Taxonomic Revision of *Pericalymma ellipticum*

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TAXONOMIC REVISION OF PERICALYMMA ELLIPTICUM

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ABSTRACT

A revision of the genus *Pericalymma* is presented. The history of *Pericalymma* (Endl.) Endl. is summarised. The morphology and stem anatomy is reviewed and several illustrations provided. Discussions covering the classification, nomenclature, statistical (ANOVA) analysis and taxonomy are provided. Tables and figures are provided as part of the discussions, summarising the results. Four species and 2 varieties are recognised, including the following new species: *P. spongiocaule* Cranfield and *P. megaphyllum* Cranfield. The new combination, *P. ellipticum* var. *floridum*, is made. Distribution maps are provided for all species and infraspecific taxa.

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CHAPTER 1.

TAXONOMY OF Pericalymma ellipticum (Myrtaceae)

1.1 INTRODUCTION

Plant taxonomic research involves extensive reviewing of literature which in some cases, such as a taxon described before the establishment of state herbaria, requires knowledge of early botanical publications. In order to correctly apply a name to a particular taxon a researcher needs to be aware of all applications of names in the taxon being studied, as well as knowledge of the Type specimens on which a name is always based. A taxonomist is concerned with nomenclature but also with circumscribing a taxon and correctly applying that nomenclature according to established protocols.

A paper by Thompson, "Redefinition and nomenclatural changes of *Pericalymma ellipticum* " (Thompson, 1983), a species endemic to the south west of Western Australia was the basis of my project. Additional literature sources, notably published research on its anatomy and genetics, were used to support my own studies concerning the possible recognition and reinstatement or changed rank of species placed in synonymy by Thompson (1983).

1.2 THE MYRTACEAE AND SYSTEMS OF CLASSIFICATION

Botanical advances over recent years have stimulated many discussions as to the best way to classify flowering plants. Several people have proposed various systems of classification but since the beginning of the Flora of Australia project there has been a trend in Australian taxonomy to follow Cronquist (Cronquist, 1988).

The position of *Pericalymma* within the classification of the Myrtaceae requires an understanding of Cronquist's division Magnoliophyta (Angiospermae). Within the Magnoliophyta the class Magnoliopsida (dicotyledons) forms an unequal split with Liliopsida (monocotyledons). The Magnoliopsida are consist of 64 orders, 318 families and around 200,000 species of the known 250,000 species. Most plants in this class are woody or herbaceous with many cases of secondary tissues derived from vascular cambium. Perianth parts are generally in 4's, 5's or multiples of these. Magnoliopsida has several subclasses, of which the Rosidae is of most interest because it contains the largest number of families of any subclass of flowering plants This subclass consists of over 58,000 species, 114 families and 18 orders. The order Myrtales consists of 12 families, with 9,000 species, of which the Myrtaceae is one of the 12 families represented. Within the Myrtaceae there are several subfamilies of which the Leptospermoideae and it's suballiance *Leptospermum* form a major component of the Australian myrtaceous flora (Briggs, 1977).

The Leptospermoideae consist of 80 genera of which 64 are represented in Australia and all but 12 are endemic. Within the suballiance *Leptospermum*, eight genera occur primarily in Australia. Originally classified under the suballiance

Leptospermum, a group of three genera, *Agonis*, *Kunzea* and *Leptospermum*, were recognised by Briggs and Johnson (1977). This classification placed these three genera in the section Fabricia within the suballiance Leptospermum and has, as a result of recent revisions (Thompson, 1983), been expanded to eight genera. The recent additions to the *Leptospermum* suballiance were *Pericalymma*, *Homalospermum*, *Sinoga*, *Neofabricia* and an undescribed genus. The increased number of genera created by Thompson did not invalidate Briggs and Johnson's assumptions of the close relationships between genera within the *Leptospermum* suballiance. In fact their interpretations of the myrtaceous inflorescence has assisted in evaluating the differences between the genera of this group.

1.3 SOURCES OF TAXONOMIC DATA

Studies in taxonomy require an ability to grasp the reality of natural relationships. In order to facilitate this concept, botanists must consider information from a wide range of sources. These varied sources of information may be obtained from literature searches (historical aspects) and many disciplines and new innovations related to plant biology. Some of these new innovations may require the use of technology which have been adapted from other scientific fields such as mathematics and chemistry. Historical papers on many Australian species are important as many of our colonial period collections were described and published outside of Australia. This trend continued until the various state herbaria were established: in Western Australia this was around 1926. These papers in many instances were printed either in Latin or verbose English or the language of the original describer. Interpretation and understanding of these works is desirable if, as in the instance of *Pericalymma* and its species, original descriptions are in various languages. *Pericalymma* was first described and published in Latin (Endlicher, 1836) and the species in various languages from 1837-1845. In 1866, G. Bentham

published the Flora Australiensis, treating all of the *Pericalymma* species as belonging to *Leptospermum.*

An understanding of the earlier descriptions is necessary to interpret Thomson's revision in 1983 in which *Pericalymma* was accepted as the preferred name for this suballiance of the Leptospermum alliance. The original specimens upon which the descriptions were based (type specimens) were lodged in various European herbaria and due to several wars and loss of records, the material in some cases has been either lost or destroyed. Thus access to these vital diagnostic nomenclatural tools have been lost as well.

1.4 ANATOMICAL EVIDENCE

Most observations on which taxonomists depend come from interpretations of morphology made with the naked eye, hand lens, microscope, and in recent times, the scanning electron microscope. These latter methods of observation have formed the bases of systematic anatomy, but with recent advances in technology these observed characters are now supported with many new analytical techniques (Woodland, 1991). The unusual spongy wood structure of the stem of some specimens of *Pericalymma ellipticum* has been studied (Bass, 1977; Johnson, 1984) along with a leaf anatomy study (Johnson, 1980). Interpretation and assessment of these papers may provide characters that will aid in species separation. It is not easy to observe distinctive anatomical characters at the genus or species levels. Relationships are so close at these levels that it is mostly a matter of a small degree of variation. The use of statistical methods can be employed to determine whether small variations are significant or not. This is true for *Pericalymma ellipticum* in which the variations at species level are complex requiring the application of several techniques to justify any taxonomic separation.

1.5 CHEMICAL EVIDENCE, CHEMOSYSTEMATICS

Chemosystematics uses the chemical constituents of plants to assess inter - and intra - specific relationships and to infer phylogeny. The use of macromolecular data, a direct gene product (protein) allows the genetic relationship among species to be determined precisely. Use of electrophoresis in plant systematics has the advantage of combining a simple methodology with maximum extractable information (Woodland, 1991). Plant proteins separated by voltage in starch gel followed by staining, shows each protein as a specific gene product. Examination of a number of enzymes an overall genetic similarity between populations, subspecies and species can be obtained. Gel electrophoresis of proteins has become a standard and extremely powerful investigation tool in many areas of plant biology. Isozyme electrophoresis in particular has had positive influences in many biological disciplines. Isozymes were originally defined as enzyme variants present in the same individuals and have become a routine source of data in population and evolution biology (Acquaah 1992). This a tool may be capable of determining probable evolutionary trends in *Pericalymma ellipticum* and an aid to separate and support the observed characters consistent with this species complex.

1.6 KEYS: A MEANS OF IDENTIFICATION

Identification of unknown specimens is usually made by using a key, which is a device whereby successive choices between contrasting statements are followed by a process of elimination until the correct name is arrived at. Modern keys are constructed of paired choices (dichotomous keys), which were first employed in

1778 by a French botanist Jean de Lamark in his publication Flore Francoise (Woodland, 1991) .

There are two main types of botanical keys: the indented and the bracketed with the former being adopted as an Australian standard in the "Flora of Australia" series. In an indented key, the paired couplet choices are identified in the same way and given the same number or letter. This is important because in large keys to many species the halves of the couplet may be separated by some distance or different pages (Woodland, 1991). Larger flora treatments and complex genera have seen the use of dichotomous keys modified to synoptical keys that are multi entry to facilitate several key starting points. This dichotomous structure will be used in preparing a key for *Pericalymma ellipticum* and its possible subspecies.

1.7 TECHNOLOGICAL ADVANCES USED IN TAXONOMY

During the 1960's, computer technology and associated programs developed rapidly. Programs have been developed which provide for automated identification of specimens using a computer. Development of personal computers (PC's) in the late 1970's and 1980's has resulted in many of these programs perfected and expanded. One of these developing programs is the DELTA system (DEscription Language for TAxonomy) a standardised format for coding taxonomic descriptions (Dalwitz & Paine; 1986). The DELTA program was considered as a possible tool to be used during this project to score taxonomic characters, produce keys and prepare descriptions of the species and subspecies. A feature of this program is the ability to separate species using real characters and this aspect was investigated but not persued for this project. Other programes were employed that had the ability to included scanned drawnings and photographic images, distribution maps were also generated using Map Info programs.

1.8 TAXON RANKING

Preparation of taxonomic descriptions and the assigning of species rank into subspecies or variety requires and understanding of nomenclature and established guide-lines in the International Code (Greuter, 1988). This project was involved mainly with the interpretation and division of the species ranking and as such the correct usage of subspecies or variety requires investigation to encompas current concepts. Under the International Code, several categories of taxa below the rank of species are recognised (Jeffrey, 1973). Names of subspecies are trinomial and have the same form as for zoological codes. Names of infra subspecific taxa may consist of more than three terms but are long and clumsy. The insertion of words indicative of rank are obligatory under the botanical code to prevent ambiguity.

Three questions were posed as the main objectives for this project and these are as follows:

1) Is the monotypic classification of *Pericalymma ellipticum* (Endl.) Schauer, fully supported by existing herbarium specimens held in Perth?
2) Variations within the species - are they significant enough for the reinstatement of at least one other species or the creation of subspecies?
3) Diversity of characters within the species sub groups - are they consistent enough to express any ecological trends?

Using the proposed research techniques it was anticipated that the *Pericalymma* species placed in synonymy may be separated and reinstated at the species level. Subspecies and varieties could be adopted where possible to clarify and support the variability expressed within this genera of the Myrtaceae.

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CHAPTER 2.

HISTORICAL ASPECTS OF Pericalymma NOMENCLATURE

2.1 INTRODUCTION

Historical trends in establishing nomenclatural ranking of taxa that predate the establishment of Australian taxonomy poses several interesting aspects that require investigation in order to apply the correct generic or specific epithets. Consistent with many early Australian flora collections, the descriptions and publication of new taxa were produced in Europe or Britain, with many of these written in either botanical Latin or the language of the author.

Pericalymma and its associated species belongs to one of these earlier collections that were described outside of Australia by different delineators from several countries. It is this aspect that has necessitated research into its historical evolution to establish which are the correct generic and specific names to be used in this revision.

2.2 DISCUSSION

Several publications were consulted during the preliminary stage of this revision in an attempt to trace the historical evolution of names applied preceding the 1983 revision. A revision by Thompson (1983), as part of a preliminary paper for a larger taxonomic work, placed several species of *Leptospermum* into synonymy under *Pericalymma ellipticum*. Many early publications concerned

with Australian flora are now represented as rare books held at a few specialist libraries and in some instances only on microfiche film. In instances where these books are not available in Western Australia I organised photocopy extracts of the desired material as interlibrary loans. This restricted access to published material is reflected in the locations of the original (Type) material, which I was able to locate at several of the herbaria cited by Thompson (1983) and it may be assumed that others were destroyed by the numerous wars that have ravaged countries like Germany.

As mentioned earlier, many flora descriptions were written in botanical Latin only which requires careful translation to avoid errors in interpretation. To some extent this problem was overcome with the introduction of a translation program that is available for personal commuters. I used this program to read Endlicher's Genera Plantarum (1836) in which both the genus *Pericalymma* and *Leptospermum* are described although the latter was originally described by Forster in 1776.

Limited collections were a bane to earlier taxonomists as not enough infraspecific variations were available and this has led to some confusion as to exact identities where complex groups are involved. This problem is evident in *Pericalymma* which was placed in *Leptospermum* as three species in the section *Pericalymma* (Bentham 1866) and eventually reverting to the single specied *Pericalymma ellipticum* (Thompson 1983). The uncertainties of this recent combination led to my further investigations of this taxon at the species and subspecies ranking while accepting the genus *Pericalymma.*

The genus *Pericalymma* was first published in 1840 by Endlicher as an attempt to formalize differences between species assigned to *Leptospermum*, a genus

described much earlier by Forster (1776). Until 1840, *Pericalymma* was considered as a section of *Leptospermum*. Usage of *Leptospermum* or *Pericalymma* remained confused as indicated by the chronological sequence of events described below until Bentham's (1866) attempted formalisation in Flora Australiensis.

Leptospermum ellipticum was described in 1837 by Endlicher and placed in *Pericalymma* in 1844 by Huegel. *Leptospermum crassipes* was described in 1842 by Lehmann and also placed in *Pericalymma* by Schauer in 1844. *Leptospermum floridum* was described by Schauer in 1844 as *Pericalymma* but placed in *Leptospermum* by Bentham in 1866. In 1866, Bentham published the Flora Australiensis series assigning all species of *Pericalymma* to *Leptospermum* section *Pericalymma*. Bentham (1866) commented: "The following three species may possibly prove to be varieties of a single one", referring to *Leptospermum floridum*, *L. ellipticum* and *L. crassipes*. Much of this generic confusion may have been a direct result of limited available collections that the earlier delineators had at hand. Development of comprehensive modern collections available to current researchers has enabled much of this confusion to be overcome, as shown by Thompson (1983). Thompson recognised that there was an ovule character that could be used to separate *Leptospermum* from *Pericalymma* and this paper provides a key showing these differences. My field observations have highlighted a macro character that appears to hold true which can be used to separate *Leptospermum* from *Pericalymma* in flowering and fruiting material. Floral bracts are persistent through flowering and are residual on old fruits in *Pericalymma* but appear to be absent in Western Australian *Leptospermum*.

2.3 CONCLUSIONS

Although Thompson's (1983) paper solving the problem of *Pericalymma* at the generic level, resulted in the original three species being placed in synonymy under *Pericalymma ellipticum*. My revision is a result of Thompson's paper and is an attempt to reinstate or recognize other ranks. I found that the material housed in the Perth herbarium collection was not consistent and showed considerable variation even within each folder. These inconsistencies indicated that the three original species, and possibly other species, may exist in this monotypic complex. This high level of variability was indicated in Thompson's (1983) paper in which it was suggested that further studies at the species or infraspecific level should be conducted. Species inconsistencies encountered in the field may make it possible to evaluate factors influencing these variations. My task was to resolve, using modern taxonomic techniques in conjunction with a larger collection of specimens, whether *Pericalymma* is a monotypic genus as proposed by Thompson (1983) or more correctly polytypic.

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CHAPTER 3.

TO BE A SUBSPECIES OR NOT TO BE A SUBSPECIES

3.1 INTRODUCTION

Organisms in their complexity and diversity, give the biological sciences a fascination that is unrivalled in many other sciences. This complexity and diversity is very evident in many botanical taxa and as a result has required the development of a structured hierarchy that enables separation and classification. The more complex the taxa the greater the need for various levels of ranking that will provide researchers with a clear and logical method of separating at the specific and possibly at the infraspecific levels.

Pericalymma ellipticum, although considered by Thompson (1983) to be a monotypic species, has over the years presented botanists with a myriad of complex and confusing characters. This array of taxonomic and observed characters indicates a complex diversity occurring between and within populations, presenting a confused concept of the species. Earlier studies of *Pericalymma* indicated that a clear separation at the species ranking may not be possible and that the use of the lower ranks of subspecies and variety may be required. Selected papers covering specific ranking and infraspecific ranks are reviewed here in an attempt to clarify usage and concepts.

3.2 SPECIES DEFINITION

The species as an evolutionary unit and as a basic concept broadly used in classification is hard to define due to the many ways in which the term has been applied in the biological sciences. Simply stated, a species implies a distinct type

or class of individuals having some common characteristics. Individual species within a population having common characteristics are considered the evolutionary basis of variations so that a species coonsists of natural populations of reproducing, genetically related individuals isolated from other populations by gene barriers. Taxonomically the species rank is the basic category to which most taxonomic information is assigned. In higher plants the species rank is recognised as the smallest population structurally distinct from all other populations.

3.4 RANKS OF TAXA

Ranks of taxa represent levels of relationships required for the purposes of classification when studying different groups of plants. The ranks of taxa cannot be defined exactly, just arranged hierarchically. No set number of diagnostic characteristics or special types of characters are involved in the designation of any group of plants to a specified category.

Species, the base rank, has been defined by many authors since the time of Linnaeus as a group of individuals that in the sum total of their attributes resemble each other to some degree. This degree of resemblance is the smallest group to which distinctive and invariable characters can be assigned and is regarded as specific. Cronquist (1968) stated "A species is the smallest population which is permanently distinct and distinguishable from all others". Many of the stated concepts although applicable provide an inclusive definition of species but when combined do not present an adequate working species concept.

Several characterised types of species have been recognised, (six in total; Radford, 1986), of which taxonomic species is of more interest for this study of *Pericalymma*. Taxonomic species can be defined as the smallest groups that are distinct and distinguishable from all others. Species are individuals that can be positively identified in nature by simple means (10x hand lens). This assemblage of morphologically similar individuals that differ from other such groups in one or more structural characteristic can be considered a species.

3.4 HISTORICAL CONCEPTS OF SPECIES

Above the level of species, the hierarchical position of taxa mainly rests upon the degree of morphological differences. At the species level and below, however there is an abrupt shift in the way that the ranks are applied. In the recognisation of species, subspecies and varieties other criteria are taken into account. These include the degree of crossability, geographical distribution and ecological preferences (Davis, 1978).

Flora writers and monographers need a practical species concept, because adequate experimental or field evidence is often lacking. Species should differ from their close relatives with at least two well correlated characters to achieve an acceptable degree of difference (Davis, 1978). Natural species are the taxonomist's building blocks, to which binomials are applied for convenience irrespective of intersterility.

Below the rank of species several world floras only recognise and use the rank subspecies. Subspecific and varietal (varietas) ranks can be desirable in floristic work but there has been generally no acceptable distinction in usage. Today

many taxonomists would be prepared to recognise the rank of subspecies with or without some degree of morphological or geographical overlap, even if the acceptable difference is small.

A meeting held by the Systematic Association in 1956 enabled zoologists and botanists to discuss general aspects and usage of the subspecies rank (Taxon, 1956). During this discussion Professor J. Heslop - Harrison indicated that there are unambiguous answers to the question "What is the subspecies", in both the international codes of botanical and zoological nomenclature. The rank of subspecies is merely one of the categories of taxa recognised below the rank of species. Professor T.G. Tutin presented at the same discussion suggested that a possible definition of a subspecies might be: " Taxa differing from one another in minor morphological characters, occupying distinct areas or isolated ecologically, but potentially capable of interbreeding without substantial reduction in fertility". The rank of subspecies is a potentially higher category than variety although interpretations of the two ranks vary; frequently what one botanist interprets as one is exactly what another accepts as the other.

