G. traversii*. Specimens collected from: "behind Gordon’s Hut, Leatham River, Wairau, 3,500ft" and in the herbarium of the Forest and Range Experimental Station at Ragiona, are similar to Martin’s material of variety *brockettii* and suggest that more collections and observations are needed.
C. petiolata

C. verbascifolia

DISTRIBUTION OF CELASTRA PETIOLATA AND
C. VERBASCIFOLIA
- C. traversii
- C. cordatifolia
- C. praestans

FIGURE 77

DISTRIBUTION OF CELMIESIA TRAVERSII, C. CORDATIFOLIA
AND C. PRAESTANS

contoured at 4000 ft
7.15 GROUP THIRTEEN

Only two species are included here, one being undescribed.

The species are:

- *Gelasia lariicifolia* Hook.f.
- *G. sp. aff. lariicifolia* Hook.f.

**Distribution**

*Gelasia lariicifolia* is widespread throughout the South Island. At present there appear to be no records of the species from the West Coast of the island but this may be due to a lack of collecting in this area. The species may be absent from the northeast of the island. The undescribed species has until now generally been included in *G. lariicifolia*. It is confined to northwest Nelson where it occurs with *G. lariicifolia* on many of the higher mountains (Fig. 79).

**Floral Morphology**

In their morphology these species are similar to the members of group fourteen. Similarity lies in the very elongated style arm, the long collecting hairs and the distant teeth on the pappus hairs. Both species differ from members of that group in having pubescent achene and glabrous disc floret corollas. These characters ally the group with group three, although they lack uniseriate achenes hairs and have longer style arms than members of the *G. nasiflora* group. Although in some respects this and the following group are similar to the previous three groups (e.g. lack of glandular hairs), they differ appreciably. This is further discussed under the following group.
Vegetative Morphology

These species are similar in both habit and morphology. They are soft-stemmed, creeping subshrubs with short, erect branchlets bearing living leaves along the whole length of the branchlets in one species (*C. laricifolia*) and having the leaves tufted at the tip of the branchlets in the other. The leaves in both cases are short, ovate, and stiff. The gross morphology of both species is intermediate between group three and group fourteen.

Notes on the Species

1. *Celmisia laricifolia* J.R. Hooker ELIZ. 2,1855,331

   The type locality for this species is Gordon's Knob in eastern Nelson. Hooker records that the species is on other Nelson mountains and that it occurs on Mount Torlesse. Since then it has been shown to have a wide distribution throughout the South Island. It occupies many different types of habitat but is particularly common as a fellfield plant. In the Arthur's Pass area it is common in rocky herbfield communities, particularly where snow-bank conditions prevail.

   As Allan (1961) comments, this species is polymorphic. Much of the variation encountered in the field is probably due to environmental differences. Apart from the species discussed below, no regional forms can be distinguished at present.

2. *Celmisia sp. aff. laricifolia*

   It became apparent in examining herbarium specimens of *C. laricifolia* from northwest Nelson that the material available could often be divided into two groups (Fig.79). A careful comparison of
SPECIES REPRESENTATIVE OF GROUP THIRTEEN

(a) *Celmisia laricifolia* from Phipps Peak, Canterbury.

(b) *Celmisia* sp. cf. *laricifolia* from Mount Cobb, Nelson.
<table>
<thead>
<tr>
<th>Colasius loricifolia</th>
<th>G. sp. cf. loricifolia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branchlets long or short with leaves usually distributed along their full length.</td>
<td>Branchlets short with leaves clustered at the tip and forming a rosette appressed to the ground.</td>
</tr>
<tr>
<td>Leaves stiff, green or grey-green, up to 2.5 cm long, mucronate.</td>
<td>Leaves strongly reflexed, brown to silver, usually 1 to 2 cm long, tapering to blunt apex surmounted by a delicate axillary point.</td>
</tr>
<tr>
<td>Scapes green with white scurfy tomentum.</td>
<td>Scapes red, glabrate.</td>
</tr>
</tbody>
</table>
C. laricifolia
C.n.sp.

FIGURE 79
DISTRIBUTION OF GEMISIA LARICIFOLIA AND G. SP. GP, LARICIFOLIA
contoured at 2000 ft
specimens has led the author to believe that two distinct taxa are represented in northwest Nelson collections filed under *C. laricifolia*. Examination of fresh specimens collected at Cerineon by Dr. D. G. Lloyd and study of plants in the field on Mount Cobb suggest that there is in this part of the South Island an undescribed species of *Celmisia* similar to *C. laricifolia*. The two species grow together in many areas and in a number of cases collections of both from the same locality have been mounted on one herbarium sheet. However, intermediate forms are not common and the two types of plant maintain their distinctness when sympatric. Cultivation of the two forms shows that the characters associated with each are maintained. The distribution of the undescribed plants is uncertain but it has not been found outside northwest Nelson. Some of the more obvious distinguishing characters are listed in Table 19.

### 7.14 GROUP FOURTEEN

Like groups four and twelve, this group is made up of a number of species forming a complex. The taxonomy of the group is complex and is discussed more fully in Chapter 11. The following species accepted by Allan (1961) are placed here:

- *Celmisia creertilenta*  
  Hook.f.
- *Celmisia crumeliformis*  
  Hook.f.
- *Celmisia alpina*  
  Kirk
- *Celmisia major*  
  Cheeseman
- *Celmisia adamsii*  
  Kirk

Other described species which are also referable to this group
are *Calamia recta*ce Colenso, *C. perpusilla* Colenso, and

*C. neo-selandica* Gandoger. *C. phelani*, which Allan groups with

*C. xerophilica*, is probably of hybrid origin, and *C. inermis* which
he regards as a "recent segregation from the complex", is placed
in group eleven.

**Distribution**

Members of this complex are widely distributed throughout New
Zealand. *C. xerophila* and *C. grandifolius* are found throughout
both the North and South Islands (Figs. 114 to 118). The only North
Auckland record of *C. grandifolius* known to the author is the type
collection by Rocker, in the Bay of Islands. *Calamia alpina* is
common in alpine bogs from northwest Nelson along the main divide of
the South Island to at least Arthur's Pass. A related taxon of
uncertain status occurs in the Westland "pakihi" lowland bogs. A
further form of this species is found in Fiordland and Stewart Island.
(Fig. 113). *Calamia major* and *C. adenii* are local coastal species
confined to the Auckland area. Populations related to the former
occur on Mount Egmont and in northwest Nelson, and an outlier of
the latter occurs on Mount Manaia near Whangarei (Fig. 116). One or
other of the species is known to occur on Great Barrier Island.

**Floral Morphology**

This group and the last are distinguished from other groups of
*Calamia* (except group thirteen) by the greatly elongated style arms
and the distant teeth on the pappus hairs. The species included here
differ from those of the previous group in being glabrous (or
occasionally slightly pubescent) and in the presence of corolla
hair including both biseriate and uniseriate types. The morphology
of the involucral bracts also differs. It is possible that groups
three, thirteen and fourteen form an evolutionary series.

**Vegetative Morphology**

Species in this group are characterized vegetatively by
several features. They arise either from a short branched woody
stock or from slender rhizomes. In the latter case the plants can
form a tight turf and can compete successfully with other turf
forming species. All members of the group have grass-like leaves
with tomentum on the lower surface and either a glabrous or a
pollicled upper surface. Some species can probably die back in the
winter months. Most populations belonging to the species in this
group are highly polymorphic and there is considerable variation of
both environmental and genetic origin.

**Notes on the Species**

Discussion of the species is postponed until Chapter Eleven
where a detailed account of the group is presented.

7.15 GROUP FIFTEEN

Only one species is placed here. This is:

*Celmisia vernicosa*

**Distribution**

This species is confined to the Subantarctic Islands of New
Zealand (Fig. 81). It is found on the Auckland Islands and on Campbell
Island but is not recorded from either Macquarie Island or the Antipodes. It is the only species of *Seligeria* known from the Subantarctic.

**Floral Morphology**

*S. vernicosae* is distinct from the rest of the genus not only in its distribution but also in its morphology. Several characters found in this species are absent from the rest of the genus, or are differently expressed. These are tabulated in Table 20.

**Vegetative Morphology**

The species forms rosettes which arise from a simple to branched, stout, woody stock (Fig. 30). The plant is able to spread by means of leafy runners which sometimes root at the tips. The leaves are glossy and glabrous with thickened recurved margins. In transverse section there is seen to be no differentiation of the mesophyll into palisade and spongy regions as in most other members of the genus, and little differentiation to give dorsal and ventral leaf surfaces.