The terms variety and subspecies both have been used ambiguously, subspecies has been used to indicate a taxon of a rank between species and variety (Benson, 1962). The actual botanical term for variety is varietas, which should not be confused with the horticultural term variety (cultivar). Varietas is the classical botanical category below the rank of species and its use requires less formal changing of names than the rank of subspecies. Modern usage of variety appears to have become the accepted wording for this rank below subspecies and is used in many floras.

Varietal ranks have more often been used to describe small races that grow outside the range of regional subspecies. This ranking can also be conveniently applied in cases where a variant forms a localised population scattered throughout the range of a species or subspecies. Unfortunately the varietal rank has also been used in other senses than for the local populations. It has been used for outstanding variants (usually herbarium material) to which taxonomists wish to draw attention and may be an expression of some natural effect. In this case as the material is further studied it may prove that it is a new species or should not have been formally named at the infraspecific level. Recent trends by many authors is to favour the use of subspecies as a higher rank above variety (Radford, 1986). Many authors believe that two ranks below species to be useful and can recognise both subspecies and variety e.g. *Rostellularia adscendens* subsp. *adscendens* var. *hispida* (Barker, 1986). Several recent floras have used a third rank below species, and although not in frequent usage the term forma appears to be a desirable extra ranking level that as taxonomy develops will be become used more frequently.

3.5 CONCLUSIONS

Taxonomy deals with the natural diversity of plants but this does not mean that we must classify all the variations formally, either below or above the species level. If a small genus contains only three species each may appear very distinct but evidently cogeneric. There is no need to create a section for each of them when a note emphasising their distinctness would suffice. Present trends in botany indicate and encourage the use of ranks below species level if enough evidence is provided to substantiate the divisions.

The use of infraspecific ranks below species may help classify the complex variation encountered in the *Pericalymma ellipticum* complex. The presence of more than one distinct character would enable the possible creation of another species or reinstatement of species placed in synonymy (Thompson, 1983). Finding one consistent usable character could warrant the creation of the subspecies rank as previously more than one population was involved. The application of varietal rank is not envisaged in this study, although the complex nature of *Pericalymma* may present usable characters to support the use of this lower ranking.

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CHAPTER 4.

WOOD ANATOMY STUDIES OF Pericalymma

4.1 INTRODUCTION

Generally, characters on which taxonomists rely for identification and classification are based on observations either made unaided or aided by the use of a 10x hand lens. Clues to the natural groups of plants and the identification of unknown specimens can be provided also by the study of cellular or tissue assemblages examined using microscopes with magnifications between 20-1000x. Portions of plant tissue or organs are processed using several different techniques, then sliced into thin sections ranging from 1-15 microns (um) using a microtome. These thin sections are usually stained and mounted on glass slides for examination under a microscope, enabling botanists to describe an enormous range of variations in microscopic details (Woodland, 1991).

Some microscopic features and patterns are unevenly distributed among plant families and these can be used as taxonomic characters. Unfortunately at generic and specific levels of classification it is not easy to find distinctive characters, due to the closeness of relationships that are mostly a matter of degrees of variation. Exceptions have been observed by wood anatomists, who have found it possible to distinguish between species within some genera. This aspect was investigated in an attempt to unravel or support the current species concepts applied to the *Pericalymma ellipticum* complex.

Several papers have been published on various anatomical features of *Pericalymma ellipticum* while still included under *Leptospermum*. One paper

investigated the unusual stem structure of *Leptospermum crassipes* (Baas, 1977) and another examined the wood anatomy of *Leptospermum* (Johnson, 1984).

4.2 STEM ANALYSIS

In 1977, Baas published a paper in which the curious swollen woody stem of *Leptospermum crassipes* was examined. Comparing these results with other *Leptospermum* species Baas revealed that the secondary xylem of *L. crassipes* had some unique features. The transition from normally differentiated juvenile wood to poorly differentiated more mature wood occurs over a very short distance (c. 100-200 um). This is characterised by an increase in cell diameter of all axial elements in such a way that vessel members and parenchyma fibres become indistinguishable. The axial elements can be referred to as vessel members and vascular tracheids, depending on the presence of small oval perforations. The tangential diameter of the axial cells increases from 20 um at the periphery of the juvenile core to 40-100 um at the periphery of the mature wood. The unusual, if not unique, wood anatomy of *L. crassipes* hinted that a comparison with data on other *Leptospermum* species was required (see below).

Comparison of *L. crassipes* & Other *Leptospermum* Species

Leptospermum crassipes	other *Leptospermum* species
Fibre tracheids and axial parenchyma indistinguishable from vessels.	Fibre tracheids and parenchyma present
Mean length of vessels 190-220 um	Mean length of vessels 440-630 um

(Adapted from Baas, 1977)

The main differences listed in the above comparison could induce systematic wood anatomists to assign *Leptospermum crassipes* to an entirely different genus. Bentham (1866) commented on the close similarities of all character states, except habit, between *L. crassipes* and *L. ellipticum*. These statements formed part of the rationale used by Thompson (1983) when L. *ellipticum*, *L. crassipes* and *L. floridum* were all placed in synonymy under *Pericalymma ellipticum*.

Johnson (1984) described the wood anatomy of *L. ellipticum* as: "Wood tends to be diffuse to porous, growth rings distinct, parenchyma scanty, paratracheal". Although this description is correct for much of the *Pericalymma ellipticum* complex there are large variations in the distinctness of the growth rings and the degree of porosity present suggesting that there may be a difference at the species level (pers. observ.). In fact, Johnson considered the differences in wood anatomy had taxonomic significance, particularly in relation to Bentham's classification of *Leptospermum*. Bentham placed *Pericalymma* as a section of *Leptospermum* showing that a generic separation was probable. Johnson (1984) indicated that both *Leptospermum ellipticum* and *Leptospermum crassipes* stood out clearly from the rest of the *Leptospermum* on account of the paucity of axial parenchyma and its tendency towards more homogeneous wood. These comments further supported Thompson's (1983) separation of *Pericalymma* from *Leptospermum* although other characters were found to be useful, notably the ovules were anatropous in *Leptospermum* and hemitropous in *Pericalymma*.

Anatomical studies were conducted in an attempt to investigate the probable differences in the stem tissues of the various populations of *Pericalymma*

ellipticum. Two stem tissue types were observed and sampled, one soft and porous and the other hard and dense.

4.3 SAMPLE SELECTION AND ANATOMICAL TECHNIQUES

Twenty six fresh stem portions were collected during population sampling of the *P. ellipticum* complex, covering the known species range and stored in a 1% alcoholic solution to prevent dehydration of the tissue. These preserved samples were sectioned using a freezing microtome to a thickness between 10-20 um. This thickness range was selected as the most suitable to demonstrate cell and tissue variability as fine microscopic details were not warranted. The sections were initially stained with toluidine blue to differentiate tissue types but this was abandoned in favour of neutral red as a suitable general purpose dye. Temporary slides were prepared using corn syrup as the mountant and a photographic record taken using 35 mm colour slide film. These prepared microscope slides were examined at 100x magnification to enable a 1mm scale eyepiece gradicle to be used for measurements of cell size and the number of large vessels present. A selection of these photographic slides was scanned using a Nikon image scanner and the images captured using a computer program to produce the figures.

Thirty seven *Pericalymma ellipticum* populations consisting of more than 10 plants were sampled from which twenty six stem samples were selected. Twenty four of these samples were sectioned of which twenty one were used for analysis. These samples were collected from Cataby in the north to Bremer Bay in the

south. While sampling these populations a species of *Melaleuca* was found growing in a similar wetland habitat displaying the characteristic inflated stem tissue similar to *Pericalymma ?crassipes*. Further south of the species range and occupying the inland wetland habitats *Pericalymma ellipticum* appeared to be replaced by several species of *Leptospermum* and *Agonis*. Slides were prepared of both the *Melaleuca* species and the an *Agonis* species to enable a comparison of stem tissues to be made with the range of *Pericalymma* stem tissues. *Leptospermum* species were not sampled as detailed wood analysis was carried out by Johnson (1984).

4.4 ANATOMICAL INTERPRETATIONS

Examination of the prepared thin stem sections obtained from the twenty one samples of *Pericalymma* revealed tissue types as expected, similar to those found by the previous authors. The generic limits established by Thompson has enabled the selected samples to represent near pure populations of *Pericalymma* removing part of the confusion created when comparisons were carried out with *Leptospermum*. Over the range of sections examined a high degree of variation was observed in cell size and the presence of thick walled fibre tracheids. The most readily observed features were the large vessels which were so abundant as to produce an extremely diffuse structure in some specimens (Figure 1). At the other extreme, the wood mostly comprised narrow, thick walled fibre tracheids, with a range of intermediates (Figures 2-5).

Comparison of the stem sections made from the *Melaleuca* species (Figure 6) showed the swollen tissue was a result of the bark layer containing large air cells (aerenchyma). The sample of *Agonis* showed the wood (Figure 7) to be of a

Stem sections of *Pericalymma*, *Agonis* and *Melaleuca* (Figures 1-7).

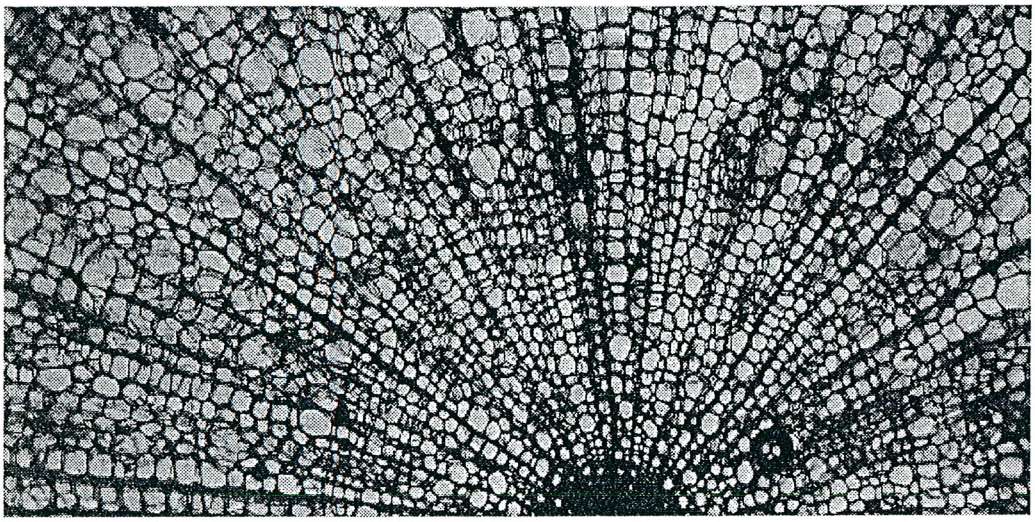


Figure 1. *Pericalymma* sample No. 8931a (40x mag.)

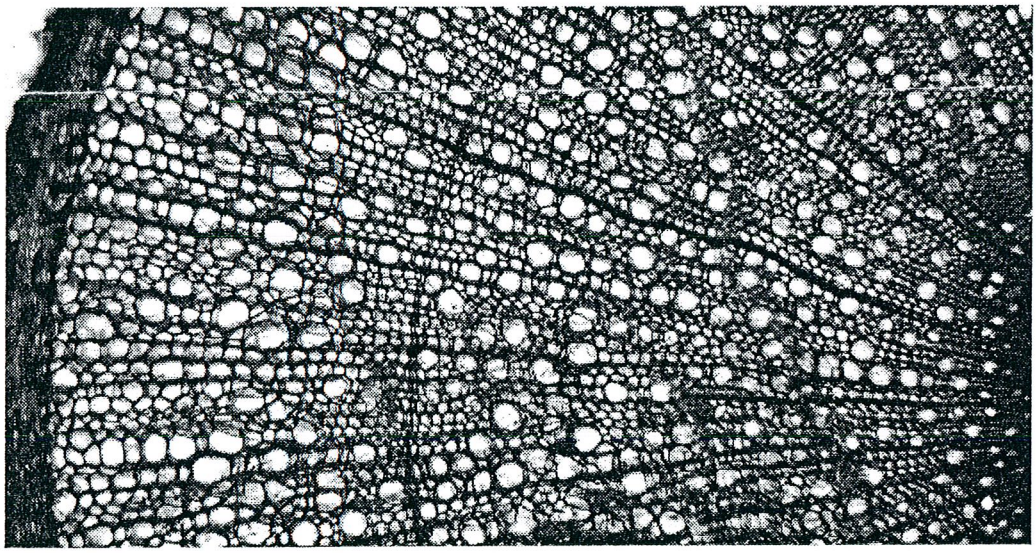


Figure 2. *Pericalymma* sample No. 9192 (40x mag.)

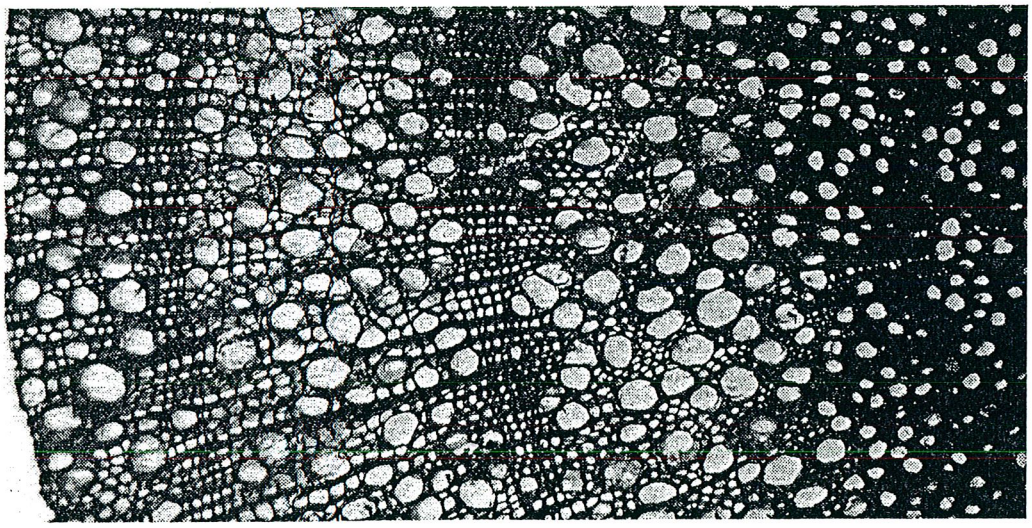


Figure 3. *Pericalymma* sample No. 8996 (40x mag.)

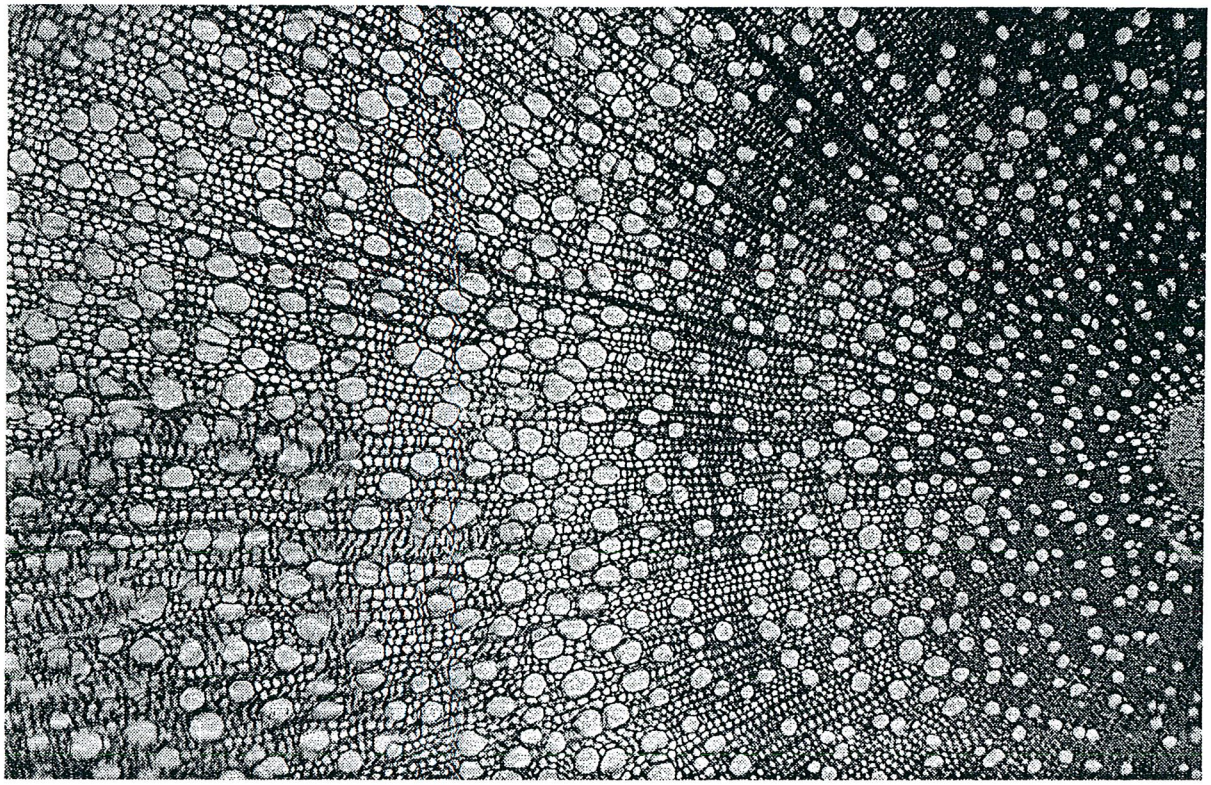


Figure 4. *Pericalymma* sample No. 9002 (40x mag.)

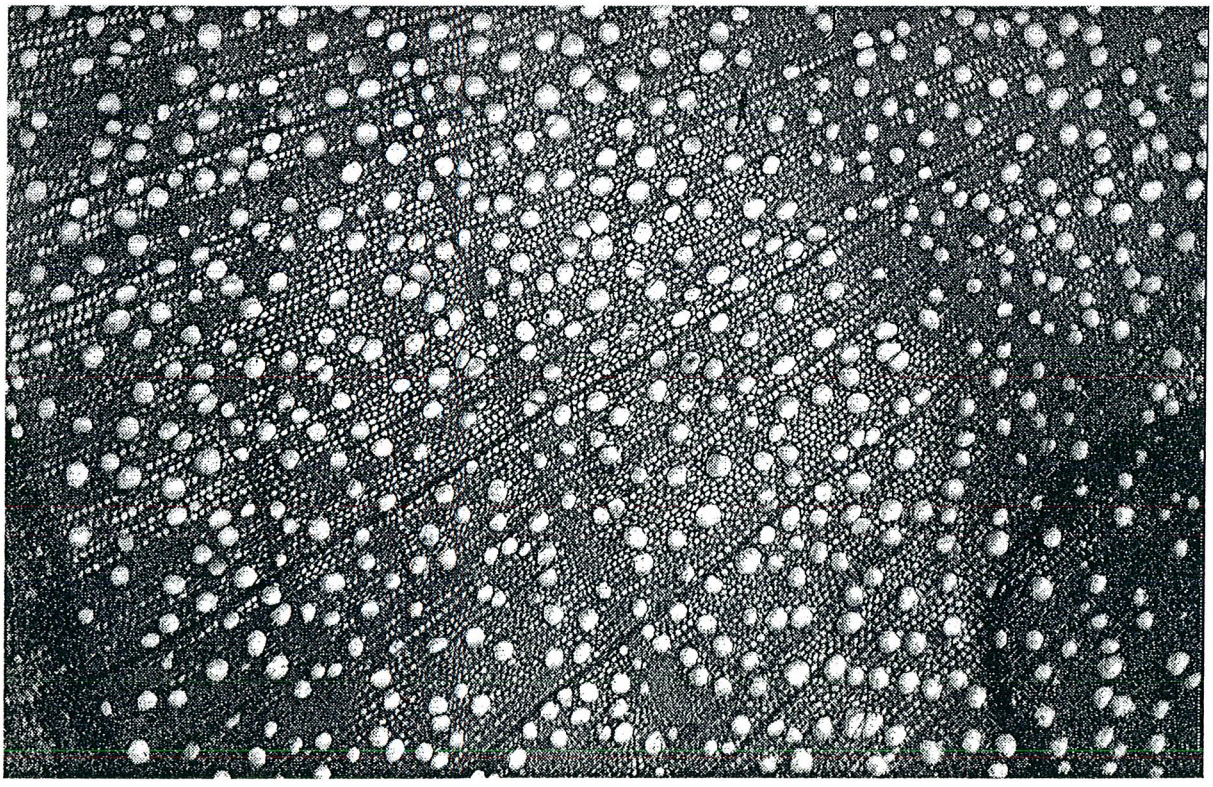


Figure 5. *Pericalymma* sample No. 8936 (40x mag.)

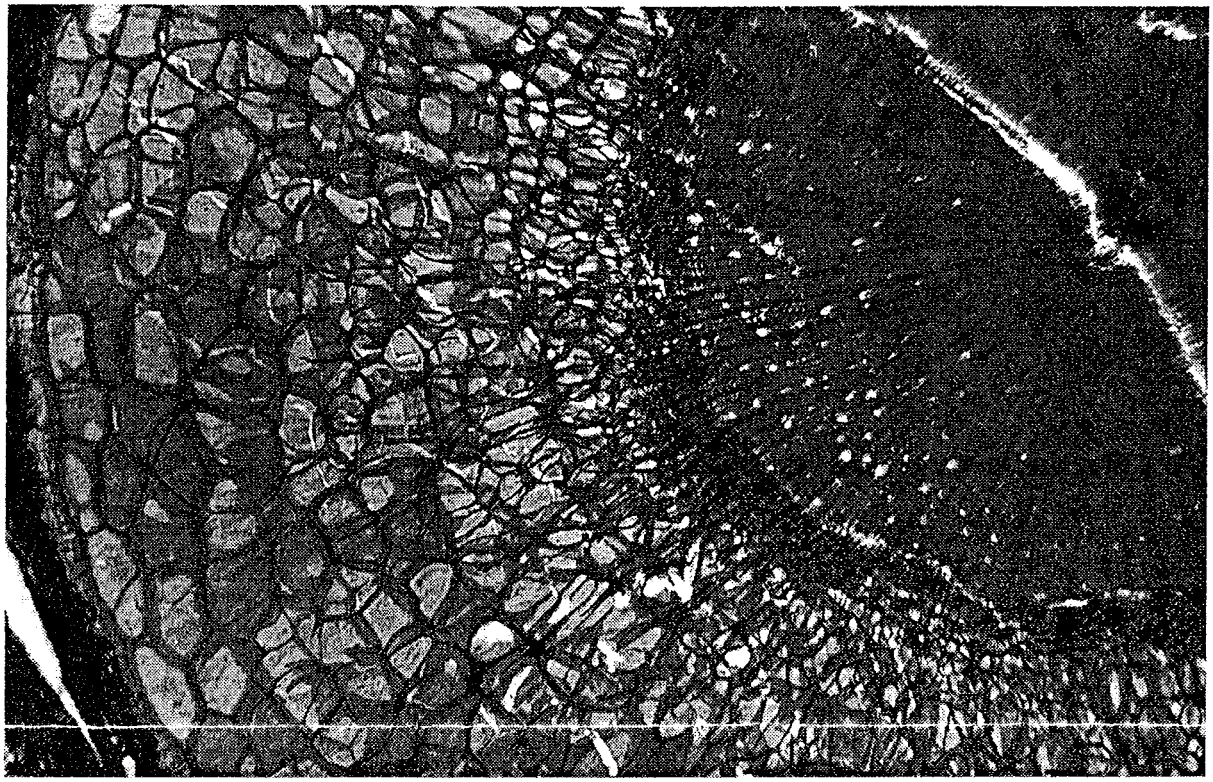


Figure 6. *Melaleuca* species (40x mag.)

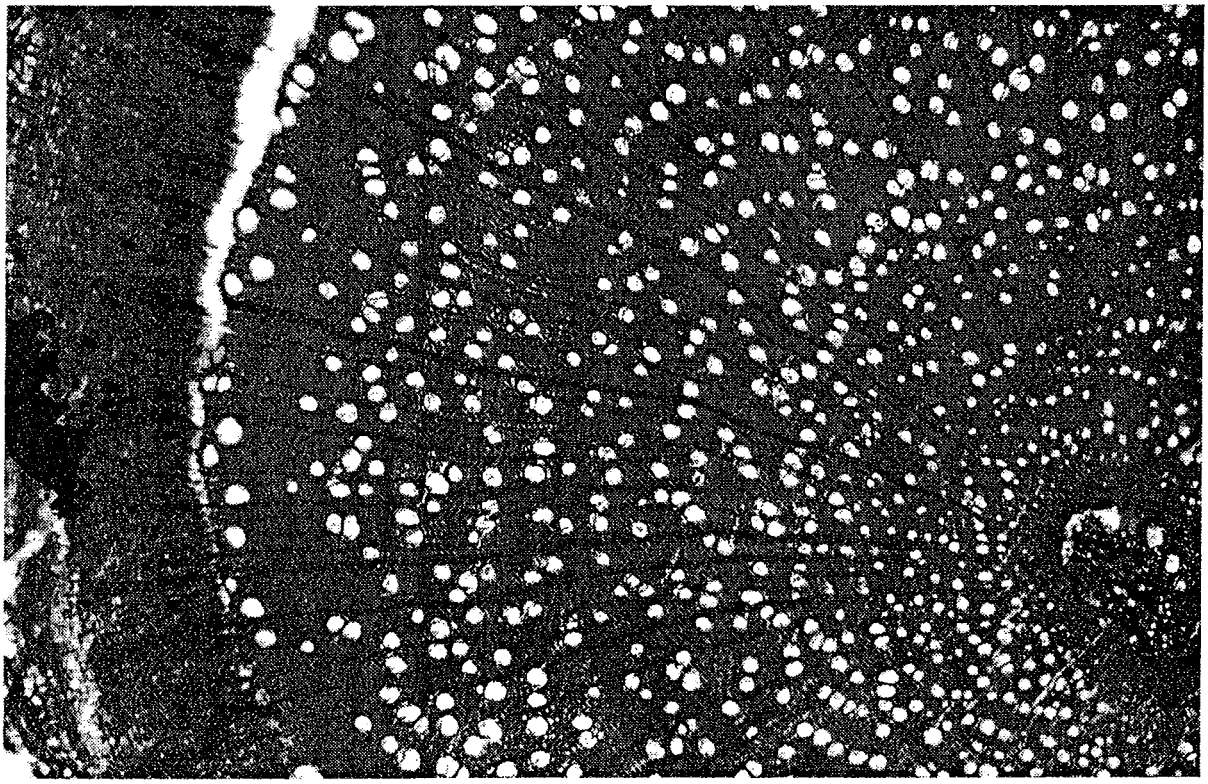


Figure 7. *Agonis* species (40x mag.)

similar tissue type to the denser type in the *Pericalymma* tissue range. Although similar the tissue was much denser and the large open vessels were reduced in number and size with a higher proportion of fibre tracheids present. This may indicate that *Agonis* is a distant relative of *Pericalymma* but belonging in the *Leptospermum* suballiance of Myrtaceae.

Table 1 shows the variation in density and size of these cells. Six measurements were done for each specimen on different tangents, and the results averaged to give the readings shown. The large vessels and fibre tracheids were counted linearly over a mm, midway between the stele and cortex.

Table 1

Average variation in cell density and size

Sampls #	Vesselss/mm	Fibres/mm	Vessel Size (mm)
8931A	17	0	0.08-0.12
8936	5-7	30-38	0.04-0.08
8944	10-11	26-30	0.03-0.08
8974	6	32	0.02-1.06
8982	5	28	0.04-0.09
8985	7	26	0.06-0.07
8993	3	18	0.06-0.11
8994	5	25	0.04-0.07
8995	6-7	40	0.03-0.05
8996	6	30	0.04-0.07
9002	7	50	0.03-0.04
9075	8	33	0.03-0.05
9083	5	24	0.05-0.07
9171	5	30	0.04-0.07
9174	7	24	0.06-0.08
9184	7	24	0.03-0.07
9185	6	28	0.04-0.07
9192	6	26	0.06-0.07
9197	3	20	0.07-0.09
9198	5	20	0.05-0.07
9199	7	33	0.03-0.07
Agonis	9	90	0.03-0.06

The average number of vessels observed varied from 3-17 cells/mm and ranged in diameter from 30-120 um.

Table 2

Average variation of cell density and size for observed stem types

Sample#	Figure#	N^{o} fibres/mm	N^{o} vessels/mm	Range of Vessels diam. (um)
8931a	1	10	17	80-120
9002	5	50	7	30-40

Table 2 shows selected samples from two previously observed stem types, that illustrates the variations in density and cell sizes present in each of these stem tissues.

4.5 DISCUSSION

This variation was also evident as a field character occurring over the range of populations, as some stems are soft and easily cut while others are harder and difficult to cut or break. The reduction in the density of vessels may be a result of evolutionary trends across the populations and associated with localised habitats. The ecology of *Leptospermum crassipes* is unusual. The species occurs in association with a number of woody *Leptospermum* species of normal habit, indicating that the swollen stem character may not be the result of evolution forces or adaptive strategies (Baas, 1977). Field observations and sampling has now shown that the above statement should referr only to the other

species of *Leptospermum* as *Pericalymma*. *Leptospermum* was absent in most *Pericalymma* habitats with the occasional cohabitation in the drier more elevated locations.

The softer stemmed populations were mainly associated with various wetland habitats, while the hard stemmed populations were commonly found in drier elevated habitats. Between these extremes populations were found that fringed the above habitats, but intermixing with this midgroup (Figures 2-4) occurred.

The generic confusion and the limited available material that was studied both by Baas (1977) and Johnson (1984) did not allow them the opportunity to observe the variations within the stem tissue that is presented here. In both instances they compared their results with other species of *Leptospermum* although each recognised that the species included under Bentham's section *Pericalymma* was different. This study on the *Pericalymma ellipticum* complex has shown a range of variations in stem tissue that suggests several species or subspecies may be involved. The stem sections studied present a reasonable variation at the extremities of the observed range but no conclusive results could be made from the intermediate samples. This gradual differentiation indicates that the soft stemmed tissue with the large open vessels may be the only possible division within the species complex. The specimen showing this tissue type (RJC #8931a, Figure 1) corresponds with the species previously identified as *Pericalymma crassipes*. Separation of *P. crassipes* from *Pericalymma ellipticum* is partly supported although other characters are required to fully substantiate this reinstatement.

Comparison of the stem sections made from the *Melaleuca* species (Figure 6) showed no similar wood type as the swollen tissue was a result of the bark layer

containing large air cells to prevent water logging of the stem. The sample of *Agonis* showed stem wood section (Figure 7) to be of a similar type to the denser extremity found in the *Pericalymma* tissue range. Although similar the tissue was much denser and the presence of the large open vessels reduced in number and size with a higher proportion of fibre tracheids present. This may indicate that *Agonis* is a distant relative of *Pericalymma* but belonging in the *Leptospermum* suballiance of Myrtaceae.

4.6 REFERENCES

Baas, P. (1977). The peculiar wood structure of *Leptospermum crassipes* Lehm. (Myrtaceae). International Association of Wood Anatomists Bulletin, 2: 25-30.

Johnson, C.T. (1984). The wood anatomy of *Leptospermum* Forst. (Myrtaceae). Australian Journal of Botany, 28: 323-337.

Woodland, D.W. (1991). Contempory Plant Systematics. New Jersey: Prentice Hall, pp. 427-433.

CHAPTER 5.

NUMERICAL SYSTEMATICS

5.1 INTRODUCTION

During the latter half of the nineteenth century a new approach to biological variation, especially intraspecific variation, was under study. Investigators examined large numbers of organisms, collected data and subjected them to statistical analysis (Briggs, 1984). When using these methods it is important to scrutinise and measure large samples of populations of related species to avoid possible bias. Individuals must be collected methodically at random and without biased selection of characters, and the data analysed without preconceived ideas or modification. Numerical taxonomy (systematics) - the grouping by numerical methods of taxonomic units based on their character states - has been assisted by the increased use and development of computer techniques. Numerical taxonomy has opened up a wide field involving the exact measurement of evolutionary rates and phylogenetic analysis (Sneath, 1973). Classification using numerical taxonomy is generally based on a matrix of character states in which taxa are constructed through various techniques designed to summarise the structure of the matrix. Most taxonomy is conducted by using phenotypic characters and separation of species using a combination of these characters. This revision of the *Pericalymma ellipticum* complex examined phenotypic variations in an attempt to justify separation at the species level and show possible relationships between the various populations.

5.2 PHENOTYPIC VARIATION

Complex interactions that occur between genotypes and the environment at the level of the cell can affect the whole plant. A gene provides the information which, in an appropriate environment, will contribute to a particular phenotype. Generally plants show greater phenotypic variability than is found among higher animals. The individual plant is open to much more environmentally induced variations over a greater part of its life span than is the animal. Given the variety of different environments a greater diversity of genotype environment interactions is possible. Plants rarely grow in ideal conditions and often the stress of the environment may kill, restrict or modify their growth. Phenotypic variation therefore should be viewed within the context of developmental variations for specific populations. Phenotypic plasticity is among the most neglected phenomenon in plant taxonomy and deserves much more careful investigation, especially the adaptive nature of any responses to the environment. *Pericalymma ellipticum* occurs over several habitat types that range from Cataby in the north to just east of Bremer Bay in the south of its range. These habitats are usually associated with swampy waterlogged leached sands that can be either lowlying or elevated on hill slopes, and appears in part to explain some of the plasticity encountered in the species. Phenotypic variations shown by herbarium material of the *Pericalymma ellipticum* complex indicated close relationships existed with other possible *Pericalymma* species. Thompson (1983) noted that the remarkable variability of *Pericalymma ellipticum* was a result of several characters that varied independently but formed a directional

cline, i.e., from north to south, and inland to the coast. Additional field studies was required in an attempt to evaluate factors influencing this variation.

5.3 POPULATION SAMPLING AND DATA SELECTION

Sampling size of *Pericalymma* populations was fixed at 10 plants from each population and plants were collected from as many of the various habitats as possible. These population samples were sorted superficially using observable characters that expressed similar habit features and were treated as subsets of the total populations. Eleven geographical areas were selected encompassing the known distribution of this complex and from these areas 43 subsets were collected (Figure 1). Figure 1 shows the populations per area from which samples of *Pericalymma ellipticum* were collected. Areas that are linked indicated habitats that are similar and shows possible related species based on inflated and non inflated stems (wood density) and flower size, denoted by collection numbers. Stem densities ranged from very soft, inflated (porous) to moderately hard, non inflated (increased fibre tracheids) as noted in the anatomical section. Populations expressing low variability of the selection characters are depicted as a primary linkage eg. Perth populations. The secondary linkages depict subsets that were sampled from the same habitat location or different locations within the same area eg. 3 subsets for the Busselton populations. These subsets were all scored using a series of measurable characters involving lengths and widths and all were recorded in mm. A total of 10 characters states were scored for all sample sets and the means of these characters were calculated (Table 1) as an initial attempt to establish a suitable data set for analysis.

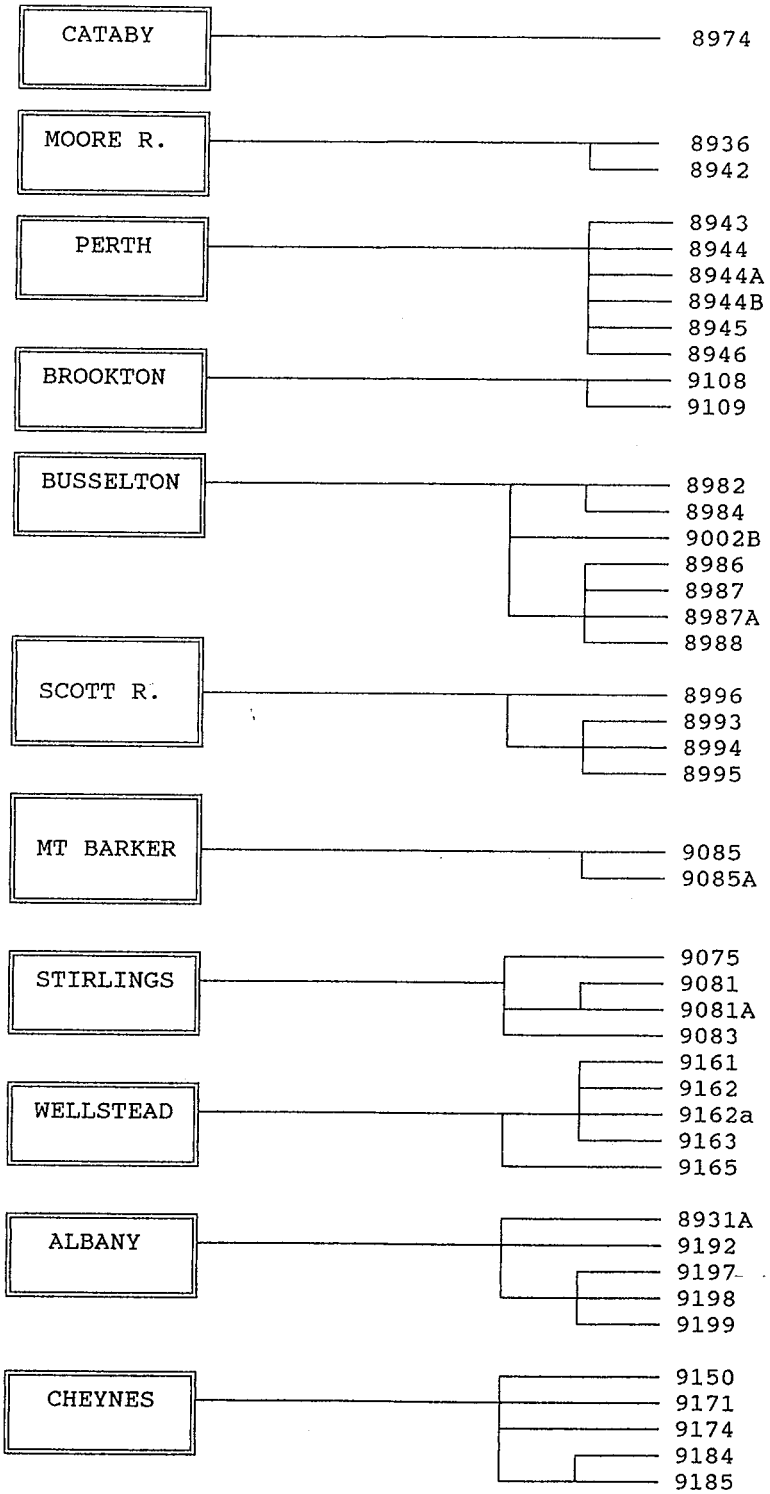


FIGURE 1

Pericalymma populations showing collection areas and collection numbers. Subsets linked to show possible taxonomic relationships within habitats.