**Notes on the Species**

*Seligeria vernicosae* J.B. Hooker Fl. Antarct. 1, 1844, 27.

This unusual species was described by Hooker from material collected during the voyage of Sir James Ross in 1840. Its confinement to the Auckland Islands and Campbell Island makes it one of a group of entirely subantarctic plants. Notes on its occurrence are to be found in several accounts of the Subantarctic Islands although there is no account dealing specifically with the species. Hooker
FIGURE 80

CELMISIA VERNICOSA

(photo:B.A.Fineran)
(1844) writes of the species:

This is a very handsome plant, to which even the beautiful drawing now prepared for publication hardly does justice, one of the specimens gathered on Campbell's Island measuring nearly a span across the leaves, from whose base across no less than thirteen flowering scape, ten of them with the blossoms fully expanded. The delicacy of the rays, tipped with a faint rose-colour, forms a striking contrast with the dark purple-eye and the glossy varnished deep green foliage. Like many other Antarctic plants it varies considerably in size, some of our specimens being scarcely one inch and a half across the leaves . . .

(Good, 1844, 35)

As habitat he gives, "on banks and rocky places near the tops of hills, alt. 1,200 feet, and near the sea on the exposed islets, 
Campbell's Island: abundant in the immediate neighbourhood of the sea". Gooday (1804) lists the species as a member of the 
Euphorbiaceae saxon on the Auckland Islands and as occurring in the hollows between rocks near the summit of Lyall Pyramids on Campbell Island. More recently Godley (1966) lists the species as a component of the higher altitude grassland on the Auckland Islands. It is of interest that the range of habitats of *Caladiea vernicosa* on the Auckland Islands almost exactly corresponds with those of *Euphorbiaceae speciosa*, and that both of these species have the same geographical range.

Two additional species have been described, both of which are similar to *Caladiea vernicosa*. *C. campbellensis* was described by Chapman from specimens collected near Venne Cove. It is mentioned in his account of the Subantarctic Islands (1890) as being locally confined to less than an acre of ground in which area only ten plants were found. Kirk, in the same year, described *C. charmani*. Chapman
<table>
<thead>
<tr>
<th><strong>Celmisia vernicosa</strong></th>
<th><strong>Rest of genus</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Style arc short and broadly triangular with the tip occupying most of the arc.</td>
<td>Style arc long with the tip either triangular or attenuated and occupying less than half the total length of the arc.</td>
</tr>
<tr>
<td>Disc florets purple or occasionally lemon.</td>
<td>Disc florets yellow.</td>
</tr>
<tr>
<td>Stamina tip bluntly obuse and little elongated.</td>
<td>Stamina tip acute to sharply rounded, always elongated.</td>
</tr>
<tr>
<td>Achenes oblong.</td>
<td>Achenes fusiform to cylindrical.</td>
</tr>
<tr>
<td>Pappus 3 mm long and plumose, pappus teeth very long.</td>
<td>Pappus less to 7 mm long, not plumose, teeth short.</td>
</tr>
<tr>
<td>Floret and involucral bract hairs dissimilar to those found in other species of Celmisia.</td>
<td>Hair types relatively uniform throughout.</td>
</tr>
</tbody>
</table>
mentions that "risk subsequently had the good fortune to obtain one in flower" and it seems likely that both descriptions were drawn up from the same population.

Sorensen (1951) reported that a search for the plant in its original locality failed to reveal it, but that W. Brockie found a solitary plant answering the description in a rock crevice on Mount Lyall. He considered it to be a hybrid between *Pleurochrysum membranaceum* and *Geilsia vernicosa* as suggested by H.R.D. Oliver. In view of this it is interesting that Cookayne commented:

On Lyall's Pyramid, at an altitude of about 1520, ... a rich vegetation occurs in the hollows between the rocks where there is plenty of soil and moisture. Here, as described above, is a dense carpet of mosses, etc., through which are growing ... *Geilsia vernicosa, Geilsia chalmersii* ... But the richest rock-vegetation of all is found in those sheltered hollows large enough for peat to have accumulated in abundance. In such spots is a rich vegetation of the large herbaceous plants common to the Southern Islandia ... *Varonica benthamii* and *Geilsia chalmersii* both grow most luxuriantly.  

(Cookayne, 1904, 283-4)

From this it is apparent that *Geilsia campbellensis* (*G. chalmersii*) was not uncommon and that if it is of hybrid origin then it must be a frequent hybrid combination. In this case it would probably be sterile and thereby unable to back-cross. The possibility remains that it is a valid species which has succeeded to the considerable ecological changes which have occurred on Campbell Island.

Allen (1951) described variety *mollicula* from Campbell Island. This is a larger plant with fuller leaves. It was commented on by earlier botanists but was not given varietal or specific status.
Although the disc florets are usually purple, several collectors have recorded variations in colour. Allen (1964) mentions that specimens have been collected from Garnley Harbour bearing disc florets of a lemon colour.
FIGURE 61
DISTRIBUTION OF CALMISIA VERNICOSA
<table>
<thead>
<tr>
<th>Group</th>
<th>Habit</th>
<th>Leaves</th>
<th>Total No. Florets</th>
<th>Involucral Bracts</th>
<th>Achenes</th>
<th>Pappus</th>
<th>Corolla Hairs</th>
<th>Style</th>
<th>Stamens Tip</th>
<th>Floret limb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>erect to sprawling subshrubs</td>
<td>linear or spreading, spatulate, ciliate</td>
<td>30 - 70</td>
<td>recurved or erect, glandular, base widened</td>
<td>pubescent, hairs bifid</td>
<td>Teeth close</td>
<td>Biseriate, widened at tip</td>
<td>Arsenal, tip triangular</td>
<td>Elongate, absciss</td>
<td>Wide</td>
</tr>
<tr>
<td>2</td>
<td>as above</td>
<td>as above</td>
<td>70 - 110</td>
<td>recurved and glandular</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Cushion subshrubs</td>
<td>needlelike</td>
<td>15 - 40</td>
<td>erect</td>
<td>pubescent, hairs bifid</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Latifolius subshrubs</td>
<td>Usually linear or spreading, spatulate</td>
<td>50 - 200</td>
<td>recurved and glandular</td>
<td>pubescent, hairs bifid</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>as above</td>
<td>as above</td>
<td>110 - 150</td>
<td>erect</td>
<td>glabrous</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Stoloniferous subshrubs</td>
<td>as above</td>
<td>130 - 150</td>
<td>recurved and glandular</td>
<td>pubescent, hairs bifid</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Latifolius subshrubs</td>
<td>as above</td>
<td>50 - 300</td>
<td>recurved, glandular and diliparid</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Stoloniferous subshrubs</td>
<td>as above</td>
<td>25 - 30</td>
<td>erect, glandular</td>
<td>pubescent, hairs bifid</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Stoloniferous subshrubs</td>
<td>oblong</td>
<td>60 - 75</td>
<td>erect</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Stoloniferous subshrubs</td>
<td>oblong</td>
<td>250 - 500</td>
<td>erect</td>
<td>as above, slightly glandular</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>as above</td>
<td>as above</td>
<td>50 - 650</td>
<td>erect and wide-based</td>
<td>glabrous</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>as above</td>
<td>as above</td>
<td>80 - 150</td>
<td>erect</td>
<td>as above</td>
<td>as above</td>
<td>as above, with uniseriate hairs</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Latifolius subshrubs</td>
<td>Needlelike</td>
<td>25 - 35</td>
<td>erect</td>
<td>pubescent, hairs bifid</td>
<td>Teeth distant</td>
<td>Glabrous</td>
<td>Arsenal, tip attenuate</td>
<td>Wide</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Stoloniferous subshrubs</td>
<td>oblong or turf</td>
<td>20 - 100</td>
<td>erect</td>
<td>glabrous</td>
<td>as above</td>
<td>as above, with uniseriate hairs</td>
<td>as above</td>
<td>as above</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Stoloniferous subshrubs</td>
<td>oblong</td>
<td>100 - 130</td>
<td>erect</td>
<td>pubescent, hairs bifid</td>
<td>Flabellate</td>
<td>Biseriate and uniseriate hairs</td>
<td>Arm short, tip short, tip-triangular, acut.</td>
<td>As above</td>
<td>As above</td>
</tr>
</tbody>
</table>
CHAPTER EIGHT

THE SUBGENERIC TAXONOMY OF NEW ZEALAND SPECIES OF \textit{CALYDISA}

Neither Cassinia nor de Candolle attempted to subdivide \textit{Calydisa} at the subgeneric level. The first formal subgeneric treatment of \textit{Calydisa} was by Hooker in 1864. He created two subgenera, and placed \textit{Calydisa vernicosa} in subgenus \textit{Japonica} and the remaining known species in subgenus \textit{Rugelisata}.