Table 1 (5.2)

Mean lengths and widths in mm for all sampled Pericalymma ellipticum populations. Number of samples collected per population and flower colours indicated: P = pink W = white

Collection number	Dimension		Vegetative leaves	Floral leaves	Bracts	Sepals	Petals	Flower colour
	No							
8931a	10	L	3.69	3.05	2.03	1.08	1.62	W
		W	0.87	0.74	1.08	1.04	1.28	
8936	10	L	6.03	4.05	3.45	2.22	4.85	W-P
		W	1.76	0.84	2.47	1.75	3.73	
8942	10	L	5.84	3.84	3.30	1.72	4.20	W-P
		W	1.65	0.78	2.33	1.54	3.27	
8943	10	L	6.65	3.92	3.05	1.76	4.33	W-P
		W	1.79	0.60	1.98	1.36	3.56	
8944	10	L	6.65	3.62	2.92	1.78	4.65	W-P
		W	1.77	0.77	1.99	1.72	3.65	
8944a	10	L	5.56	4.30	3.00	1.80	4.52	P
		W	1.63	0.72	1.98	1.49	3.56	
8944b	7	L	6.26	3.33	2.80	1.60	4.09	W
		W	1.86	0.64	2.00	1.41	3.20	
8945	7	L	5.76	4.41	3.41	1.87	4.37	P-W
		W	1.77	0.81	2.36	1.83	3.40	
8946	10	L	4.85	4.37	3.60	1.91	4.51	W
		W	1.65	0.85	2.52	1.98	3.53	
8974	10	L	6.90	3.48	3.03	1.89	4.47	W
		W	2.05	0.77	2.05	1.71	3.60	
8982		L	6.15	3.06	3.74	2.19	4.31	P-W
		W	1.18	0.96	2.47	1.68	3.64	

Table 1 (5.2.1)

8984	10	L	5.84	3.89	3.79	2.29	5.17	P-W
		W	1.76	0.99	2.72	1.56	4.48	
8986	7	L	7.53	3.01	3.47	2.03	4.83	P-W
		W	2.53	0.51	1.93	1.97	3.94	
8987	6	L	4.86	3.42	3.78	2.20	5.07	P-W
		W	1.67	0.65	1.90	1.92	4.35	
8987a	5	L	8.64	3.74	4.12	2.42	5.32	W
		W	2.92	0.64	2.18	1.90	4.20	
8988	10	L	5.89	3.29	3.37	2.02	4.93	P-W
		W	2.00	0.61	2.08	1.88	4.15	
8993	10	L	3.19	2.94	1.64	1.15	1.86	P-W
		W	1.03	0.69	1.01	1.06	1.24	
8994	7	L	5.54	3.87	2.97	1.73	4.50	W
		W	1.50	0.59	1.74	1.56	3.23	
8995	4	L	5.25	3.55	3.10	1.70	3.55	P-W
		W	1.48	0.43	1.88	1.55	3.33	
8996	10	L	8.09	2.49	2.18	1.19	2.93	P-W
		W	3.26	0.52	1.10	1.27	2.70	
9002b	10	L	6.45	3.06	3.16	1.95	4.62	W
		W	1.83	0.67	1.85	1.64	3.50	

Table 1 (5.2.2)

9075	10	L	5.81	3.79	3.37	1.93	4.38	W
		W	2.09	0.87	2.28	1.64	3.53	
9081	10	L	4.56	3.77	3.41	2.29	4.43	W
		W	1.52	0.90	2.33	1.95	3.57	
9081a	6	L	3.58	3.33	3.18	1.90	4.33	W
		W	1.67	0.80	2.32	1.70	3.57	
9083	10	L	5.21	2.82	3.28	1.80	4.22	W
		W	2.10	0.76	2.06	1.55	3.39	
9085	10	L	4.16	3.07	3.01	1.90	4.12	P
		W	1.53	0.74	1.85	1.46	3.29	
9085a	3	L	4.20	3.27	3.00	1.87	4.10	W
		W	1.50	0.80	2.03	1.63	3.30	
9108	10	L	5.93	4.21	3.08	1.82	3.76	P-W
		W	1.18	0.79	1.67	1.55	3.05	
9109	10	L	6.98	4.13	3.15	1.67	4.01	P-W
		W	1.57	0.70	1.86	1.65	3.38	
9150	10	L	4.57	3.10	3.09	1.84	4.16	W
		W	1.79	0.66	2.11	1.59	3.30	
9161	10	L	3.89	2.52	0.75	2.79	1.64	W
		W	1.45	0.75	2.79	1.89	1.58	
9162	4	L	4.63	3.60	2.68	1.68	3.63	P-W
		W	1.58	0.80	1.83	1.40	2.80	
9162a	7	L	3.83	2.59	2.71	1.87	3.86	P-W
		W	1.50	0.79	2.01	1.47	3.16	
9163	10	L	4.14	2.82	2.99	2.01	4.05	P-W
		W	1.44	0.70	1.98	1.49	3.24	
9165	10	L	3.37	2.77	3.06	1.65	3.55	W
		W	1.39	0.74	2.03	1.41	2.95	

Table 1 (5.2.3)

9171	4	L	5.88	3.00	2.13	1.60	3.80	P-W
		W	2.18	0.63	1.25	1.43	2.60	
9174	10	L	3.38	2.40	2.53	1.51	3.94	P-W
		W	1.60	0.77	1.68	1.42	3.05	
9184	10	L	3.53	2.71	2.93	1.72	3.66	W
		W	1.64	0.99	2.04	1.46	2.88	
9185	10	L	4.17	2.65	2.79	1.71	3.64	W
		W	1.63	1.04	2.18	1.46	2.95	
9197	10	L	4.70	3.26	2.14	1.22	0.00	W
		W	1.58	0.80	1.09	1.12	0.00	
9198	10	L	3.61	2.52	2.61	1.58	3.70	P-W
		W	1.60	0.58	1.74	1.39	2.94	
9199	8	L	3.66	3.30	2.93	1.60	3.66	P-W
		W	1.51	0.70	1.61	1.45	3.04	

From Table 1 mean bract lengths were deemed as the most suited variable for which analysis of population variations could be carried out, as this character appeared to be the least subjected to environmental or seasonal changes and was persistent on old residual fruiting material. The bract lengths were selected due to the ease of accurate measurement as the bracts are concave, width measurements varied upon the amount of pressure applied during measurements.

Other measurable characters although possibly not consistent enough for numerical analysis were examined. Polygon graphs were selected as 5 different characters could be displayed on each graph. The axes of the graph were numbered 1-5 and assigned the following characters:-

1. leaf length
2. floral leaf length
3. bract length
4. sepal length
5. petal length

Using all the mean length characters scored in Table 1, a series of polygon graphs were plotted, in which the characters were positioned on axes 1-5, all of

equal length and scale. The plotted points were joined and the resultant graphs show a series of polygon shapes that appeared to be fairly consistent in form but with apparent visible differences on several axes.

5.4 HYPOTHESIS

The following hypothesis was developed to test and establish any significant variations in the population means for bract lengths. Further analysis of selected populations examined all of the character means in an attempt to provide a basis for species separating.

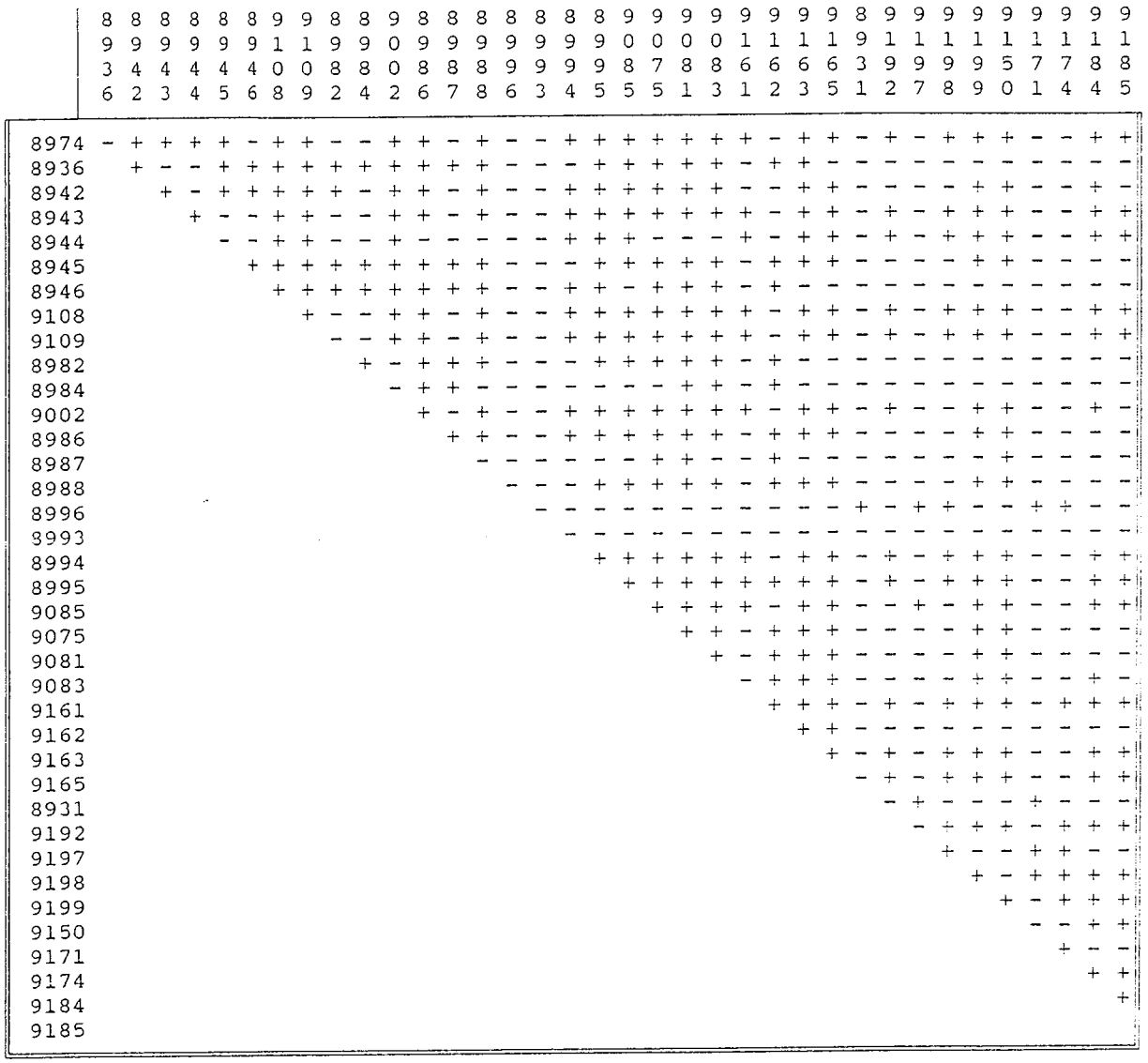
Ho: The means of the bract lengths are equal for all populations of *Pericalymma ellipticum.*

Ha: The means of the bract lengths are not equal for all populations of *Pericalymma ellipticum.*

5.5 DATA ANALYSIS

Data analysis was carried out using a Minitab statistical program for one-way ANOVA (Analysis of Variance). ANOVA was used to compare the variations of bract lengths for the subsets within the area populations and each subset from outside the area populations.

POPULATIONS



\+ = NON SIGNIFIANT ANOVA VARIATION OF MEANS
\- = SIGNIFIANT ANOVA VARIATION OF MEANS

FIGURE 2

Analysis of ANOVA data comparing like (+) and unlike populations (-).

Appendix 1 shows in tabular form the means and the 95% confidence intervals of all 37 subsets using a pooled standard deviation. The resultant table shows one major data entry error for population sample 8974 and the remaining data are too clustered and confused for interpretation purposes, due to the population complexity and number of samples. Individual ANOVA's were carried out using the corrected data for sample 8974 in an attempt to reduce the pooling effect created by the larger sample size. Some subsets were recombined during the preliminary analysis as they were found not to be significantly different (8944A and 8944B) and treated as a single population (8944).

Appendix 2 shows several samples of the individual ANOVAs to illustrate significant variation of the means and several non significant variations for selected populations. Significant variations are shown as 2 lines on a bar graph in which the separate lines depict the means (*) and the 95% confidence intervals (---) for each population with no overlapping of the 2 lines. If overlapping occurs then the population means are not significantly different. Each subset was compared with all other subsets and Figure 2 is a summary of these results. Individual analysis was necessary to establish if any significant differences between the means occurred on a one to one basis. Example 1 of Appendix 2 (8974, 8936) shows an underscored graph that is not distinct (slight overlapping of confidence intervals) and the checking of F calculated values against F critical table values with degrees of freedom of 1 and 18 was necessary. The F calculated value 8.99 from example 1 and the F critical table value of 8.28 at a 1% confidence level indicated that the means were significant as the F calculated value was greater than the F critical value. This procedure was used to separate other populations that appeared uncertain as to the level of

significance presented by the underscoring graph and the probability value from the analysis table.

In Figure 2 the populations that are significantly different are indicated as negative (-) and those that are not significantly different as positive (+). Comparing populations 8974 and 8944, no significant difference was found and it may be concluded that these two populations are similar. Comparing populations 8974 and 8936 a significant difference was indicated and it may be concluded that these two populations are not similar. From the data in Figure 2 one population (8993) was found to be highly significantly different from any other population but when accepting that some populations should be similar, this extreme variation suggests a need for further investigation. Table 2 shows the frequency and the percentage of individual populations that are significantly different from each other (*F) and the frequency of non significant (NSF) populations.

Data in Table 2 is calculated by counting the number of - symbols from Figure 2 to obtain the frequency of significant populations and the + symbols the non significant populations for each collection number. The percentage of significant populations is determined from the total number of populations eg. 8974 has 12 out of 36 populations (33%) that are significant.

TABLE 2

Number of individual populations that are significant (*F) or non- significant (NSF) on the bases of oneway ANOVA analysis

	*F		NSF
POPULATION	No.	%	No.
8974	12	33	24
8936	17	47	19
8942	14	38	22
8943	13	36	23
8944	19	52	17
8945	14	38	22
8946	19	52	17
9108	10	27	26
9109	10	27	26
8982	22	61	14
8984	27	75	9
9002	12	33	24
8986	12	33	24
8987	26	72	10
8988	15	42	21
8996	31	86	6
8993	36	100	0
8994	13	36	23
8995	8	22	18
9085	11	31	25
9075	13	36	23
9081	12	33	24
9083	12	33	24
9161	17	47	19
9162	21	58	15
9163	10	27	26
9165	11	31	25
8931	33	92	3
9192	23	64	13
9197	30	83	6
9198	18	50	8
9199	11	31	25
9150	12	33	24
9171	31	86	5
9174	27	75	9
9184	16	44	20
9185	19	52	17

*F = frequency of a significant population from other populations

NSF = Frequency of a non significant population from other populations

From Table 2 populations that are significantly different in the upper 50% range, allowed an arbitrary sort of like populations to be conducted. This arbitrary sort indicated that a least 42% of the sampled populations were significantly different from each other. This analysis of the subsets that covered the range of the populations indicated that the degree of separation was still too broad and further analysis was warranted with combinations of similar subsets within the arbitrary geographic population boundaries (Figure 3). Combining similar area populations reduced the overall sample size from 43 to 23 subsets. Several of these combinations were a direct result of the previous analysis that indicated populations separated on flower colour from the same sample site or from different habitat positions within the same location were not significantly different.

ANOVA analysis of the within populations to check the validity of these population combinations was undertaken. Populations that were not significantly different were combined and Table 3 shows the relationships of all the populations with other like populations in an attempt to examine the overall possible combinations.

From the data in table 3 two populations appeared to have no affinities (8993 and 8996) with any of the other populations. This lack of likeness includes populations from the same arbitrary areas although different habitats were involved.

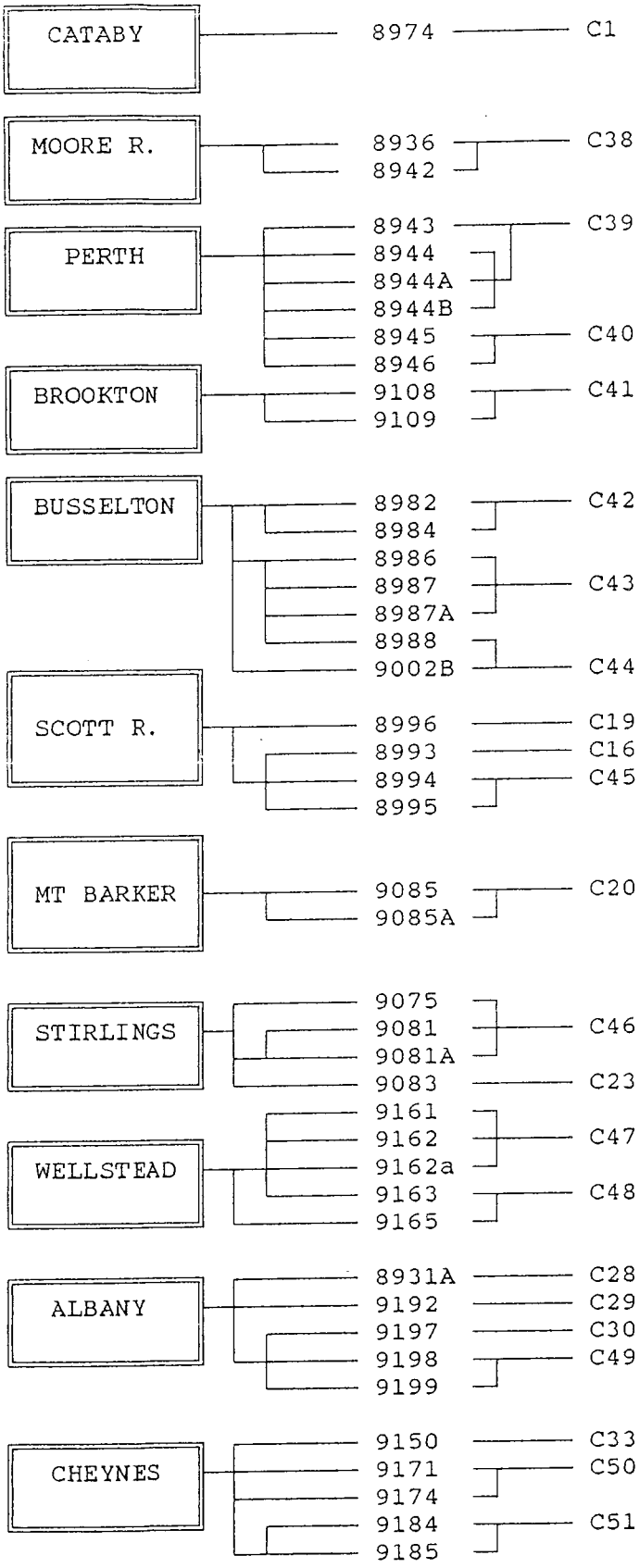


FIGURE 3
Combination of similar populations while maintaing area boundaries.
The resultant population is coded with a C number for analysis.

	COMBINED POPULATIONS																						
No.	C 1	C 38	C 39	C 40	C 41	C 42	C 43	C 44	C 19	C 16	C 45	C 20	C 46	C 23	C 47	C 48	C 28	C 29	C 30	C 49	C 33	C 50	C 51
C1		-	+	-	+	-	-	+	-	-	+	+	-	+	+	+	-	+	-	+	+	-	+
C38			-	+	+	-	+	+	-	-	-	-	+	+	+	-	-	-	-	-	+	-	-
C39				-	+	-	-	-	-	-	+	+	-	-	+	+	-	+	-	+	+	-	+
C40					-	+	+	+	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-
C41						-	-	+	-	-	+	+	+	+	+	+	-	+	-	-	+	-	+
C42							+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C43								-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-
C44									-	-	+	+	+	+	+	+	-	-	-	-	+	-	-
C19										-	-	-	-	-	-	-	+	-	+	-	-	+	-
C16											-	-	-	-	-	-	-	-	-	-	-	-	-
C45												+	-	+	+	+	-	+	-	+	+	-	+
C20													-	+	+	+	-	+	-	+	+	-	+
C46														+	+	-	-	-	-	-	+	-	-
C23															+	+	-	-	-	-	+	-	-
C47																+	-	+	-	+	+	-	+
C48																	-	+	-	+	+	-	+
C28																		-	+	-	-	-	-
C29																			-	+	+	-	+
C30																				-	-	+	-
C49																					+	+	+
C33																						-	+
C50																							-
C51																							

\+ = LIKE POPULATIONS
\- = UNLIKE POPULATIONS
C = COMBINED POPULATIONS FROM FIGURE 2

FIGURE 4

Analysis of ANOVA data comparing combined like populations to showing relationships between populations.

AREA	POPULATION No.	LIKE POPULATION *
CATABY	8974	SINGLE SAMPLE
MOORE R.	8936	8942
	8942	8936
PERTH	8943	8944 8944A 8944B
	8944	8944A 8944B 8943
	8944A	8944B 8944 8943
	8944B	8944 8944A 8943
	8945	8946
	8946	8945
BROOKTON	9108	9109
	9109	9108
BUSSELTON	8982	8984 8986 8987 8987A 8988
	8984	8982 8986 8987 8987A 8988
	8986	8982 8984 8987 8988 002B
	8987	8982 8984 8987A 8988
	8987A	8982 8984 8987
	8988	8986 8987 9002B
	9002B	8988 8986
SCOTT R.	8993	
	8994	8995
	8995	8994
	8996	
MT BARKER	9085	9085A
	9085A	90085
STIRLINGS	9075	9081 9081A 9083
	9081	9075 9081A 9083
	9081A	9075 9081 9083
	9083	9075 9081 9081A
WELLLSREAD	9161	9162 9162A 9163 9165
	9162	9161 9162 9163 9165
	9162A	9161 9162 9163 9165
	9163	9161 9162 9162A 9165
	9165	9161 9162 9162A 9163
ALBANY	8931	9197
	9192	9198 9199
	9197	9198 8931
	9198	9199 9192 9197
	9199	9198 9192
CHEYNES	9150	9184 9185
	9171	9174
	9174	9184 9185 9171
	9184	9185 9150
	9185	9174 9184 9150

TABLE 3
Population comparison from same areas
(Within populations)

* Populations that are not significantly different from a given population

Summation of the ANOVA analysis results for these combined subsets (Figure 4) in which populations were tested for variance within the subsets and against the arbitrary sample boundaries as shown in Figure 3. Data analysis indicated that population 8993 was once again highly significant with no similar affinities to other sampled populations.

Table 4 shows the significance levels of the analysed populations and selection of the top 70% of the highly significant groups (*F), indicated that 30% of the populations vary significantly.

TABLE 4

Number of combined populations that are

significant (*F) or non-significant (NSF) based on oneway ANOVA analysis

	*F		NSF
POPULATION	No.	%	No.
C1	10	45	12
C38	14	64	8
C39	12	55	10
C40	15	68	7
C41	9	41	13
C42	20	91	2
C43	16	73	6
C44	11	50	11
C19	19	86	3
C16	22	100	0
C45	10	45	12
C20	10	45	12
C46	14	64	8
C23	10	45	12
C47	6	27	16
C48	10	45	12
C28	20	91	2
C29	12	55	10
C30	19	86	3
C49	12	55	10
C33	8	36	14
C50	19	86	3
C51	12	55	10

*F = frequency of a significant population from other populations.

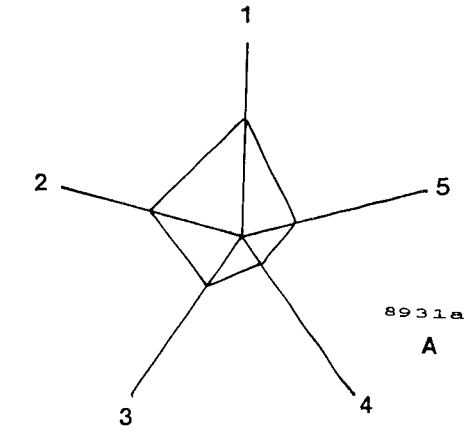
NSF = frequency of a non significant population from other populations.

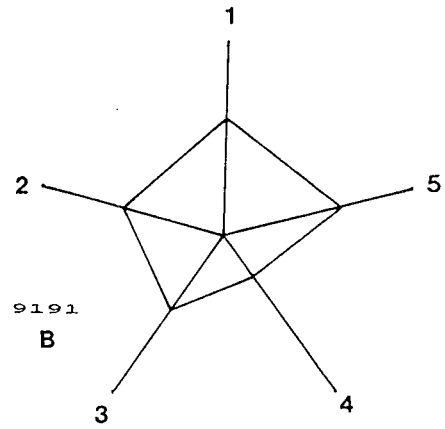
Accepting this ANOVA analysis for the combined area populations has indicated that the highly (80-100%) significant populations 8931A(C28), 9197(C30), 9171, 9174(C50) are similar to each other but vary from the other populations with the exception of 8993(C16) that should be similar to the others but appears to be distinct and may be a result of other influences. In Table 4 the top 85% of the significant populations encompassed the above 5 populations but also included another 3 populations 8996 (C19) and 8982, 8984 (C42) of which 8996 appears unique, 8982, 8984 remain confused as indicated in Table 3. The use of others characters may show that population 8993 is at an extreme of the species range or possibly an intergrade with an unknown population. Population 8996 appears to be unique with some alliances to 8931A, 9197 and 9171 although the use of other characters may be warranted to complete separation and indicate a possible new species. The remaining populations that fall in the top 70% level of the combined area ANOVA (Table 4) consisted of several populations that although indicating a highly significant difference, revealed under analysis that they are not significantly different from each other and have some affinities with other populations.

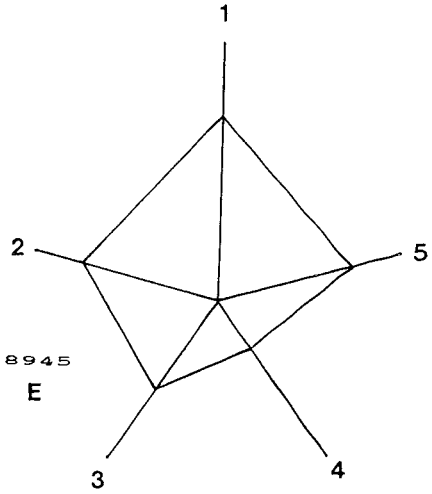
It was obvious from this data that other characters and possibly other techniques were required to assist with the sorting of the populations in an attempt to relate these populations to species concepts.

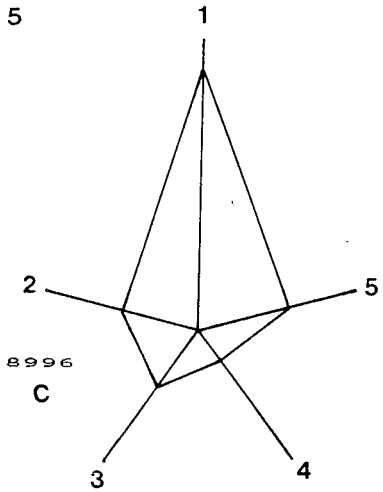
5.6 POLYGON GRAPHING

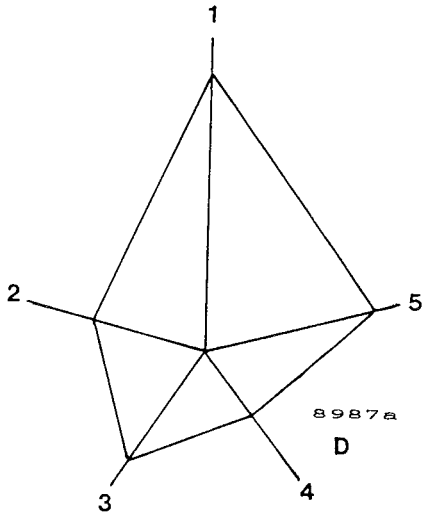
Figure 5 shows 5 defined polygon shapes that was found to be constituent within the *Pericalymma ellipticum* complex. This constituency of shape variability











LEGEND

1. Leaves
2. Floral Leaves
3. Bracts
4. Sepals
5. Petals

FIGURE 5
Polygon graphs of tentative *Pericalymma* taxa.
(mean lengths in mm)
A-E represent taxa with collection numbers

enabled the grouping of 5 possible species or subspecies levels (A-E) for *Pericalymma* to be segregated. When comparing actual populations of *Pericalymma* with the separated polygon divisions a tentative sample sorting was completed. Comparing these sorted groups with the results of the ANOVA analysis the divisions established were very similar. Polygon graphs allow for a broader interpretation of results to be accepted as we are only comparing graph shapes and visualising all of the characters. ANOVA looks critically at selected mean variations mathematically using narrow unbiased data and applying to a set acceptance level which is usually $p = 0.01$. Comparing the results from these two methods the populations that show overlapping (intergrade) problems are consistently the same, although ANOVA analysed only involved bract lengths. Table 5 shows the results of this tentative separation of *Pericalymma ellipticum* populations using both the ANOVA results and polygon graphing. Comparing both sets of data with the collected samples it became apparent that there were two major groups that could be easily separated. This initial separation was based on stem types related to the swollen soft stems typically found in *Pericalymma crassipes* and the normal hard stem type of *Pericalymma ellipticum*. In Table 5 this division is reflected in the tentative species groups A-B for the *P. crassipes* complex and D-E for the *P. ellipticum* complex, while species C remains a possible new species. Species C shows a relationship to group A-B as it has swollen softish stem character but with other major character difference.

TABLE 5

Tentative species and associated populations

TENTATIVE SPECIES	POPULATIONS
A	8931A, 8993, *9171, *9083, *9197
B	*8946, 9081, 9085, 9150, 9161, 9162, 9163, 9165, 9174, 9184, 9185, 9192, 9198, 9199
C	8996
D	8943, 8944, 8974, 8982, 8986, 8987A, 9002B, 9109
E	8936, 8942, 8945, 8984, 8988, 8994, 8995, 9075, 9108

* Shows possible intergrades between taxa

A comparison of Tables 4 and 5 with Figure 5 was carried out to examine the ANOVA generated divisions based on percentage of significance at various levels and polygonal graph divisions. The results of this comparison are presented in Table 6.

TABLE 6

Comparison of percentage levels of ANOVA significance to sampled populations and the resultant tentative species divisions

SIGNIFICANCE (%)	POPULATIONS		TENTATIVE SPECIES
70-100	C42	8982	D
		8984	E
	C43	8986	D
		8987	D
	C19	8996	C
	C16	8993	A
	C28	8931A	A
	C30	9197	*A
	C50	9171	*A
		9174	B
50-69	C38	8936	E
		8942	E
	C39	8943	D
		8944	D
	C40	8945	E
		8946	*B
	C44	9002B	D
	C46	9075	E
		9081	B
	C29	9192	B
	C49	9198	B
		9199	B
	C51	9184	B
		9185	B
0-49	C1	8974	D

C41	9108	E
	9109	D
C45	8994	E
	8995	E
C20	9085	B
C23	9083	*A
C47	9161	B
	9162	B
C48	9163	B
	9165	B
C33	9150	B

* Indicates a possible intergrade species

C = a combined population with an assigned arbitrary number

The data in Table 6 show that several of the population combinations that were selected for analysis are in fact a mixture of the species groups A-E. This mixing of populations may account for the closeness of variations in the ANOVA results that indicated that some populations had affinities when field evidence hinted otherwise. Species groups A and C were separated in the upper 70% as indicated in table 4 with one intergrade (*A) species mixed in a closely related species group B. The D group appears to segregate at the 70% level while the E group partly separates at the 50% level. High levels of variability appear to be present in the B group as representation of this group is common in both the 0-49% and 50-69% levels.

To select a true representative specimen from the species A-E (Table 5) a further set of polygon graphs were drawn which displayed all of the mean length characters for each of the selected species Figure 5. This set of graphs illustrated clearly that there was a difference although the basic shape is similar.

Considerable variation in leaf and petal lengths (characters 1 and 5) was demonstrated, while the remaining 3 characters are basically the same with little length variations. From these graphs it was clear that other characters required closer investigation if a complete separation was to be possible at the species rank. Table 7 lists all 5 of mean lengths of the species selected used to plot the polygon graphs shown in Figure 5.

TABLE 7

POLYGON GRAPH DATA FOR POPULATIONS A-E

mean lengths in mm

SPECIES	1	2	3	4	5
A 8931A	3.7	3.1	2.0	1.1	1.6
B 9192	3.5	2.8	2.8	1.5	3.5
C 8996	8.1	2.5	2.2	1.2	2.9
D 8987A	8.6	3.7	4.1	2.4	5.3
E 8945	5.8	4.4	3.4	1.9	4.4

1 = LEAF LENGTH, 2 = FLORAL LEAF LENGTH, 3 = BRACT LENGTH, 4 = SEPAL LENGTH, 5 = PETAL LENGTH

5.7 ANOVA ANALYSIS OF ANATOMICALLY SEPARATED POPULATIONS

Applying ANOVA analysis to the 5 possible populations separated as a result of the anatomical studies, the following scheme (Appendix 3) was developed as a test to check the validity of the variations described. In the previous chapter on

wood anatomy, variations observed indicated that a tentative separation of the populations may be possible but further investigations were required. Results indicated that there was a group that would easily separate but other groups showed up as a continuum and the divisions were arbitrary and inconclusive. Analysis was carried out using the data for all 5 length and width characters for the selected populations. Table 8 shows the mean lengths for the anatomically separated populations extremes along with 3 intermediates.

TABLE 8

POLYGON GRAPH DATA FOR ANATOMICAL DERIVED POPULATIONS

mean lengths in mm

POPULATION	1	2	3	4	5
8931A	3.7	3.1	2.0	1.1	1.6
9192	3.5	2.8	2.8	1.5	3.5
8996	8.1	2.5	2.2	1.9	2.9
9002	6.5	3.1	3.2	2.0	4.6
8936	6.0	4.1	3.5	2.2	4.9

1 = LEAF LENGTH, 2 = FLORAL LEAF LENGTH, 3 = BRACT LENGTH, 4 = SEPAL LENGTH, 5 = PETAL LENGTH

Superficially using the mean lengths from table 8 it is apparent that there is some variation between the populations that require closer investigation. Considering that populations 8931A, 9192 are close and that 9002, 8936 appear to be related

and that 8996 appeared to be unique earlier now shows some affinities to the other populations. This indicates that further analysis of all the characters (length and width) using one-way ANOVA require investigation and Appendix 3 presents these results of this investigation.

Appendix 3 shows that not all of the characters are mutually exclusive and this diverse variation has been investigated earlier and was one of the main reasons for selecting bract lengths for analysis. The data presented a similar pattern to the previous analysis in that certain populations separated easily while others remained confused and complex. No one character could be used to effectively separate all the populations and a combination of characters was required. In Figure 6 an attempt has been made to demonstrate the populations that are significantly different for each character. Each polygon shape represents a floral character depicting the separated populations on the axes 1-5. Lines were drawn joining populations in which the individual characters aree not significant while the significant characters are not joined. From the leaf length character it is clear that population 1 and 2 are similar, but different from populations 3, 4 and 5 which are similar to each other. Populations 3 and 2 are significantly different for the leaf length character as are populations 5 and 1. Population 2 using the leaf widths is similar to populations 4 and 5, while 1 and 3 have no alliance to any of the populations. Floral leaf lengths are not significantly different for all of the populations while the floral widths do show a degree of non significance. From this illustration it would appear that petal length may be the best character to base any analysis upon. This character was rejected as habitat and environmental factors and the possible damage inflicted by insects can result in loss or alter the petal size drastically. Bract length was selected as the character least likely to be damaged or altered by external forces. In fact it is a feature of

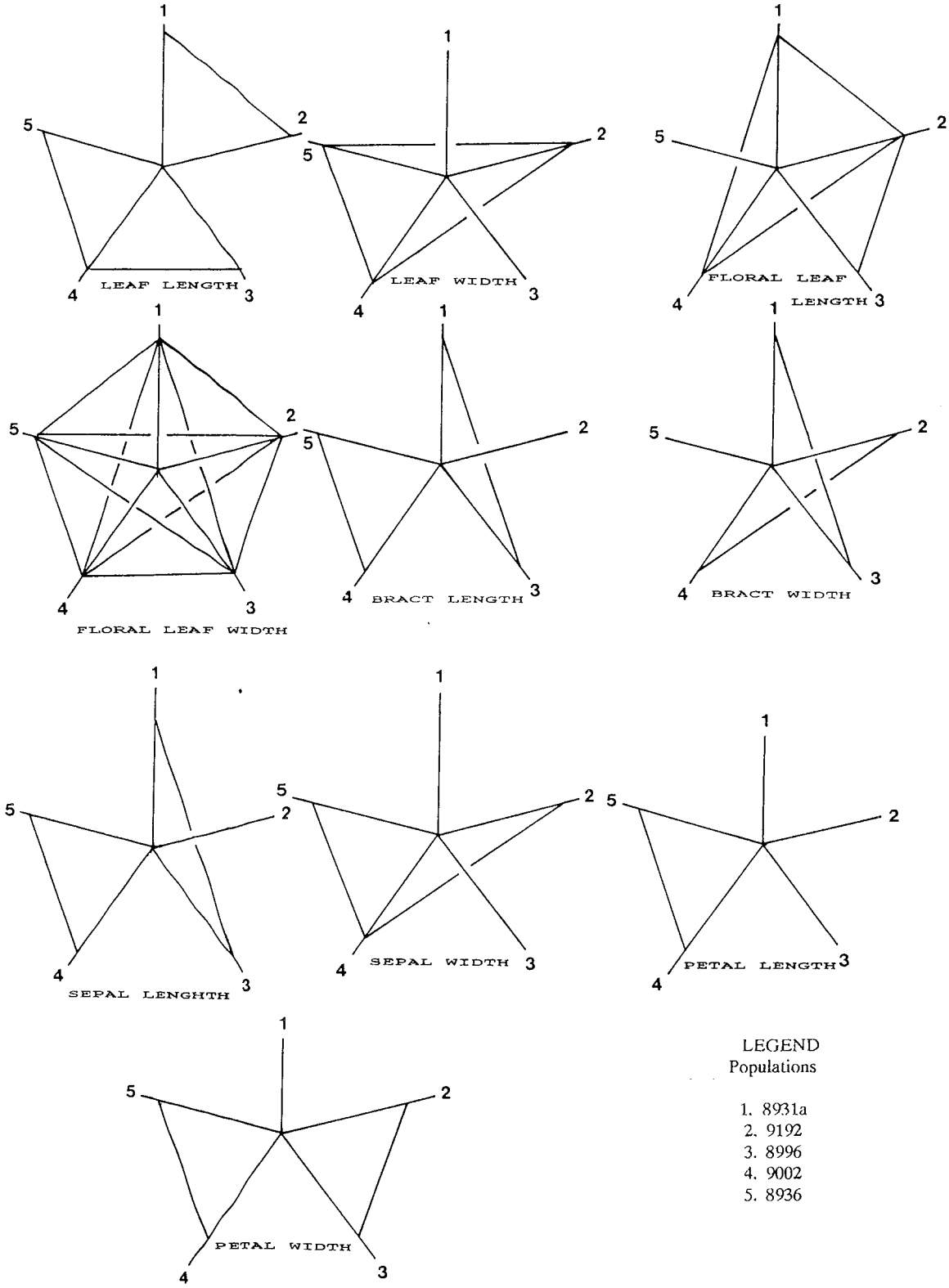


FIGURE 6
Graphic representation populations with similar floral character measurements (lengths in mm). Linked populations have characters that are not significant

Pericalymma that the bract persists even at the old fruit stage. Sepal length was another possible character which could have been used, but could be damaged by the above mentioned factors.