Kirk and Cheeseman did not make any formal subdivisions of the genus and Cheeseman used Hooker's subgeneric name when referring to \textit{Calydisa vernicosa} in his account of the Subantarctic Islands (Cheeseman, 1919).

Allen, in 1961, formally subdivided the genus into three sections with supporting subsections and series. His classification was based primarily on vegetative characters and habit and his subdivision was explained in the comment that, "vegetatively the New Zealand species fell into three rather well marked groups, but I have not found any correlated flower or fruit characters to justify the erection of subgenera". His classification was commented on in the introduction to this study and will be further discussed in this section.

On several occasions informal groupings of species have been suggested. One by Sir George Fenwick is of interest for the curious relationships suggested rather than its scientific value. (Fenwick, 1920).
8.1 A PROPOSED SUBGENERIC CLASSIFICATION

In the previous chapter, the New Zealand species were clustered into groups on the basis of both morphological and non-morphological data. If these groups are to emerge as part of a formal classification they must be both ranked and named. Only the first of these operations will be carried out in this study.

A comparison of the groups formed shows that equal differences between them do not always exist. It is not advisable to give them equal rank.

Only one group stands out from the others sufficiently to be considered as having generic status. This is the monotypic group consisting of *Celmisia vernicosa*. The unity which binds together the mainland New Zealand species does not extend to this species. Such characters as the obconic achenes, plumose pappus hairs, obtuse clefted tips, corolla hair types and short style arms serve to distinguish the species from all others at present placed in the genus. In addition, the disc floret colour is unknown in other species of *Celmisia* but is shared with *Pleuronychium*.

Although the chromosome number appears to be the same as that recorded for most other species of *Celmisia* the level of ploidy is not necessarily an indication of generic coincidence since the same number has also been recorded for *Pachystegia* and for at least two species of Australian *Olearia*. Rather, the number indicates the probable common origin of many of the Australasian *Asteraceae*. Exclusion of *Celmisia vernicosa* from the genus would limit *Celmisia* to southeastern Australia and mainland New Zealand (including
Stewart Island). The retention of C. vermicosa in the genus could require the status of Pleurophyllum as a separate genus to be questioned, since in some respects its morphology approaches Celmisia vermicosa. In turn this would involve a number of macrophyllous species of Celmisia, some having morphological affinities with Pleurophyllum (Drury, pers. comm.). The inclusion of all these in one "portmanteau" genus would rapidly lead to an awkward and probably unnatural classification in which generic limits would be likely to become rapidly meaningless.

The mainland New Zealand species of Celmisia were earlier divided into fourteen groups. However, these may be aggregated into a smaller number of subgeneric categories. The following remarks refer only to the New Zealand species of Celmisia, Celmisia vermicosa and the Australian species being excluded from the discussion.

At the highest level three major groups emerge. Allen (1961) observed that three major groups could be formed, though the groupings do not exactly correspond. He recognized two woody groups separated on the basis of the distribution of the living leaves on the branchlets, and also a herbaceous group with the leaves arising in tufts and having the leaf sheaths elongated to form a pseudo-stem at the tip of each branchlet. In this study, his herbaceous group is divided into two parts and the woody species are formed into one major species group. This is discussed later in this chapter.

As Table 21 indicates, there are no absolutely clearcut subdivisions of the genus, although there are definite trends present.
It is likely that several evolutionary sequences have occurred in different parts of the genus, involving both advanced and less advanced groups of species.

The first and second groups of Allen make up what might be termed the "woody" species in the genus. Included are groups one, two, four, five, six, and seven in the previous chapter. All possess the following features in common:

Glandular hairs on the involucral bracts
Pubescent achenes (except G. haastii)
Shortly-triangular style branch tips
Widened tips to the corolla hairs, where present
Recurved involucral bracts (except G. haastii and most of group one)
Only biserrate hairs on the corolla

Although Gelsea haastii differs in two of the above features from the other woody species, it is, in other respects, so similar to members of group four that it cannot be excluded from this section.

The third group informally discussed by Allen is more complex since it includes more than one discrete set of groups. The species included by Allen may be subdivided on the basis of stilar and pappus morphology, and by other correlated characters. In groups ten, eleven and twelve the style are tip is similar to that found in the woody species, and is short and triangular. In groups thirteen and fourteen however, the tip is greatly attenuated. The pappus hairs of groups ten, eleven and twelve are closely toothed whereas those of group fourteen are distantly toothed and most of those of group
thirteen are distinctly toothed. In addition, the former groups have
tufts of leaves arising from a woody branched stock whereas those of
the latter arise from either a slender stock or from rhizomes. Both
sets of groups are separated from the woody species of the earlier
groups in not possessing glandular hairs on the involucral bracts
(except for a few stubby ones in group ten), in tending to have glabrous
to glabrate anthers, in not having widened tips to the biserrate
ovule hairs, in the greater diversity of ovule hair types, and in
the involucral bracts being erect.

As mentioned, group thirteen is morphologically allied to group
fourteen. Group three is similar in some respects to both these
groups. The three groups form a series as shown in Table 22. At
present it seems best to accommodate these in one division, since,
though group fourteen is very distinct, it is morphologically close to
both group three and group thirteen. The latter two groups are very
unnaturally placed if classified with the predominantly woody species
in groups one to seven.

This leaves two groups unaccounted for. Both are sufficiently
dissimilar to other groups for each to be classified in a distinct
division. The first consists of *C. glandulosa*. Although this
species possesses glandular hairs and recurved involucral bracts, it
differs from the woody species in the shape of the style arms, the
possession of distinct ovule hair types and in its development of
stolons and rhizomes. The second group, of *C. bellidifolia* and
possibly *C. hemisepala*, differs from all others in the genus in the
growth form (weak decumbent stems rooting at the nodes and forming
<table>
<thead>
<tr>
<th>Characters</th>
<th>Group three</th>
<th>Group thirteen</th>
<th>Group fourteen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit</td>
<td>Woody, cushion-forming.</td>
<td>Woody, tufted or decumbent.</td>
<td>Not woody, tufted or rhizomeous.</td>
</tr>
<tr>
<td>Achenes</td>
<td>Pubescent.</td>
<td>Pubescent.</td>
<td>Glabrous (or rarely with a few weak hairs.)</td>
</tr>
<tr>
<td>Achenal hairs</td>
<td>Bifid with few uniseriate hairs in some forms.</td>
<td>Bifid only.</td>
<td>Bifid (if present).</td>
</tr>
</tbody>
</table>
a serpentine mat), in the form of the corolla hairs, and in the leaf morphology. The style is similar to that found in *G. glandulosa* and tends towards that found in group fourteen. However, it differs from *G. glandulosa* in the complete absence of any glandular hairs. The overall result is that the New Zealand species are placed into five sections within *Celmisia*. One species is removed from the genus and is placed tentatively in a new genus. The groupings are shown in Table 25.

**Within the divisions outlined above, some groups are more closely related than are others. For example, group four is closely linked morphologically to group five and slightly less so to group six. However, groups one and two are not as closely linked to any of these groups. Nevertheless, the insertion of a new level in the hierarchy between the five divisions and the fourteen groups is not attempted since the overall effect would be to complicate the classification without introducing a proportional amount of new information.**

This study has resulted in a three-tiered classification. At the highest level the species have been divided into two genera. At the middle level the members of the major genus are divided into five sections. At the lowest level are the groups which were defined in section seven of this treatment.

The categories used for each of these levels are genus, subgenus and section. The use of the category "section" for the fourteen groups is justified insofar as it will allow the use of the category "series" to include sets of species within the groups.
<table>
<thead>
<tr>
<th>Group</th>
<th>One</th>
<th>Two</th>
<th>Three</th>
<th>Four</th>
<th>Five</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>13</td>
<td>8</td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE XXXI**

**PLACING OF GROUPS WITHIN A TAXONOMIC HIERARCHY**

*NEW ZEALAND SPECIES ONLY*
The use of "subgenus" follows Moore (1966) and Allan (1961), the latter having commented that he did not find flower or fruit characters to "justify the erection of subgenera" when he dealt with Galinsia.

3.2 COMPARISON OF ALLAN'S (1961) TREATMENT AND THAT PROPOSED BY THE AUTHOR

As in Allan's treatment, Galinsia varicosae has been separated from all other species. His Limpae is little changed. Group three is moved to join groups thirteen and fourteen, and six and seven are shifted to the Limpae from Section Galinsia Subsection Stoloniferae and Section Galinsia Subsection Serratae respectively.