5.8 CONCLUSIONS

Data from both one-way ANOVA variance analysis and polygon graphing indicated that some populations could be separated as both methods supported similar divisions. The ANOVA results agreed with the drawn polygon graph shapes even though the results were based on a different number of characters and confidence levels. The polygon graph takes into account all characters and gives a quicker visual method of separation but discounts any possible relationships between the populations if extreme variations from the established shape were encountered. The ANOVA analysis indicated that, as was previously suspected by Thompson (1983), the complex nature and the plasticity of characters in *Pericalymma* required more than a simple investigation method. ANOVAs accurately allowed populations to be tested and their relationships to be studied over the full habitat distribution of the complex. Both analysis methods indicated that *Pericalymma ellipticum* could be divided into at least 5 species or a combination of subspecies.

The numerical analysis of the data has supported the impression that population 8931A as unique, an assumption made from previous anatomical studies of the stem tissues. The other tentative classifications based upon the anatomical assumptions in most cases, have been found to be correct and in some cases extended in an attempt to separate close populations. Population 8931A, although unique, has affinities to other populations, 9192 and 8996. Population

8996 appears to be unique and separates from 8931A and 9192 when other characters are taken into account indicating that this may be a new species. This becomes clear when the polygon graphs are consulted and has been supported by further ANOVA analysis using other characters as indicated by the polygon. The overlap of data for populations 9192 and its close affinity to 8931A tend to suggest that this may be a subspecies of 8931A. Populations 9002 and 8936 are still very confused and separation is difficult as there appears to be a plasticity of characters in both populations that overlap. This would suggest that these two populations are similar and that a subspecies may be evolving that requires further investigation. The main difference appears to be the length of the petals that is a character influenced by other external factors and may warrant the rank of variety.

5.9 REFERENCES

Briggs, D. and Walters, S.M. (1986). Plant variation and evolution. 2nd ed. Cambridge: Cambridge University press, pp. 205-207.

Sneath, P.H.A. and Sokal, R.R. (1973). Numerical Taxonomy. San Francisco: W.H. Freeman and Company.

Thompson, J. (1983). Redefinitions and nomenclatural changes within the *Leptospermum* suballiance of Myrtaceae. Telopea, 2: 379-383.

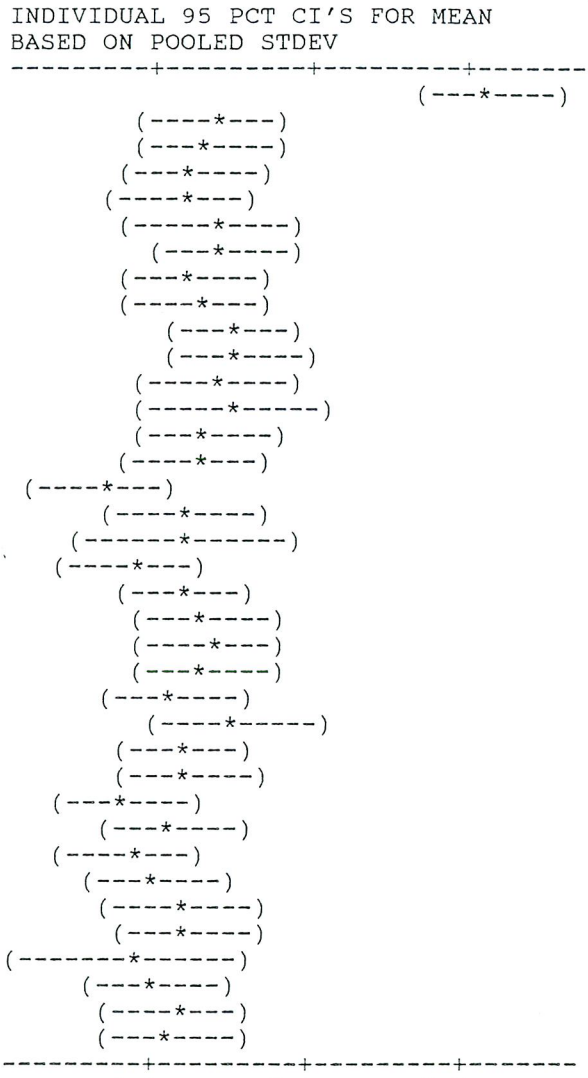
APPENDIX 1

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	36	307.63	8.55	2.68	0.000
ERROR	303	965.38	3.19		
TOTAL	339	1273.01			

LEVEL	N	MEAN	STDEV
8974	10	7.800	10.191
8936	10	3.450	0.284
8942	10	3.300	0.283
8943	10	3.050	0.242
8944	10	2.920	0.175
8945	7	3.414	0.234
8946	10	3.600	0.442
9108	10	3.080	0.361
9109	10	3.150	0.409
8982	10	3.740	0.381
8984	10	3.790	0.331
8986	7	3.471	0.335
8987	6	3.783	0.264
8988	10	3.370	0.254
9002a	10	3.170	0.206
8993	10	1.640	0.272
8994	7	2.971	0.221
8995	4	3.100	0.346
8996	10	2.180	0.336
9085	10	3.010	0.378
9075	10	3.370	0.271
9081	10	3.410	0.325
9083	10	3.280	0.308
9161	10	2.790	0.354
9162	7	3.829	0.403
9163	10	2.990	0.401
9165	10	3.060	0.259
8931	10	2.030	0.149
9192	10	2.810	0.370
9197	10	2.140	0.433
9198	10	2.610	0.428
9199	8	2.925	0.377
9150	10	3.090	0.260
9171	4	2.125	0.250
9174	10	2.530	0.245
9184	10	2.930	0.347
9185	10	2.790	0.311

POOLED STDEV = 1.785



APPENDIX 1

One way ANOVA showing the mean bract lengths for all *Pericalymma* populations based on a pooled standard deviation at the 95% confidence interval.

APPENDIX 2

```
ANALYSIS OF VARIANCE
SOURCE      DF        SS         MS         F        p
FACTOR       1    0.8820     0.8820      8.99    0.008    **
ERROR       18    1.7660     0.0981
TOTAL       19    2.6480

                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
 LEVEL       N       MEAN      STDEV    --------+---------+---------+--------
8974        10     3.0300     0.3401     (-------*--------)
8936        10     3.4500     0.2838                      (-------*-------)
                                        --------+---------+---------+--------
POOLED STDEV =     0.3132                    3.00      3.25      3.50


ANALYSIS OF VARIANCE
SOURCE      DF        SS         MS         F        p
FACTOR       1    0.3645     0.3645      3.73    0.069   NS
ERROR       18    1.7610     0.0978
TOTAL       19    2.1255

                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
 LEVEL       N       MEAN      STDEV    ---------+---------+---------+-------
8974        10     3.0300     0.3401    (----------*---------)
8942        10     3.3000     0.2828                (---------*---------)
                                        ---------+---------+---------+-------
POOLED STDEV =     0.3128                    3.00      3.20      3.40


ANALYSIS OF VARIANCE
SOURCE      DF        SS         MS         F        p
FACTOR       1    0.0020     0.0020      0.02    0.881  NS
ERROR       18    1.5660     0.0870
TOTAL       19    1.5680

                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
 LEVEL       N       MEAN      STDEV    ----+---------+---------+---------+--
8974        10     3.0300     0.3401    (---------------*---------------)
8943        10     3.0500     0.2415      (---------------*---------------)
                                        ----+---------+---------+---------+--
POOLED STDEV =     0.2950                  2.88      3.00      3.12      3.24
MTB > aovo c1 c5

ANALYSIS OF VARIANCE
SOURCE      DF        SS         MS         F        p
FACTOR       1    0.0605     0.0605      0.83    0.375  NS
ERROR       18    1.3170     0.0732
TOTAL       19    1.3775

                                        INDIVIDUAL 95 PCT CI'S FOR MEAN
                                        BASED ON POOLED STDEV
 LEVEL       N       MEAN      STDEV    --------+---------+---------+--------
8974        10     3.0300     0.3401             (-----------*-----------)
8944        10     2.9200     0.1751     (-----------*-----------)
                                        --------+---------+---------+--------
POOLED STDEV =     0.2705                    2.85      3.00      3.15
```

APPENDIX 2

Selected ANOVA anaylsis of individual populations to show significant (**) and non significant (NS) populations.

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	
FACTOR	1	1.984	1.984	14.40	0.001	**
ERROR	18	2.481	0.138			
TOTAL	19	4.465				

LEVEL	N	MEAN	STDEV
8931	10	0.8700	0.2791
9192	10	1.5000	0.4447

POOLED STDEV = 0.3713

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

```
---+---------+---------+---------+---
 (------*------)
                   (------*------)
---+---------+---------+---------+---
 0.70      1.05      1.40      1.75
```

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	
FACTOR	1	0.3645	0.3645	7.80	0.012	NS
ERROR	18	0.8410	0.0467			
TOTAL	19	1.2055				

LEVEL	N	MEAN	STDEV
9002	10	1.9500	0.2506
8936	10	2.2200	0.1751

POOLED STDEV = 0.2162

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

```
--------+---------+---------+--------
 (--------*--------)
                  (--------*--------)
--------+---------+---------+--------
      1.92      2.08      2.24
```

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p	
FACTOR	1	0.002	0.002	0.01	0.927	NS
ERROR	18	4.116	0.229			
TOTAL	19	4.118				

LEVEL	N	MEAN	STDEV
9192	10	2.7200	0.4417
8996	10	2.7000	0.5121

POOLED STDEV = 0.4782

INDIVIDUAL 95 PCT CI'S FOR MEAN
BASED ON POOLED STDEV

```
-+---------+---------+---------+-----
 (---------------*---------------)
(---------------*---------------)
-+---------+---------+---------+-----
2.40      2.60      2.80      3.00
```

APPENDIX 3

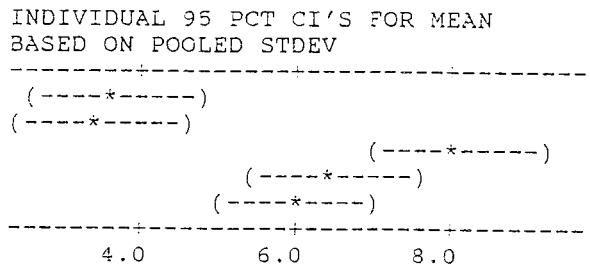
LEAF LENGTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	152.78	38.19	14.01	0.000
ERROR	45	122.64	2.73		
TOTAL	49	275.42			

LEVEL	N	MEAN	STDEV
8931	10	3.690	0.515
9192	10	3.470	1.213
8996	10	8.090	2.438
9002	10	6.450	2.310
8936	10	6.030	0.783

POOLED STDEV = 1.651



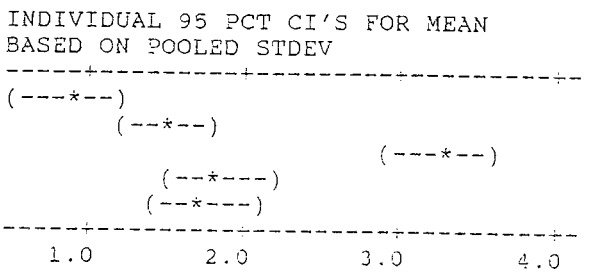
LEAF WIDTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	30.811	7.703	29.05	0.000
ERROR	45	11.931	0.265		
TOTAL	49	42.742			

LEVEL	N	MEAN	STDEV
8931	10	0.8700	0.2791
9192	10	1.5000	0.4447
8996	10	3.2600	0.3514
9002	10	1.8300	0.3093
8936	10	1.7500	0.4790

POOLED STDEV = 0.5149



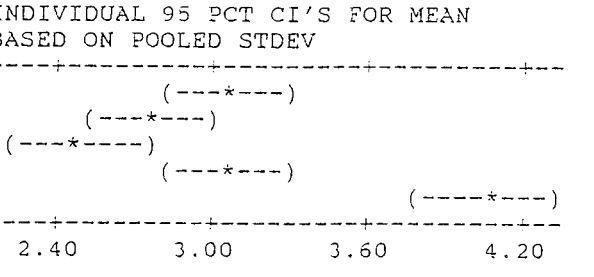
FLORAL LEAF LENGTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	13.515	3.379	20.41	0.000
ERROR	44	7.284	0.166		
TOTAL	48	20.799			

LEVEL	N	MEAN	STDEV
8931	10	3.0500	0.4378
9192	10	2.7700	0.3974
8996	9	2.4889	0.3480
9002	10	3.0600	0.4526
8936	10	4.0500	0.3837

POOLED STDEV = 0.4069



APPENDIX 3

ANOVA analysis of all characters based on anotomically separated species groups.

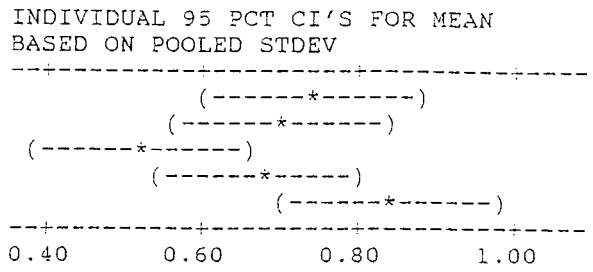
FLORAL LEAF WIDTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	0.5052	0.1263	2.77	0.039
ERROR	44	2.0046	0.0456		
TOTAL	48	2.5098			

LEVEL	N	MEAN	STDEV
8931	10	0.7400	0.2011
9192	10	0.7000	0.2160
8996	9	0.5222	0.1394
9002	10	0.6700	0.3020
8936	10	0.8400	0.1647

POOLED STDEV = 0.2134



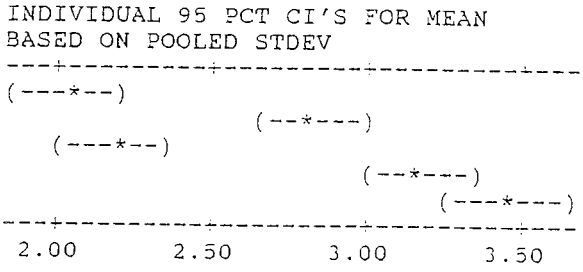
BRACT LENGTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	15.0212	3.7553	47.80	0.000
ERROR	45	3.5350	0.0786		
TOTAL	49	18.5562			

LEVEL	N	MEAN	STDEV
8931	10	2.0300	0.1494
9192	10	2.8100	0.3695
8996	10	2.1800	0.3360
9002	10	3.1600	0.2011
8936	10	3.4500	0.2838

POOLED STDEV = 0.2803



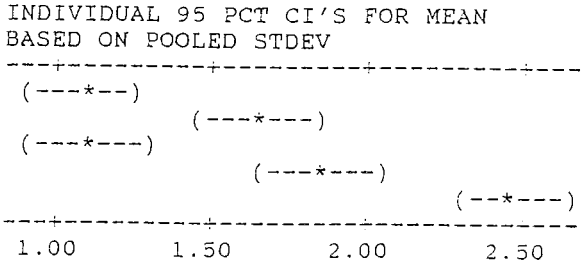
BRACT WIDTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	13.3780	3.3445	36.47	0.000
ERROR	45	4.1270	0.0917		
TOTAL	49	17.5050			

LEVEL	N	MEAN	STDEV
8931	10	1.0800	0.2658
9192	10	1.6500	0.4035
8996	10	1.1000	0.3127
9002	10	1.8500	0.2677
8936	10	2.4700	0.2359

POOLED STDEV = 0.3028



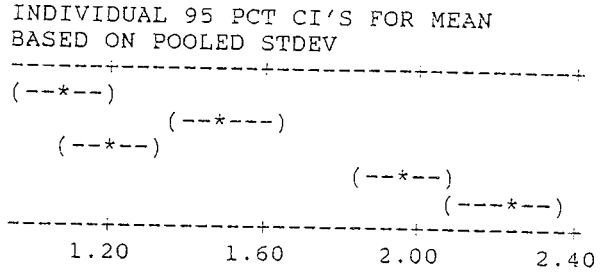
SEPAL LENGTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	9.4460	2.3615	61.82	0.000
ERROR	45	1.7190	0.0382		
TOTAL	49	11.1650			

LEVEL	N	MEAN	STDEV
8931	10	1.0900	0.1969
9192	10	1.5000	0.2000
8996	10	1.1900	0.1370
9002	10	1.9500	0.2506
8936	10	2.2200	0.1751

POOLED STDEV = 0.1954



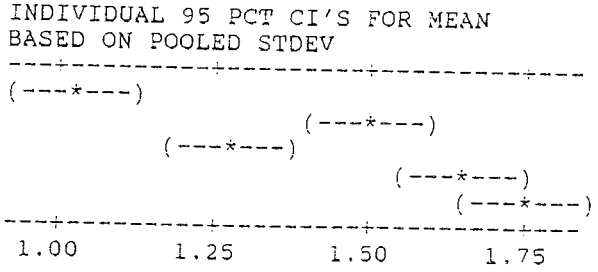
SEPAL WIDTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	3.3800	0.8450	35.87	0.000
ERROR	45	1.0600	0.0236		
TOTAL	49	4.4400			

LEVEL	N	MEAN	STDEV
8931	10	1.0300	0.1059
9192	10	1.5100	0.1287
8996	10	1.2700	0.1494
9002	10	1.6400	0.2319
8936	10	1.7500	0.1179

POOLED STDEV = 0.1535



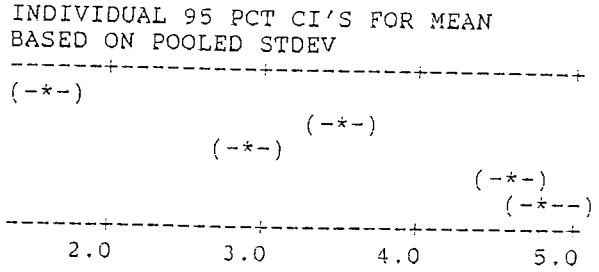
PETAL LENGTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	69.361	17.340	161.96	0.000
ERROR	45	4.818	0.107		
TOTAL	49	74.179			

LEVEL	N	MEAN	STDEV
8931	10	1.6200	0.2098
9192	10	3.5000	0.2867
8996	10	2.9300	0.4692
9002	10	4.6200	0.3048
8936	10	4.8500	0.3100

POOLED STDEV = 0.3272



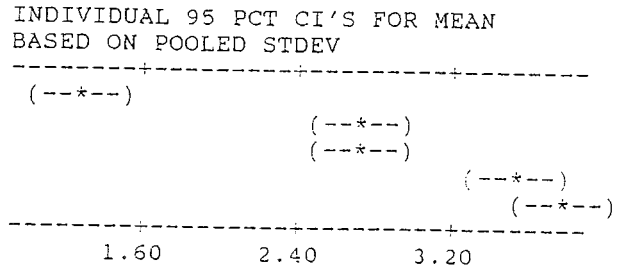
PETAL WIDTH IN MM

ANALYSIS OF VARIANCE

SOURCE	DF	SS	MS	F	p
FACTOR	4	36.807	9.202	59.90	0.000
ERROR	45	6.913	0.154		
TOTAL	49	43.720			

LEVEL	N	MEAN	STDEV
8931	10	1.2800	0.1989
9192	10	2.7200	0.4417
8996	10	2.7000	0.5121
9002	10	3.5000	0.4216
8936	10	3.7300	0.3057

POOLED STDEV = 0.3919



CHAPTER 6.