In his Section Galinsia, Subsections Stoloniferae and Serratae have been removed to the Limpae. Subsection Canivitosa has been placed in a new subgenus and Subsections Peticolatae and Necotabiles have been combined. Subsection Anustatae Series Lineares is raised to subgeneric rank with the addition of C. adenii and C. major from Subsection Anustatae Series Lanceolatae. Allan's Section Limpae Subsection Fabricatae is transferred to the subgenus containing group fourteen.

The two systems agree in the relative placement of many species. This is significant since they were approached from different angles. Nevertheless, the differences in emphasis are considerable and probably reflect the complex nature of the genus and the extent to which convergence of differently evolved lines has complicated the picture.
TABLE XXIV

COMPARISON OF ALLAN'S 1961 CLASSIFICATION
AND THAT USED IN THIS STUDY

<table>
<thead>
<tr>
<th>section</th>
<th>subsection</th>
<th>series</th>
<th>species</th>
<th>section</th>
<th>subgenus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignosae</td>
<td></td>
<td></td>
<td></td>
<td>A1</td>
<td></td>
</tr>
<tr>
<td>Rosulatae</td>
<td></td>
<td></td>
<td></td>
<td>A2</td>
<td></td>
</tr>
<tr>
<td>Serratae</td>
<td></td>
<td></td>
<td></td>
<td>A3-1</td>
<td>A</td>
</tr>
<tr>
<td>Stoloniferae</td>
<td></td>
<td></td>
<td></td>
<td>A3-ii</td>
<td></td>
</tr>
<tr>
<td>Caespitosae</td>
<td></td>
<td></td>
<td></td>
<td>A5</td>
<td>B</td>
</tr>
<tr>
<td>Pelliculatae</td>
<td></td>
<td></td>
<td></td>
<td>A6</td>
<td>C</td>
</tr>
<tr>
<td>Spectabiles</td>
<td></td>
<td></td>
<td></td>
<td>D1</td>
<td>D</td>
</tr>
<tr>
<td>Petiolatae</td>
<td></td>
<td></td>
<td></td>
<td>D2-1</td>
<td></td>
</tr>
<tr>
<td>Angustatae</td>
<td></td>
<td></td>
<td></td>
<td>D2-ii</td>
<td></td>
</tr>
<tr>
<td>Antarcticae</td>
<td></td>
<td></td>
<td></td>
<td>D2-iii</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E1</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>new genus</td>
<td></td>
</tr>
</tbody>
</table>
Genus *Calmsia* Subgenus *Ionopsis* J.D. Hooker. *Fl. Antarct.* 1, 1854, 34.


**Diagnostic characters.** Herbaceous with simple or branched woody stock; stoloniferous; leaves arranged in flattened rosettes, close-sat. Lamina linear, glabrous, glossy above. Scape monocephal. Involucral bracts erect; venation simple; hairs of three types, fimbriate, biseriate with upperpart uniseriate, and biseriate with terminal cell tapering and thin-walled. Achene obconic, pubescent with duplex hairs only. Pappus unequal, hairs less than thirty, plumose. Corolla hairs biseriate with terminal cells tapering towards tip. Disc corolla purple to lemon. Style arc short, with broad triangular tip occupying all the arc. Stamina tip broad and obtuse.

**Species.** *Calmsia vernicosa* Hook.

Genus *Calmsia* Cassini in Dict. Sci. nat. 37, 1835, 259.


**Diagnostic characters.** Subshrubs or woody-based herbs with branched or simple stock; a few species rhizomaceous or stoloniferous; leaves fimbriate along branches, sometimes in terminal tufts, or forming a rosette and usually pseudo-stem made up of leaf sheaths. Lamina variable, usually linear, spatulate or lancololate, usually with tomentum below and either glabrous or with a pellisile above. Scapes
samosaphalic. Invaginated bracts erect or recurved; venation simple or compound; hairs of several types, glandular and ciliate, biciliate hairs sometimes with upper parts uniseriate, a tapering thin-tailed terminal cell not present.

Schenecylindric or fusiform, glabrous or pubescent with simplex, uniseriate or glandular hairs. Pegs unequal, hairs usually more than thirty, not pubescent. Corolla hairs (if present) either uniseriate or biciliate with elongated widened terminal cells. Disc corolla yellow. Style very long, tip triangular to attenuate and not occupying more than half the length. Stamen tip elongated and sub-acute.

Type. *Selmisia longifolia* Cassini

Subgenus *Selmisia*

This must include the Australian type species. The taxonomy of the Australian species is uncertain at present and must await further field studies and comparison of the various forms included in *S. longifolia* at present. It is likely, though, that only Australian species will be placed in this subgenus when the taxonomy of *S. longifolia* is sorted out.


Diagnostic characters. Erect to procumbent woody subshrub, sometimes mat-forming; living leaves arranged either in rosetate tufts at the tips of branches or distributed along them, often intricately. Lacinia linear to spatulate, short,
usually tomentose below. Scapes usually slender. Involucral bracts usually recurved (erect in a few species); venation simple or compound; fibriate, glandular hairs usually present, eglandular hairs (if present) either uniseriate with one or more basal cells and a parallel-sided terminal cell, or biseriate. Achenes fusiform to cylindric; usually pubescent with eglandular duplex hairs, occasional glandular or eglandular uniseriate hairs present. Pappus hairs toothed with close barbs. Corolla hairs biseriate, widening towards a blunt oblique tip. Style axis long and parallel sided, tip triangular. Stamens tip elongated, acute.

Section nov. = *Galmisia* Section *Ligustae* Subsection *Inbricatae* Series *Echusiae* Allen E.H.L.2.1, 1964, 965

**Diagnostic characters.** Erect or procumbent subshrubs often rooting at the nodes; living leaves distributed along the branchlets. Lamina short and linear with one to three veins parallel to the axis. Involucral bracts erect (occasionally recurved), base slightly widened; glandular hairs short, eglandular hairs with several basal cells. Total number of flowers less than 150. Achenes cylindric fusiform. Corolla hairs (if present) often forming a cluster near the corolla base tips.

Section nov.

**Diagnostic characters.** Procumbent subshrubs; living leaves usually distributed for a short distance along branches. Lamina short and oblong with three veins parallel to axis. Involucral bracts recurved; base narrowed; glandular hairs long, eglandular hairs with one to two basal cells, often paired. Total number of florets less than 150. Achenes fusiform, simplex hairs long.

**Species.** *Gelania brevifolia* Cockayne, *G. angustifolia* Cockayne.


**Diagnostic characters.** Procumbent, sometimes mat-forming subshrubs; often rooting at the nodes; living leaves arranged in rostrate tufts at tip of branches. Lamina spatulate (linear in one species); venation compound. Involucral bracts recurved; base narrowed; glandular hairs long, eglandular hairs with several basal cells. Total number of florets less than 200. Achenes fusiform, simplex hairs short.


**Diagnostic characters.** Leaf lamina spatulate, scape slender, plant not excessively viscid.

Series Viscossae Allan Fl.H.Z.1,1961,967.

Diagnostic characters. Leaf lamina linear, scape stout, plant excessively viscid.

Species. Calamia viscosa Hook.f.

Section nov.

Diagnostic characters. Vegetatively very similar to members of the first series of the previous section. Involucral bracts erect, biserrate eglandular hairs present, glandular hairs absent. Total number of florets less than 150. Achenes fusiform, glabrous.

Species. Calamia beastii Hook.f.

Section nov. = Calamia Section Calamia Subsection Stoloniferae Allan Fl.H.Z.1,1961,966. (in part)

Diagnostic characters. Procumbent subshrubs, stems creeping and rooting at nodes, living leaves in tufts at ends of branches, sheaths sometimes forming a pseudo-stem. Lamina elliptic to linear-oblanceolate, margins serrated to irregularly toothed; venation compound. Involucral bracts recurved; base narrowed; glandular hairs long, eglandular hairs with several basal cells. Total number of florets usually about 150. Achenes fusiform, duplex hairs short.


Section nov. = Calamia Section Calamia Subsection Serratae Allan Fl.H.Z.1,1961,966.

Diagnostic characters. Subshrubs or woody based herbs arising from a simple or branched woody stock; living leaves in tufts
at ends of branchlets, sheaths often forming a pseudo-stem.

Lamina elliptic to lanceolate. Involucral bracts disorphic with outer wide, triangular and spreading, inner narrower and erect or occasionally recurved; glandular hairs present.

Scapes sometimes absent. Total number of florets up to several hundred. Achenes fusiform to cylindrical, with duplex hairs and sometimes short glandular hairs.

**Species.** Calaminia holocarica (Forst.f.) Hook.f., C. dallii Buchen., C. hieracifolia Hook.f., C. cockburniana Petrie.

**Subgenus nov. Calaminia Section Calaminia Subsection Stoloniferae Series Glandulose Allan Fl.N.Z. 1, 1961, 966.**

**Diagnostic characters.** Hairs in rosette tufts. Lamina with glandular hairs only; short and spatulate; coarsely toothed. Scapes slender. Involucral bracts erect, glandular and eglandular hairs present. Achenes with duplex hairs. Pappus hairs conspicuously barbed, teeth close. Corolla hairs biciliate and parallel-sided. Style arms lanceolate, tip elongated.

**Species.** Calaminia glandulosa Hook.f.

**Subgenus nov. Calaminia Section Calaminia Subsection Caespitosa Allan Fl.N.Z. 1, 1961, 966.**

**Diagnostic characters.** Creeping mat-forming herb with branchlets woody at base and rooting at nodes; living leaves distributed along whole length of terminal branchlets; lamina oblong, venation simple, glabrous on both sides. Scapes slender. Involucral bracts oblong, erect, a few eglandular hairs present.
Achenes cylindrical, glabrous. Pappus unequal, hairs conspicuously barbed, teeth close. Corolla hairs biserrate, made up of cuboidal cells, parallel sided. Style are lanceolate, tip elongated.

Species. *Celmisia bellidicidae* Hook. f., possibly *C. thomsonii* Choisy.

Subgenus nov. = *Celmisia* Section *Celmisia* Allan Fl. N.Z. 1, 1961, 966. (in part)

**Diagnostic characters.** Herbs, woody at base with living leaves resolute at the tip of a simple or branched stock; sheaths ascending so as to enclose the shoot in a pseudo-stem. Lamina generally large and linear, oblong or lanceolate; tomentose below in most species; venation parallel. scape generally stout. Involucral bracts erect, venation simple or compound, fibrilicate, glandular hairs uniseriate with either one basal cell and a long twisted terminal cell or with several basal cells and a long thin-walled straight terminal cell, glandular hairs usually absent; achenes fusiform, usually glabrous or glabrate. Pappus toothed, teeth close. Corolla hairs either biserrate and parallel-sided or long-uniseriate. Style are long and parallel-sided, tip triangular. Stamen tip elongated, acute.

Section nov. = *Celmisia* Section *Celmisia* Subsection *Anastatae* Series *lanceolatae* Allan Fl. N.Z. 1, 1961, 966.

**Diagnostic Characters.** Lamina lanceolate or linear, usually with a thick pellicle on the grooved upper surface. Involucral
breasts not widened at the base; venation simple, eglandular
hairs with one basal cell and a long twisted terminal cell,
few short glandular hairs sometimes present. Achenes sparsely
pubescent. Corolla hairs biserrate.

Species: Calmia Lyallii Hook. f., C. petrii Cheesem.,
C. lanceolata Gkn., C. sp. (= C. coriacea var. lancifolia Cheeseman,
in part)
C. pumiliorum Fettie, C. sp.of petrii.

Section nov. = Calmia Section Calmia Subsection Pelliculatae
Allen Fl.R.Z.1, 1964,966.

Diagnostic characters. Lamina lanceolate to oblong, usually
with a thick pellicle on the grooved upper surface. Involucral
bracts widened at the base; venation simple or compound;
glandular hairs absent, eglandular hairs uniseriate and of both
types. Achenes glabrous or with a few weak hairs at top.
Corolla hairs biserrate.

Species: Calmia coriacea Hook. f., C. mirodi Hook. f., C. subia
Cheesem., C. morgandi Cheesem.

Section nov. = Calmia Section Calmia Subsections Peticulatae and
Spectabilis Allen Fl.R.Z.1,1964,966.

Diagnostic characters. Lamina lanceolate to oblong, sometimes
with a pellicle, upper surface smooth or grooved. Involucral
bracts not widened at the base; venation simple; glandular
hairs absent, eglandular hairs uniseriate with one basal cell
and a long twisted terminal cell. Achenes glabrate or with few
weak hairs (pubescent in one species). Corolla hairs both
uniseriate.
Diagnostic characters. Lamina conspicuously petiolate, tenement of lower surface white to pale buff. Involucral bracts with no tuft of pigmented hairs at tip.


Diagnostic characters. Stock usually simple. Lamina conspicuously petiolate, tenement of lower surface pale buff to deep brown with a marginal fringe of deep brown hairs. Involucral bracts with a terminal tuft of brown pigmented hairs.

Species. Celmisia cordatifolia Buchan., C. traversii Hook.f.

Series = Celmisia Section Celmisia Subsection spectabilis Allen Fl.N.Z. 1, 1961, 966

Diagnostic characters. Stock usually well branched. Leaves varying from petiolate to cuneate in different populations, tenement of lower surface white to deep buff in different populations. Involucral bracts with no tuft of pigmented hairs at tip.

Species. Celmisia spectabilis Hook.f.
Subgenus nov. = Calaminia Section Calaminia Subsection Angustatae
Series Linearae and lanceolatae (in part), and
Calaminia Section Lycopsis Subsection Inbricateae

Diagnostic characters. Raisinaceous herbs or woody to semi-woody procumbent or mat-forming sub-shrubs; living leaves in woody and semi-woody forms distributed along the length of the branchlets, that of herbaceous forms in a terminal tuft.
Leaves narrow-linear to oblong in herbaceous forms, needle-like in woody forms; usually tomentose below; venation simple with usually one medial vein. Scape slender, much reduced in mat-forming species. involucral bracts erect; venation simple; fimbriate and eglandular hairs present, the latter consisting of either a single basal cell and a long twisted terminal cell or of several subcylindrical cells; tip often pigmented, glandular hairs absent. Achenes fusiform, pubescent or glabrous, hairs (if present) duplex with few uniciliate hairs at top of achenes in some species. Pappus toothed with moderately close or distant teeth. Corolla hairs either biseriate and parallel-sided or long-uniseriate. Style axis long and parallel-sided, tip elongated sometimes greatly attenuated. Stamina tip elongated and acute.

Section nov. = Calaminia Section Lycopsis Subsection Inbricateae
Series Home Allan E.L. & E. 1, 1961, 966. (in part)

Diagnostic characters. Mat or cushion-forming woody or semi-woody subshrubs usually forming a tight compact carpet or cushion. Scape extremely reduced. Involved bracts with a single basal cell and a long twisted terminal cell. Achenes pubescent with
uniseriate hairs sometimes present at the tip of the achenes.

Pappus hair teeth close. Corolla hairs uniseriate and parallel-sided. Style are tip elongated.

**Species.** Calmias *scopilifera* Hock.f., *C. erymenta* Kirk, *C. elevata* Simpson and Thomsen.

**Section now.** = Calmias Section Lignosae Subsection Lignosae Series Lignosae Allen Fl.M.Z.I., 1961, 966. (in part)

**Diagnostic characters.** Semi-woody procumbent sub-shrub, sometimes with the branches buried and the leaves in terminal tufts, usually with branchlet tips erect and living leaves distributed along whole length of branchlets. Scape slender.

Involucral bract hairs with single basal cell and a long twisted terminal cell. Achenes pubescent with duplex hairs only.

Pappus hair teeth distant. Corolla glabrous. Style are tip attenuate.

**Species.** Calmias *larticifolia* Hock.f., *C. sp. cf. larticifolia* Hock.f.

**Section now.** = Calmias Section Calmias Subsection Augustatae Series Lignosae Allen Fl.M.Z.I., 1961, 966.

**Diagnostic characters.** Rhizomaceous herbs, sometimes turf-forming, sometimes arising from a closely branched stock. Scape slender. Involucral bracts with both hair types. Achenes glabrous. Pappus hair teeth distant. Corolla hairs of both types. Style are tip attenuate.

CHAPTER NINE

HYBRIDISM

As in many New Zealand genera there is considerable hybridism occurring in this genus. There is at present no evidence for hybridism amongst the Australian species, although further field studies may show that it does occur.