A REVISION OF THE GENUS Pericalymma (Myrtaceae)

6.1 INTRODUCTION

A revision of *Pericalymma* (Endl.) Endl. (Myrtaceae) is presented with a short discussion on each species. *Pericalymma* is a genus of 4 species endemic to the south west of Western Australia. Thompson's (1983) revision of *Leptospermum* reinstated *Pericalymma* as a monotypic genus based on *Pericalymma ellipticum.* The genus was recognised in a monograph by Endlicher in 1840. Later, Bentham (1866) reduced *Pericalymma* to a section of *Leptospermum.*

I have revised the genus and dealt with individual species complexes, reinstating earlier specific epithets as well as creating new taxa. My account of *Pericalymma* was based on limited herbarium material and extensive field collections. Earlier sections investigated several techniques and species characteristics, the results of these studies are used to help support and segregate four species.

Pericalymma ellipticum has been maintained and *Pericalymma crassipes* has been reinstated; *Pericalymma floridum* has been retained as a variety of *Pericalymma ellipticum.* Two new species are presented along with their protologues in this chapter. These are *P. megaphyllum* Cranfield sp. nov. and *P. spongiocaule* Cranfield sp. nov. A further two possible species were located in the literature (Chapman, 1991), *Pericalymma roseum* and *Pericalymma teretifolium*, both described in 1852. Type photographs for both species were located at the Western Australian Herbarium (PERTH) and were determined as species of *Kunzea.*

6.2 METHODS

This revision is based on the gross morphology of herbarium and fresh material supported by the evidence presented in the initial chapters. Measurements were taken from dried material, detergent-softened where possible. All taxa have been studied in the field to record habit and habitat data, as well as flower colour.

Material housed in Perth was examined. Type photographs of *Pericalymma floridum* (*Leptospermum*), *Pericalymma roseum* and *Pericalymma teretifolium* were sighted. Other types were located but not sighted, and assumptions have been made based on type descriptions. Nominated types of new taxa have been lodged in PERTH.

Diagnoses are provided for infraspecific taxa, and new combinations are presented. The key to species includes all species, infraspecific taxa are keyed out under the respective species.

Maps are provided showing the distribution of all taxa. Localities were plotted by latitude and longitude and maps drawn using a Map Info computer program. The map data was taken from all herbarium collections, vague and general localities have not been mapped.

The conservation status of all species and infraspecific taxa has been assessed and coded where appropriate, according to Department of Conservation and Land Management's rare and endangered flora criteria.

6.3 MORPHOLOGY

Habit. All species are shrubs less than 2.5 m tall. One species appears to attain a height less than 0.45 m and have gnarled stems. All species have dichotomous spreading branchlets with various leaf densities and clustering. Flowers are terminal, white or pink and either solitary or paired.

Stems. Several species (usually single stemmed) have inflated or swollen stems with soft tissue which is brittle. Other species have non-inflated stems with harder tissue that is structurally stronger and are usually multi-stemmed at ground level.

Stem tissues were examined microscopically previously (Chapter 4), and the variations observed by comparing the number of large open vessels with the number of thick walled fibre tracheids present for each sample. Two basic tissue types were observed, one composed of very open tissue which corresponds to the small inflated stemmed species of *Pericalymma crassipes*, and the other type forms a continuum of open to dense tissues of all of the taller species with either inflated or non-inflated stems. The development of this character appears to be a direct reflection of the habitat and stem structural requirements of the different species.

All species appear to be fire-sensitive. The inflated stem species appear to become easily stressed and may die during prolonged droughts or modified habitat.

Leaves. The leaves are simple and vary in size from 1 to 12 mm long and are sessile. The lamina ranges from obovate to narrowly obovate, flat or folded abaxially. Vegetative leaves were investigated in an attempt to find a reliable key character. The range of size and shape variation exhibited was too complex with considerable overlapping present. In Figure 1 a selection of the larger leaves depicting all species is presented to demonstrate this variation. All leaves are drawn at 64x magnification and a mm scale is provided. The leaf shapes are generally narrowly obovate with the exception of sample #8996 which has large obovate leaves and corresponds to *Pericalymma megaphyllum* sp. nov. The obvious presence of a midrib appears to occur mainly in specimens that represent *Pericalymma ellipticum* and are not visible in *Pericalymma crassipes* although varying degrees of ribbing can be seen in other species.

Floral leaves. The 3-5 floral leaves vary in shape and are sessile, or they may be absent (*P. megaphyllum*). The base of the floral leaf is winged; the size of this wing depends upon the position of the floral leaf in relation to the floral bracts. These leaves are usually paired and opposite with the next pair rotated 90 degrees. The lower leaves in some instances can be mistaken for vegetative leaves and the upper leaves tend to merge into the floral bracts. This transitional development from vegetative to floral leaves to floral bracts accounts for the irregular number of floral leaves in the species descriptions.

Floral bracts. The floral bracts are basically ovate, membranous, 1-5 mm long, with varying degrees of hairiness. Similar to the floral leaves, they occur in alternating pairs and have an upper and a lower presentation. The lower bracts tend to be confused with the upper floral leaves and in some instances may have

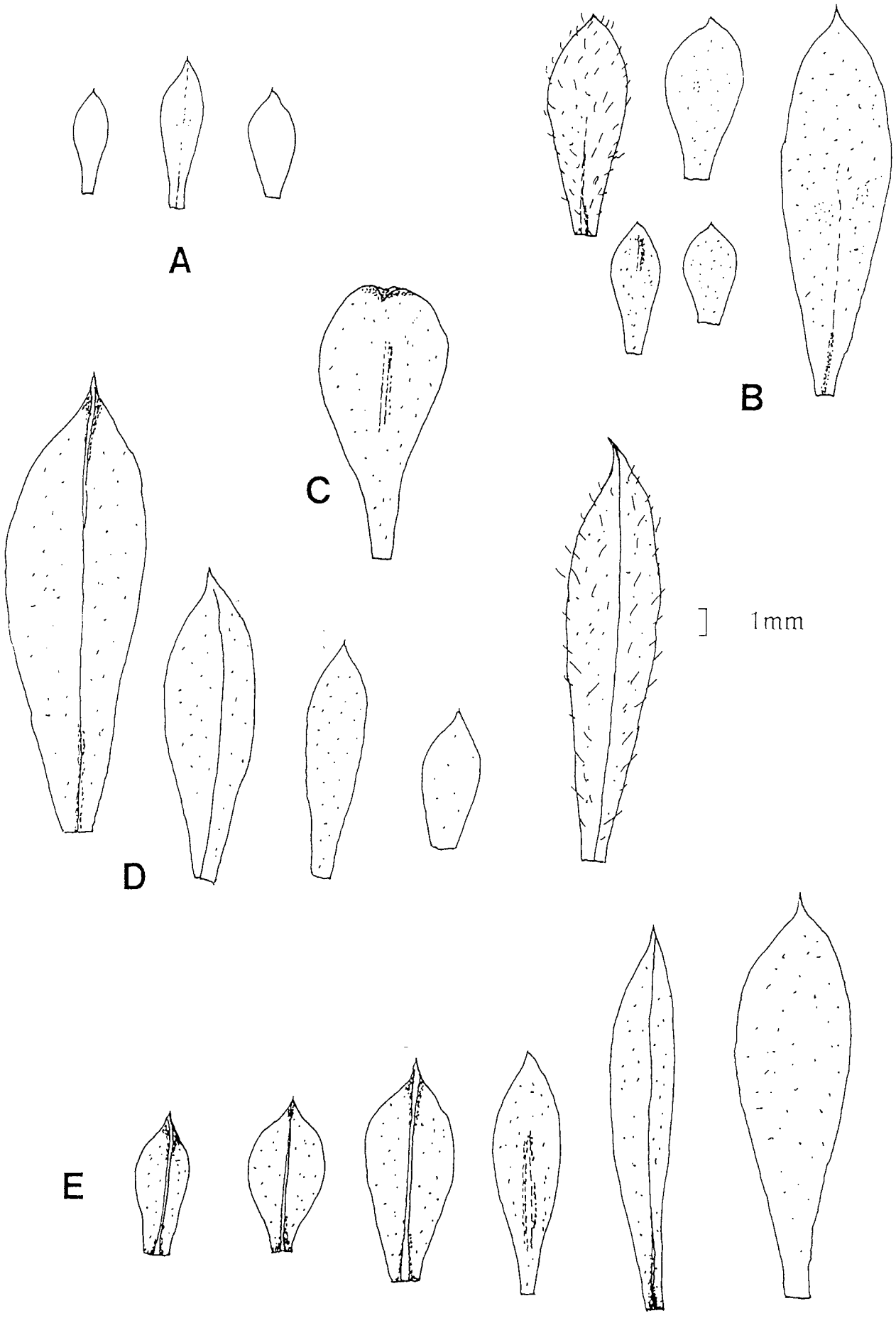


Figure 1. Leaf morphology. A, P. crassipes, B, P. spongiocaule, C, P. megaphyllum, D, P. ellipticum var. floridum, E. P. ellipticum.

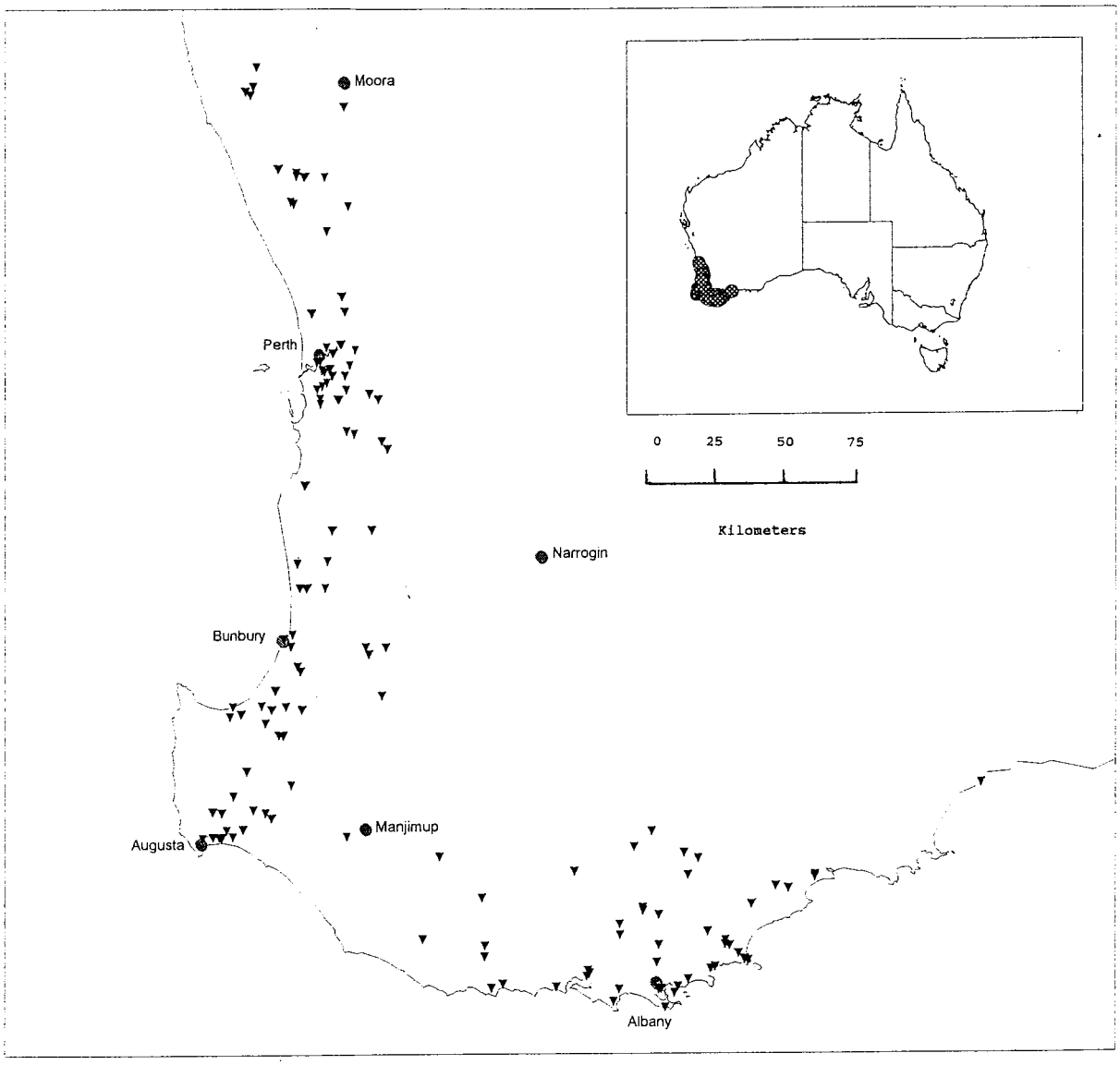
photosynthetic tissue present. The persistence of the bracts on old fruits can be used as an aid in determining vegetative samples of *Pericalymma*.

Figure 2 shows the developmental trend from vegetative leaves to floral bracts indicating that an adaption of vegetative structures is initiated for floral development. These adaptations are a result of flower bud initiation in which the vegetative leaf development is slowed and the leaves modified to protect the developing flowers.

Flowers. The *Pericalymma* flower is similar in appearance in all species with variations in size. There are usually 1 or 2 sessile flowers on the apex of the branchlets. One flower is usually fully open while the other is a well developed bud or an immature fruit. The petals show greater variations in presentation and size, ranging from 1-6 mm long. All petals were measured from the apex to the point of attachment to the hypanthium. *Pericalymma crassipes* petals are small and tend to be inrolled slightly, and are greenish white in colour. Other species of *Pericalymma* have pink or white flowers and tend to be large and presented at 90 degrees to the hypanthium. *Pericalymma ellipticum* var. *floridum* has the largest flowers and it is this feature that characterises this variety.

6.4 GEOGRAPHICAL DISTRIBUTION AND HABITATS

The distribution of the genus *Pericalymma* as shown in Map 1 extends from Cataby in the north to Bremer Bay in the south. Species are restricted to specific habitats in this area. These habitats are frequent in the south west and occur further east than indicated by the distribution of *Pericalymma*. These eastern



Map 1 showing distribution of all Pericalymma species.

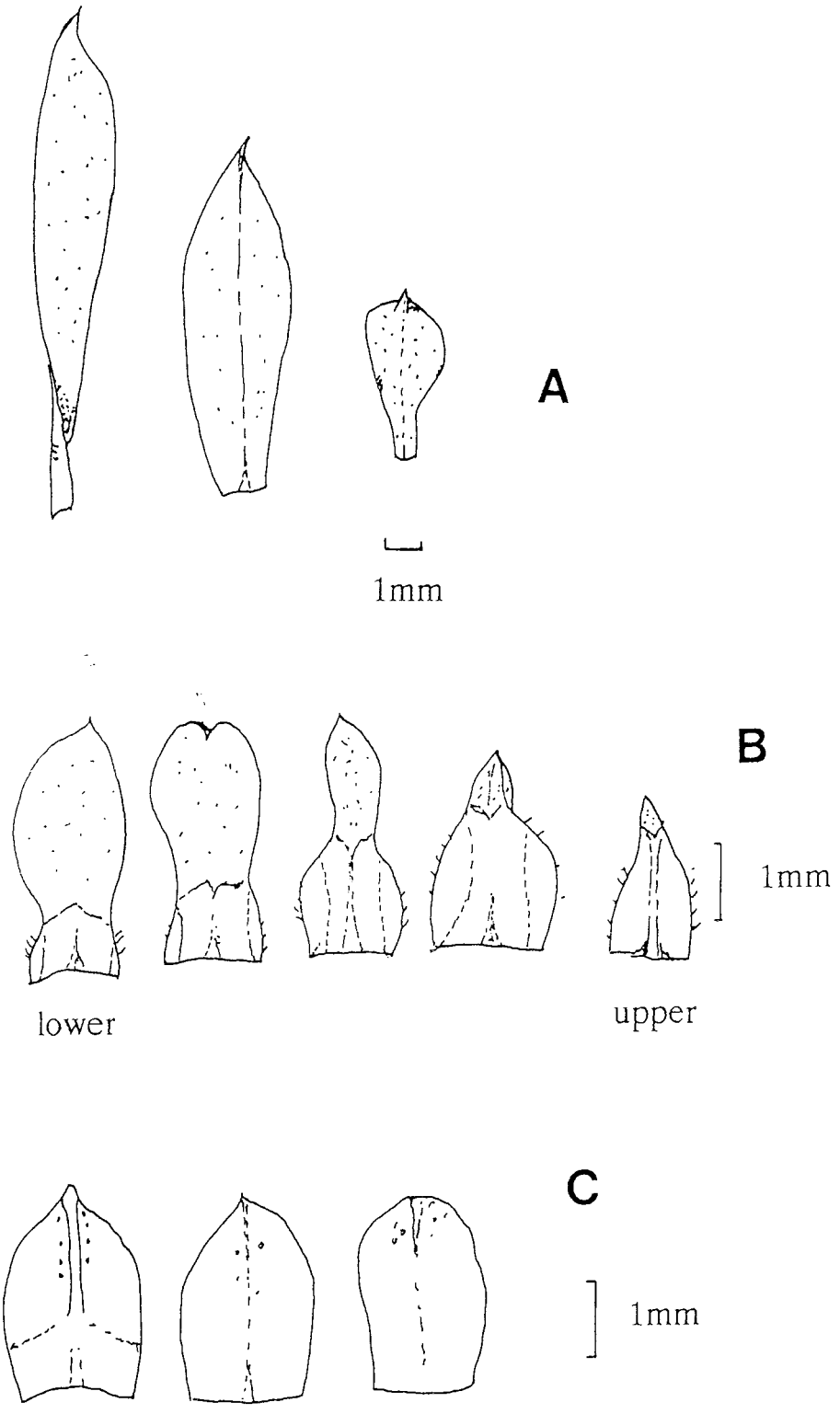


Figure 2. Morphology of vegetative, floral leaves and bracts. A, vegetative leaves, B, floral leaves, C, floral bracts.

habitats are usually dominated by *Agonis* species in the wetter regions and usually replaced by *Leptospermum* species in drier elevated locations. *Pericalymma* species occur in various micro and macro habitats of which there are 3 basic types. Figure 3 depicts these three types of habitats showing possible ecological or evolutionary development of the species, although the direction of this development is unknown.