9.1 EVIDENCE FOR HYBRIDISM

When discussing hybridism in a genus such as Calothamnus, several difficulties immediately become apparent. Firstly, many cases of hybridism probably go undetected because either the progeny are similar to one or other of the parent species, or because the hybrids cannot be recognized as such. The taxonomist must have some idea of what he expects a particular hybrid to look like before he can detect it in its natural environment. Secondly, it is probable that many hybrids never produce progeny since indirect evidence suggests that most Calothamnus hybrids are at least partially sterile. Thirdly, accurate artificial crossing of various species presents almost insurmountable problems since there may be up to 450 hermaphrodite and 120 female florets on each head. In addition seed-set is variable and in some species there is a great susceptibility to insect damage of seeds. A fourth point in the case of Calothamnus is that all the species examined so far have chromosome complements at meiosis of 54 or more, and it is difficult to detect small aberrations in nuclear division. In addition to being present in large numbers, the chromosomes are small and often not easily stained (Hair, pers. comm.).
As discussed earlier, though at first it appears that there is ample opportunity for hybridisation to take place, there is actually a low level of allopatry between closely related species. Although hybrids or suspected hybrids appear to be frequent, when it is considered that up to fifteen species may be growing in one area, it becomes apparent that the actual frequency of hybrids is quite low. Probably a number of mechanisms play a part in preventing hybridisation, some like flowering time being readily detectable in the field while others such as aberrant embryo development are only to be discovered through anatomical study.

Evidence for hybridisation has, of necessity been indirect, insofar as hybrids have not been synthesised during the course of this study. Also, as mentioned above, it has not been generally possible to use cytological data. Irregularity in meiosis has been observed in several cases however, and in at least one case has been linked with probable hybridism. This involved a specimen of *C. glandulosa* from the Bealey Valley. Since being examined cytologically, the plant has shown the development of characters intermediate between *C. glandulosa* and *C. peticolata*, and field evidence suggests that this is the probable origin of the plant.

In a few instances, hybridism has been known for many years and is well enough documented to be accepted with little question. This is particularly the case with hybrids which have been initially described as species and later rejected. Examples are *Caloecia pseudo-Ivallii* (*C. spectabilis* × *Ivallii*) and *Ivallia* (*C. spectabilis* × *peticolata*).
Before accepting a hybrid origin for plants encountered in the field when field evidence alone is used, it is necessary to satisfy several requirements. It is necessary to determine whether or not the plant in question belongs to an already recognized taxon or may even be a new species or subspecies. It is obvious that in the past the temptation to label variants as hybrids has been yielded to with unfortunate results in some instances. Generally, however, Calaminia hybrids occur as small numbers of individual plants, sharply differentiated from the surrounding species. Also, if the plant can be recognized as having characters intermediate between those of already recognized species hybridism may be suspected if plants with intermediate characters are always found growing with the suggested parent species. In addition, a small range of variation may be indicative of a hybrid origin if the plants concerned are partially sterile, although this may also apply to apomictic or partially apomictic populations.

More difficult situations occur where the suspected hybrids, although not necessarily fully fertile, are sufficiently so to form swarms by back-crossing with the parent species. In such cases, regional mapping of the plants is valuable, and by using scatter diagrams it is usually possible to trace the parentage of hybrid material. Sometimes extreme variation in the field together with climal variation leading in each direction towards particularly well-established species may be useful in indicating hybridism.

In all types of hybridism encountered in the genus, "marker
characters" have been valuable. These are characters diagnostic for particular species and which persist in hybrid progeny. Thus the presence of ferruginous hairs on the undersurface of the leaf is usually indicative of hybridism involving Galenia traversii, and the linear stiff leaves of Galenia squilliflora persist in hybrids with other species to give rise to many of the plants classified as G. guamae and G. lineata. Field evidence has usually confirmed deductions made on the basis of "marker characters".

9.2 RECORDED HYBRIDS

The following hybrids are accepted as being well authenticated. In no cases have they been produced artificially (at least during the course of the present study) but in most cases the suggested parentage is based on reliable field evidence. In few cases is genetic evidence available to suggest hybridism.

The earliest studies of hybridism in the genus appear to be those of Cockayne. Since then many reports have been made of hybrids, some well documented and others less so. An unfortunately large number are supported by only the slightest field evidence. These cases have been omitted from the list. A full list is provided by Allen (1964) where the evidence for nine hybrids is summarized and a list of 49 further hybrid combinations is set out, with the proviso that they, "have been recorded or suggested, some with good to fair field evidence, some supported by herbarium specimens, others more speculative". The list below differs from Allen's mainly in its conservative nature although some combinations not recorded by Allen
are shown.


This is known now to be *C. spectabilis* x *C. lvallii* (Fig. 82). It is not uncommon throughout the Canterbury foothills wherever the parent species meet (Fig. 85). Field evidence suggests that the progeny are at least partially fertile. Scatter diagrams of a sample from the parents and from hybrid progeny taken from Cairn Hill on the Harper Range show that there is a transition in leaf dimensions from one species to the other as hybrid material is considered. However, the sample showed that leaf sheath pigmentation was additive in the hybrids, the degree of pigmentation being in the ratio of 0.34: 1.75: 1.66 for *C. lvallii*, *C. spectabilis* and the hybrids, respectively.

Genetic evidence supports the view that the hybrid is fertile since meiosis appears to be perfectly regular (Hail, per. comm.). Similarly, pollen fertility is reasonably high although the quantity of pollen produced may be low. Also achenes collected from *C. pseudo-lvallii* on the Big Hill Range were seen at the Canterbury University Botanic Gardens and produced seedlings. However, damping off occurred at the cotyledon stage and so it was not possible to rear *F*₂ progeny.

In at least one instance there seems to be clear evidence of introgression having occurred. At Haite Brun Hut specimens of *C. spectabilis* collected by Miss B. Macmillan and Mrs M. Bulfin both of
FIGURE 82

*Celmisia spectabilis x Lyallii* (C. pseudo-Lyallii)

Plants shown include F₁ progeny, back-crosses with *C. spectabilis* and *C. spectabilis* from Big Hill Range, South Ashburton Valley.
Botany Division, Lincoln, can be matched with hybrid material from
the Harper Range. The specimens are nearer *C. spectabilis* than
*C. lyallii* but show quite clearly some of the characters of the latter.
According to Miss MacMillan there are only a few scattered plants
present though *C. lyallii* is quite common, and in this case it seems
likely that the preponderance of *C. lyallii* has resulted in the intro-
gression of *C. spectabilis.*

**Representative Specimens.**

CHR 10262 Grari George Laing: CHR 102911
Mount Wall, V. Cott; CANU 10160-10162 Mount Potts, J. E. Ward;
CANU 6995 Fog Peak.

   *C. spectabilis* var. mollis (Cook.) Cheeseman Rep. N.Z. Fl. 1925, 946.
Cookyan observed that "it is very probably a hybrid between
*C. petiolata* and *C. spectabilis." Allen (1961) supports this view
without qualification. Field observations suggest that a hybrid
origin is very likely for plants which approach Cookyan's description
of *G. mollis.* Plants seen by the author at the head of the Bealey
River and in the east branch of the Hanlin are intermediate between
the two species mentioned and are only found in association with
them. —Probably the hybrid is quite widely distributed in areas where
the species are sympatric. No data is available on either fertility
or cytology but the absence of any swarming suggests that the hybrids
are either sterile or have a low level of fertility (Fig. 86).

**Representative Specimen.**

CHR 10230 Hillis Peak, Cookyan, 12. 1. 26;

Considered by Cockayne to be a hybrid between Celmisia spectabilis and C. traversii, this hybrid was first described from specimens collected near Hanmer. It has since been found in a number of areas where both the above species occur. Allen (1961) remarks, "specimens I have seen in the field match Cockayne's description very well and appear to be sterile". On Mt. Cobb a range of intermediates between the species suggests that the $F_1$ hybrids are at least partly fertile (Fig. 83).


Allen (1961) comments that "field evidence leaves little doubt that the specimens placed under this name are of origin C. coryana × spectabilis and are probably sterile". The hybrid origin suggested has been generally accepted. Herbarium material suggests such an origin though there is little information available on the situation in the field.

**Representative Specimen.** CMB 107431 Scaly Range, R. Hacon, 9.1.53.
5. *Gelmania spectabilis × gracilentis*

Evidence for this hybrid is derived entirely from the field. Occasionally in communities containing plants of both *Gelmania spectabilis* and *G. gracilentis*, narrow-leaved *G. spectabilis*-like plants are encountered. These are morphologically intermediate between the two species. Dr J.B. Heir has found *Gelmania* to be perfectly normal in a plant from Makahu Saddle in the Kaweka Range, though there exists no evidence in the field for any swarming.

**Representative Specimens.** CSR 65259 Central Ruahine, *Drace*, 1946; CSR 116429 Desert Road, *Drace*, 1946; CSR 116428 Ruahine Range, *Drace*, 1947; CSR 4342 Hanera, *Christensen*.

6. *Gelmania spectabilis × craminifolia*

One specimen collected in the northern Tararua Ranges has been given this suggested origin. Although no field data is available, herbarium evidence suggests that the origin may be correct.

**Representative Specimen.** CSR 131665 Northern Tararua, *Drace*, 1962.

7. *Gelmania spectabilis × impax*

Documented by one specimen collected in the Ruahine Ranges by A.P. *Drace*.—The species concerned were sympatric and the suggested origin for the plant appears quite possible.

**Representative Specimen.** CSR 86913 Ruahine Range, *Drace*, 1959.

8. *Gelmania spectabilis × angustifolia*

Two plants were collected by the author on the Big Hill Range in the upper South Ashburton Valley early in 1966. The plants were intermediate between *Gelmania spectabilis* and *G. angustifolia*, and both
species were very common in the immediate vicinity. A plant grown at Botany Division, Lincoln, did not survive.

Representative Specimens. CHR 17514, 175109 Big Hill Range, D. Givens, Feb. 1966;


Plants collected on Mt. Hiraibiro were suggested to be of origin *Celmisia norrissonii* × *C. traversii*. Allan in 1954 commented that in the field the plants fell into three distinct groups. The first had broad lanceolate leaves of nearly norrissonii shape, a white pellicle above, white tomentum on the midrib, and floccose scapes. The second group had leaves of a traversii-shape, lanigerose margins, pilose midribs below, and darker tomentum. The third group had leaves slightly broader than those on *C. norrissonii*, a white midrib, and soft white tomentum which was not at all buff. This suggests that there might be some fertility at the F₁ level but a cytological check has not been made, nor has it been possible to determine the degree of fertility of the achenes.

10. *Celmisia norrissonii × lylaitii*

This hybrid has been reported from the Mt. Cook area. No field data is recorded but the cross is not unlikely in view of the probable close relationship between the species (Fig. 85). The cross was not observed at Green Lake in January, 1967 by the author, though both species were present.

Representative Specimens. CHR 6303 Sebastopol; CHR 6797 Hooper Valley, Cockayne, 1919;
11. *Calymenia coriacea × pseuduncii*

Specimens collected by Leing from Arthur's Pass have been given this origin. Once again field data is lacking but the cross is a possible one.

**Representative Specimen.** CMR 6280-85, Twin Creek, **Leing**, Jan 1927;

12. *Calymenia coriacea × petiolata*

This origin is suggested by specimens from the Hooker Valley collected by C.J. Burrows. Once again the field situation is not known.

**Representative Specimen.** CAM Hooker River, **C.J. Burrows**, Dec 1955;
CAM 4822 Hooker River, **C.J. Burrows**, Jan 1955;

13. *Calymenia coriacea × petriol*

This origin is suggested for plants collected by the author at Green Lake above Lake Herewai in January, 1967. Infrequent plants with characters intermediate between those of the suggested parents were found in a tussock community containing several species of *Calymenia*. At one site measurements were made of the distances between the suspected hybrid and the nearest plant of each of the major species of *Calymenia* present. This was done for each of four quadrats. The results are set out below, with measurements in feet:

<table>
<thead>
<tr>
<th>Species</th>
<th>10</th>
<th>-</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. coriacea</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. petriol</em></td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td><em>C. verbascifolia</em></td>
<td>1.5</td>
<td>7</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td><em>C. lanceolata</em></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.5</td>
</tr>
</tbody>
</table>
From these figures it becomes obvious that there is a very great chance of crossing occurring and it is not surprising that what appear to be F₁ hybrids are not infrequent.

14. **Colmidea lyallii × petrii**

These two species do not meet frequently and where they do is usually in the marginal areas between dry and wet zones. Usually, however, where the species are sympatric, field evidence indicates that hybrids are not infrequent, even though the species are separated to some extent by ecological preferences. At Green Lake, Fiordland, the species appear to have hybridised wherever they are adjacent (Fig. 35).

**Representative Specimens.** CIR 6307 Batemans, Dec 1927; CIR 10241 Bold Peak, Simonen and Thomson.

15. **Colmidea lyallii × armstrongii**

Specimens collected by O.J. Burrows on the Foulter Range were tentatively identified as being of hybrid origin between these two species. However, the occurrence of *S. armstrongii* on this relatively dry range has not yet been confirmed.

**Representative Specimen.** OAW 6126 Foulter Range, O.J. Burrows, Dec 1962.

16. **Colmidea lanceolata × petrii**

This is suggested as the origin of isolated plants found by the author in the tall tussock communities on the north side of Green Lake, Fiordland. A quadrant analysis gave the following. Measurements are in feet.
17. *Galaxia traversii* × *verbascifolia*

The former occurs in eastern Fiordland occupying a strip down through the western side of Lakes Te Anau and Manapouri from Key Summit in the north to the Kum in the south (Fig. 36). On mountains such as Mt. Luxmore specimens indistinguishable from *G. traversii*, as it is found in the north of the South Island, are common. However, as one moves further west one finds that the plants become more *verbascifolia*-like until by the time the western Fiords are reached the plants look quite like pure *Galaxia verbascifolia*. One of the most obvious features of *G. traversii* is the deep buff tomentum of the tomentum on the leaf with a conspicuous border of brown hairs on the margin. In areas such as Takaha Valley and Green Lake it is possible to get a whole range of forms with plants with pale tomentum growing alongside ones with heavily pigmented tomentum, while a foot or so away there may be intermediate forms (Fig. 35). Allan’s *G. gracilenta* may be one part of this general trend from one species to the other. It is suggested here that *G. traversii* is in the process of introgressing into *G. verbascifolia* and that there is at present a virtual dilution of the characters associated with *G. traversii* as one
FIGURE 83

GELIDIA TRAVERSII X VERBASCIFOLIA

Part of probable hybrid swarm from Takahe Valley showing range in tomentum colour.
move from east to west in Floridani. A suite of specimens are being grown at R.S.L.R. Lincoln to study the situation in more detail.

18. Calamia traversii x peticolata

In the Lewis Pass area occasional plants intermediate between these two species are found. Since both species mentioned above occur in this area they may provide the parentage for these occasional specimens.

19. Calamia verbascifolia x holosericea

This origin was suggested by C.J. Burrows for specimens collected on Peak G near Kuwai Saddle in 1963. The herbarium material seen suggests this origin, the specimens having the general leaf shape of C. holosericea but also having the leaf texture and tomentum of C. verbascifolia. Specimens from near Homer Tunnel also suggest this origin for similar specimens.


Calamia coriaceae var. lanierea (Petrie) Cheeseman Man, N.Z. Fl. 1925, 195.

Although this is dealt with here it would probably be best dealt with separately since the name appears to possibly involve more than one entity. Cockayne and Allan (1932) referred to the name as belonging to forms of Calamia peticolata x spectabilis while in Allan (1961) the origin C. coriacea x peticolata is suggested for specimens collected by Petrie in the Takitimu Mts. While the first of these
suggestions is undoubtedly wrong since C. specabilis does not appear to come south of the Waitaki Valley, if C. verbascifolia is substituted for C. petiolata then it is possible that some forms may be referable to the origin suggested by Allen. Specimens which seem to answer to Petrie's description have been collected by the author on Mt. Tennyson in the Garvie Mts., and in the Mountburn. Rather than being hybrids it appears that such specimens are an eastern form of C. verbascifolia and are chiefly distinguished from western forms by having glabrous achenes (western forms are glabrate), tomentum on the upper surface of the leaf, and by having more silky tomentum on the underside of the leaf. On Mt. Tennyson, which is near the type locality, the specimens seen did not show any real evidence of being of hybrid origin but rather appeared to form quite a natural population.

Representative Specimens. GANU 10183 Harris Saddle, E. Given, Nov 1966; CHR 9875 Ocean Peak, V. Zottin, 4-1-35; CHR 76603 Poole; CHR 108934 Fiord trip A. Poole.


Armstrong described this species from Canterbury, but apparently his specimens have been mislaid. As Allen (1961) comments "in herbaria, under this name, is included a somewhat diverse assemblage of forms". Cheeseman comments that Stewart Island forms differ from mainland ones in having longer and narrower leaves with more revolute margins, thinner tomentum and longer scapes. Since this form is probably worthy of specific rank, subsequent remarks will refer to the mainland forms included under this name. There is
generally good evidence in the field to show that *Celmisia sessiliflora* is involved in the origin of plants included in *C. linearis*. The following are forms referable to the species, in which the probable parentage is known. (Fig. 84).

21. *Celmisia sessiliflora × viscosa*

The author and H. Connor collected from the Big Hill Range in the upper South Ashburton Valley, specimens of a low-growing *Celmisia* forming small patches about a foot across. The vegetative parts matched Armstrong's description closely. In the immediate vicinity of the plants the only species found were *Celmisia viscosa* and *C. sessiliflora*. Only three plants of the suspected hybrid were seen and in each case the two species were growing so close together that they almost touched both each other and the suggested hybrids. A plant taken at the time is being grown at Botany Division, Lincoln. **Representative Specimens.** CBR 175108 Big Hill Range, D. Given and H. Connor, Feb. 1966.

22. *Celmisia argentea × greasila*

Specimens of *C. linearis*-form from Mount Haungatum in Otago are almost certainly of the origin given. The only other species seen near the summit of the mountain is *C. coriacea* which is absent from the past bogs where the suggested hybrid is found. Both suggested parents are found growing close together. **Representative Specimens.** CBRU 4435, 4436 Haungatum, D. Petrie, Dec 1876; CBR 112527 Mount Haungatum, G. Simpson.
CELMISTA HYBRIDS OF C. LINEARIS TYPE

(a) **Celmisia sessiliflora** x unknown from Hunters Hills. Vegetatively similar to type of **C. spadenii**;

(b) **Celmisia sessiliflora** x **C. gracilenta** with putative parents on left. Photographed near Harris Saddle.
25. *Calocephalum sessiliflorum* × *acricentra*

This is the origin suggested for plants from the Runners Hills in South Canterbury, and grown at the University of Canterbury Botanic Garden (Fig. 84 a). The role of *C. acricentra* has not yet been proved in the field in this case, though in the case of similar plants from Malte Brun, the role of both species is very likely. Plants from near Harris Saddle are undoubtedly of this origin.

**Representative Specimen.** CER 176447 Malte Brun, Macmillan and H. Simpson, 1.5.67


Cheesman described this species from material collected in several different parts of the Southern Alps. Allan suggested that the plants were hybrids of the origin *C. acricentra* × *sessiliflorum* or *C. insignis* × *sessiliflorum*. The former is unlikely since *C. insignis* has an extremely limited range. The former is more possible but does not account for the buff tomentum which usually characterizes plants placed here. Much of the material placed here appears to be of the origin *C. traversii* × *sessiliflorum*.

**Representative Specimens.** CER 130661 Mount Arthur, Gibbs, July 1910; CER 130665 Mount Technical, Gibbs.

25. *Calocephalum sessiliflorum* × *spectabilis*

Some hybrids of the *C. compacta* type are probably of this origin, on the basis of field data.

**Representative Specimens.** CER 144796 Lewis Pass, Given, 28.12.62; CER 75674 Gordon Pyramids, Hay, 13.4.52.

This was compared with *C. haastii* by Petrie, but Cheeseman considered that there was no close relationship with that species. Cockayne and Allan suggested the origin *C. haastii × hectori*. Though some plants appear to almost certainly be of this origin, further data is needed before the status and possible hybrid nature of plants answering the description can be determined.

27. *Colmaea amstroncii x aesciliflora*

Specimens collected from Mt. Trovatore by C.J. Burrows were tentatively determined by their collector as such. The leaves definitely suggest *C. amstroncii* and are long and narrow with a pellicle. However, no field evidence is available to determine accurately the parentage of the specimen.

**Representative Specimen.** G2N1 Mt. Trovatore, C.J. Burrows, Feb 1963.


The authors described this variety as being similar to the type "in shape and habit but the upper surface white with a thin papery tomentum". Allan mentions the type as having the "lamina up to 3 x 1 cm., minutely but distinctly apiculate; tomentum of upper surface of very dense short soft hairs separating as a pellicle". Very similar material was collected in January, 1967 by the author and D.C. Lloyd on the north end of the Pisa Range at an altitude of 5,500 ft. The general habitat was similar to that mentioned by Simpson and Thomson, and a comparison of the specimens collected on the Pisa Range
with the type sheet showed that it could probably be referred to
Simpson and Thomson's variety. Only two isolated plants were seen
and they were both growing very close to both C. haastii and C. viscosa.
It is possible that the variety may be a distinct form but at present
field evidence suggests a hybrid origin between the two species
mentioned, both of which in combination could give the characters of
C. haastii var. tomentosa. Growing material is located at Botany
Division, Lincoln.

**Representative Specimen.** CHR 50941 Rock and Fillar Range, G. Simpson.

29. **Calanthe densiflora × proemene**

Although these two species occupy distinct adjacent ranges of
distribution, at several points they overlap slightly. At the western
limit both species are found on the Hector Range, above the south end
of Lake Wakatipu and at the heads of the Devlin and Ngakonai Valleys.
Here plants answering to the description of both species sensu stricto
can be found together with numerous intermediate forms. These forms
are best recognized by the very thin tomentum on the underside of the
leaf and the variation in leaf toothing which occurs. Plants of
intermediate forms as well as the species themselves were taken from
this area by the author early in 1966 and are now growing at Botany
Division, Lincoln. The suggested hybrid origin is supported by
cytological evidence, Dr J.D. Hair reporting that meiosis is irregular
in the intermediate form.

**Representative Specimen.** CHR 175185 Mount Tenyson, D. Given.

30. *Celmisia glansulosa* x *patiulata*

This hybrid was not suspected until a plant which was
supposedly *C. glansulosa* was examined by Dr J.B. Reid and found to have
a very irregular meiosis. On re-examining the plant, which is
growing at Botany Division, Lincoln, it was found that it did not
entirely match other specimens of *C. glansulosa*. Since that time
the plant has diverged further and characters such as pigmentation
of the sheath, and a much larger size have appeared. Field evidence
suggests the possibility that the plant may be of hybrid origin, the
parent species being *Celmisia patiulata* and *C. glansulosa*. The plant
was collected near the Bensey Glacier at Arthur's Pass.

31. *Celmisia glansulosa* var. *latifolia* x *major*

A specimen collected from Mt. Egmont has been ascribed to this
origin. A suite of specimens plus the suspected parents were collected
by A.P. Bruce in 1963, and on the evidence provided by these specimens
the suggested origin appears most plausible, the suggested hybrids
being intermediate between the two parents.

**Representative Specimen:** CHR 131492 Mt. Egmont 3,600Ft., A.P. Bruce,
Dec 1963.

32. *Celmisia bicrenifolia* x *allanti*

Specimens from north-west Nelson suggest this origin. The
evidence has only been examined in the herbarium, two sheets being
lodged with Botany Division, Lincoln. The labels on the sheets read,
"Specimens of 1 and 2 (suspected parents) numerous, specimens of
3 (suspected hybrid) few; all growing in joint crevices of the bare
granite. No other Celmisia present."

Representative Specimen. CHR 108388-89 Head of Slate River, J.A. Hay, 6.6.51.

33. Celmisia allanii x lateralis

A sheet at CHR contains putative parents plus the suggested hybrid. The specimens collected on the Travers Range in Nelson were found in the second basin on Mt. Robert, just within bushline and the label on the sheet records, "C.allanii, C.lateralis, and putative hybrid within 4 square yards". Field evidence strongly supports this origin for the plants in question.

Representative Specimen. CHR 129060 Travers Range, A.P. Druce, 24.4.62.

As well as the above cases of reasonably well documented hybridism in the genus, other hybrids have been suggested to account for intermediate-type specimens. Examples are Allen's suggestion that hybrids occur where Celmisia petiolata and verbascifolia meet, intermediate populations between C.brevifolia and C.squarifolia in the Mt. Cook area, and Martin's suggestion that on the Red Hills (Nelson), three subspecies of C.spectabilis meet and hybridize.
### Table XXV

**Records of Redetermination in Ciliata**

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**This table records the number of well substantiated or probable hybrids within and between the groups of species.**
- C. lyallii x spectabilis
- C. lyallii x coriacea
- C. lyallii x petriei

FIGURE 85

DISTRIBUTION OF CELMESTA HYBRIDS AND PARENTS
- C. spectabilis x traversii
- C. spectabilis x petiolata
- C. traversii x petiolata or verbascifolia

C. petiolata-verbascifolia

C. traversii

C. spectabilis

C. traversii

FIGURE 86

DISTRIBUTION OF CEMISTA HYBRIDS AND PARENTS
FIGURE 67

HYBRID COMBINATIONS BETWEEN GROUPS OF SPECIES

Numbers are those of the groups established in chapter seven. Diameters of circles are in proportion to the number of hybrid combinations recorded. Only combinations for which there is adequate evidence are included.