Type 1 Habitat. Fringing permanent to semi permanent water bodies with associated inundation areas. Occurring in isolated locations throughout the species distribution. Soils are usually leached sands with thin peaty surfaces.

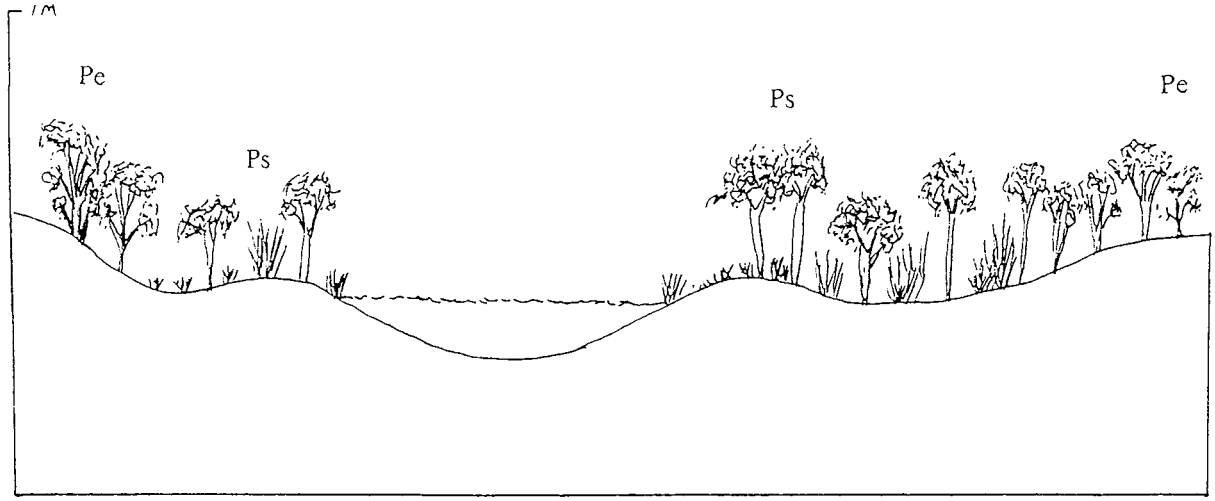
Type 2 Habitat. Low lying poorly drained plains or swampy interdunes to plains with successive swampy flats. Areas subjected to seasonal inundation with fresh water. Soils are leached sands with a peaty surface and a low pH and some associated fringing lateritic gravel soils.

Type 3 Habitat. This is an elevated habitat, mostly occurring in hilly areas on seasonally swampy platforms or foot slopes with drainage channels. Soils are mainly leached sand with some clayey sands associated with lateritic soils.

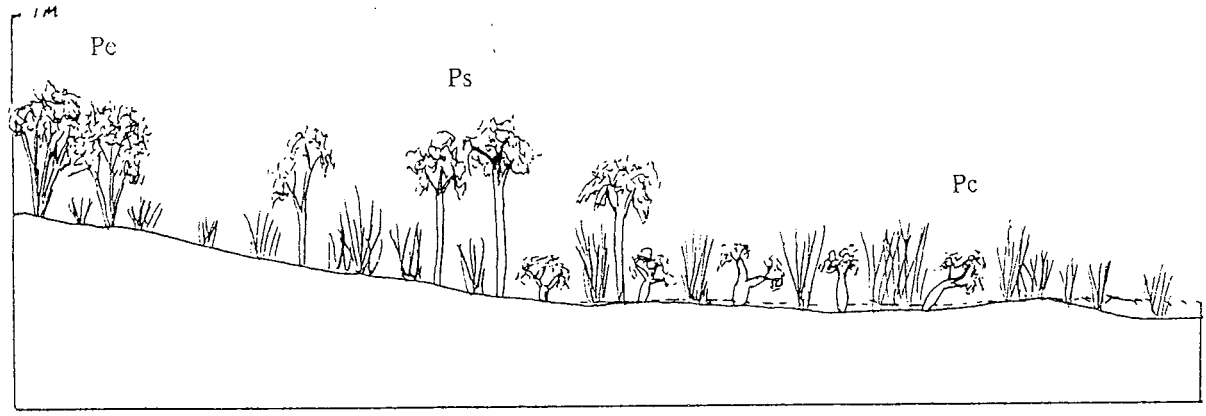
6.5 DISCUSSION

The cumulative results of all morphological studies has enabled the reinstatement of species placed in synonymy (Thompson , 1983) and the creation of two new *Pericalymma* species. No one character could provide a clear and precise separation at the species level, and several correlated characters were required.

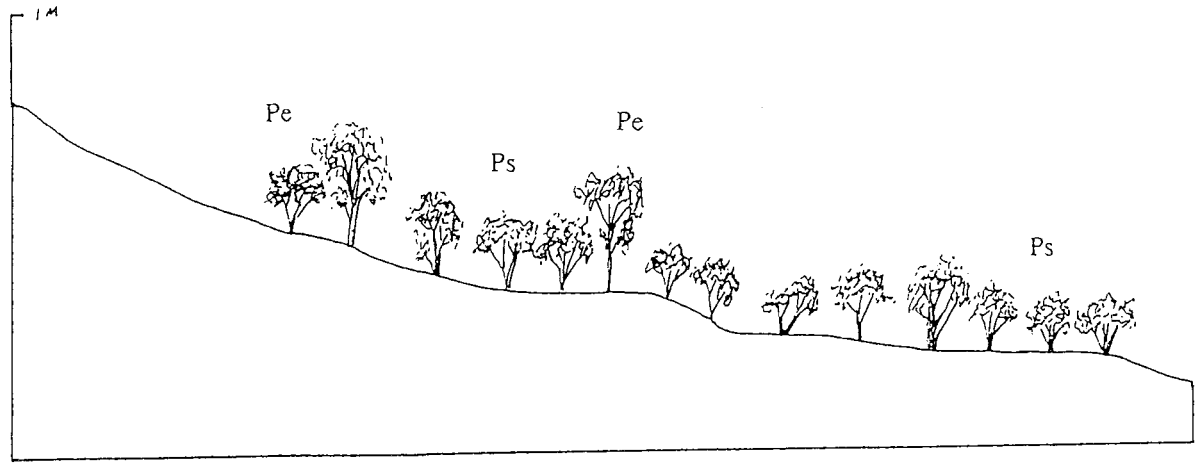
SCHEMATIC PERICALYMMA HABITATS



Type 1 Fringing permanent water bodies



Type 2 Seasonably flooded low plains



Type 3 Elevated seasonably flooded areas

FIGURE 3. Showing 3 habitat types and species niche. Pc = P. crassipes, Ps = P. spongiocaule, Pe = P. ellipticum.

Investigation into the stem histology of *Pericalymma ellipticum* concluded that a distinct tissue type could be recognised. The tissues observed correlated with two basic stem types with a continuum of tissues between the extremes. These extremes represent the soft inflated and the harder non-inflated stems which correspond to the accepted species concepts. The open porous tissue corresponded to the inflated stemmed forms of *Pericalymma crassipes* and its possibly allied species, provided a distinct character that could be used in a key. The observed overlapping of both the inflated and non-inflated stems groups required other techniques to be employed to separate other species within the stem subgroups.

Known populations of *Pericalymma ellipticum* were investigated using Analysis of Variance (ANOVA) as a statistical method to establish differences between area populations and species populations. This study indicated that at the species level several populations were significantly different and others differed only slightly. The soft stemmed species were found to be consistently different from the harder non inflated stemmed species. This observation confirmed that area populations in some instances were significantly different. Where physical habitats prevented and isolated populations, the development of a uniform species occurred. Populations from the south west of Western Australia where habitats are not as isolated, tend to be mixed and the merging of the species became more common in comparison with the northern and drier area populations.

Polygon graphing of the populations carried out earlier developed a data set that illustrated a possible division at the species level. Comparing these results with the ANOVA data it was possible to separate four species. Sorting of the

herbarium collection of *Pericalymma ellipticum* into the new species indicated that the true *Pericalymma ellipticum* could be separated further into two varieties.

6.6 Pericalymma

Pericalymma (Endl.) Endl., Genera Plantarum 2: 1230 (1840). *Type*: *Leptospermum ellipticum* Endl.

Dwarf shrubs to tall shrubs, branchlets dichotomous, flexuose. Leaves alternate, entire, coriaceous. Flowers terminating on short branchlets, 1 or 2 per branchlet; bracts merging with vegetative leaves and floral leaves. Floral tube (hypanthium) cup shaped. Sepals 5. Petals 5 spreading, broadly obovate, longer than sepals with a row of short hairs at the base. Stamens indefinite in a single ring, free, shorter than the petals; filaments filiform; anthers versatile; cells parallel, longitudinally dehiscent. Ovary 3 celled; ovules up to 5 per cell, peltate, hemitropous. Style inserted in a deep depression in the summit of the ovary; stigma peltate. Fruit a woody capsule; 3 valved. Seeds 1 per cell, developed from the lowest ovule, with a close pattern of minute protuberances.

6.7 KEY TO THE SPECIES OF Pericalymma

A. Main stems swollen, stem tissue soft and porous

B. Leaves 0.6-1.4 mm wide ..... *P. crassipes*

B. Leaves 1-5 mm wide

C. Petals 1.3-2 mm long, white-greenish white, inrolled slightly ..... *P. crassipes*

C. Petals 2.5-5 mm long, white - pink, not inrolled

D. Bracts 1.7-2.8 mm long, leaves broadly obovate ..... *P. megaphyllum*

D. Bracts 2.1-3.7 mm long, leaves obovate to narrowly obovate ..... *P. spongiocaule*

A. Main stems not obviously swollen, stem tissue firm ..... *P. ellipticum*

6.8 FIELD KEY TO THE SPECIES OF Pericalymma

A. Main stems swollen, with soft tissue

B. Stems gnarled, less than 0.45 m high ..... *P. crassipes*

B. Stems erect, to 1.6 m high

C. Leaves 4-11 mm long, broadly obovate, stems up to 0.35 m high ..... *P. megaphyllum*

C. Leaves 1.8-7 mm long, narrowly obovate, stems up to 1.6 m high ..... *P. spongiocaule*

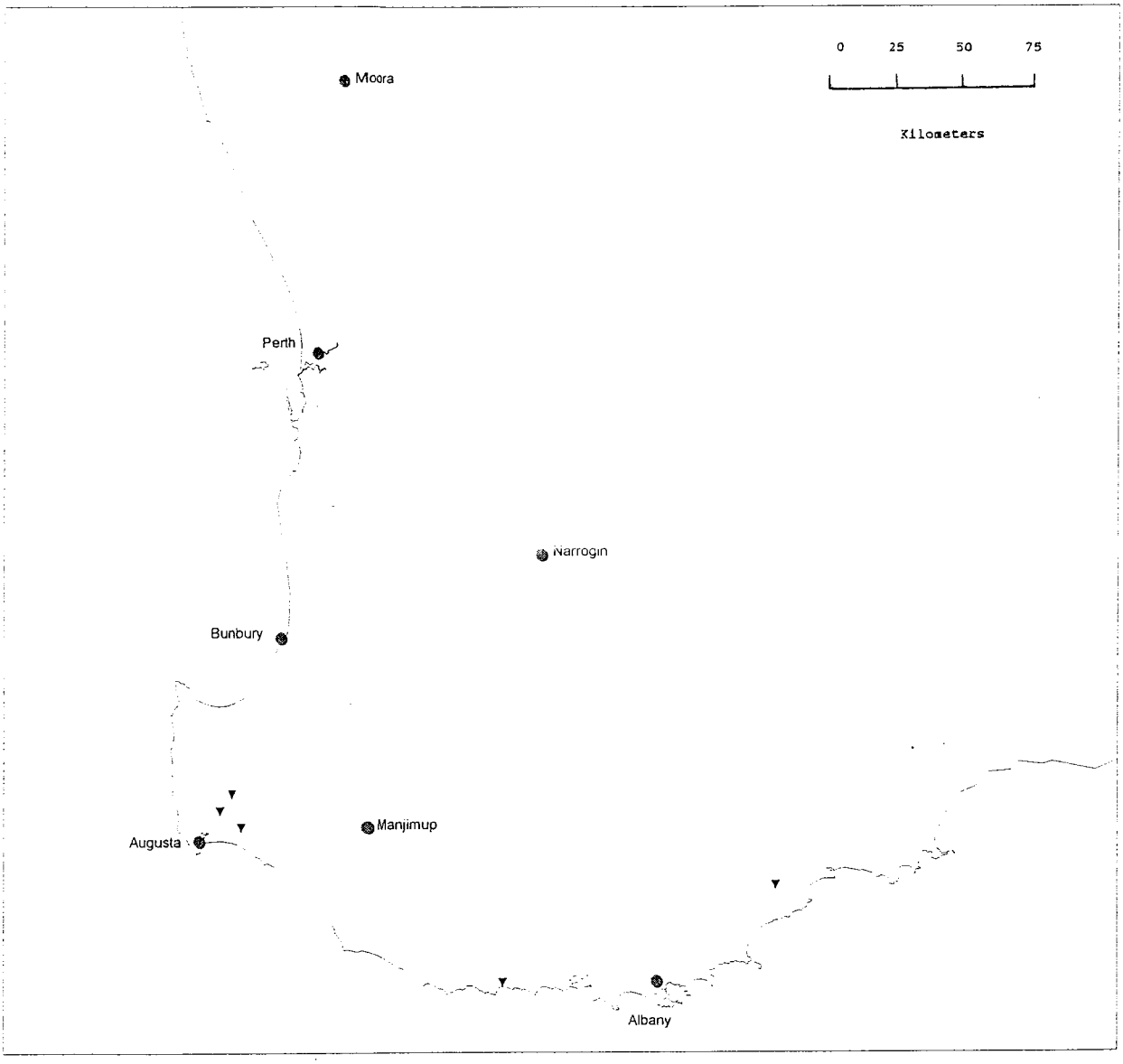
A. Main stems not obviously swollen, with firm tissue..... *P. ellipticum*

6.9 TAXONOMIC TREATMENT, DESCRIPTIONS OF TAXA

Pericalymma crassipes Schauer, Plantae Preissianae 1. (1844) 120. Type: Albany, October 1840, Preiss. No. 155 (holo: Lund not sighted).

Dwarf shrub to 45 cm high. Stems gnarled, inflated and soft. Leaves alternating, clustering near ends of branchlets; lamina narrowly obovate, 2.8-4.5 x 0.6-1.4 mm, glabrous, folded, venation indistinct, apex acute sometimes recurved. Floral leaves 3-5 sessile, obovate, 2.3-3.7 x 0.3-1.0 mm, with membranous basal wings, apex acute. Bracteoles 4, 2 upper and 2 lower, opposite and alternating, sessile, ovate, 1.1-2.2 x 0.5-1.8 mm, green to light brown; margins ciliated to glabrous, adaxial surface hirsute to glabrous, hairs simple; apex acute to obtuse. Sepals alternating with petals on hypanthium rim, triangular, 0.9-1.6 x 0.9-1.2 mm, hirsute, margins ciliate, apex obtuse slightly hooded. Petals white to greenish white, ovate sometimes inrolled, 1.3-2.0 x 1.0-1.8 mm, margins crisped, apex obtuse. Stamens erect, inflexed, filament filiform, 1.0 x 0.20-0.25 mm; anthers ovate topped with a gland, 0.3-0.35 x 0.3 mm. Hypanthium 2.5-2.6 x 2.0-2.5 mm, glabrous to sparsely hirsute; ovules 0.25-0.30 x 0.10-0.15 mm. Style 1-2 x 0.3 mm. Fruit 2.5-3.5 x 2.5 mm glabrous to hirsute. Seeds 1-3, obovate, 1.35-1.50 x 0.5-0.6 mm, testa papillose, brown to black.

Distribution. Pericalymma crassipes occurs from Betty's Beach near Albany to the Scott River plain near Augusta, the area of coastal south west Western Australia. The distribution map (Map 2) is derived from Western Australian Herbarium specimens.



Map 2 Pericalymma crassipes distribution.

Habitat. Occuring mainly on coastal fresh water swamps (Type 2 habitat). Sandy soils with high peat content, acidic and seasonally flooded. These habitats are usually dominated by tall sedges under which *Pericalymma crassipes* can be found. The flowers of this species are small and hidden among the sedges indicating that a specialised pollinator is involved or that selfing occurs.

Flowering period. October to November.

Conservation status. Not considered rare or endangered although occurring in restricted habitats.

Pericalymma spongiocaule Cranfield, sp. nov.
Type: Mount Barker, 12 Nov. 1993, Cranfield 9085 (holo: PERTH).

Shrub to 1.6 m high. Stems straight erect, inflated and soft. Leaves alternate, scattered or clustered near ends of branchlets; lamina narrowly obovate, 1.8-7.0 x 0.7-2.7 mm, glabrous, partially folded, venation obscured, oil glands obvious, apex acute reflexed to straight, immature leaves hirsute or with scattered hairs. Floral leaves 4, sessile, obovate, 1.0-4.5 x 0.1-1.5 mm, with membranous basal wings, apex acute. Bracteoles 3-4, 1 or 2 lower and 2 upper, opposite and alternate, sessile, ovate, 2.1-3.7 x 1.1-3 mm, light brown, hirsute to glabrous, margins hirsute, apex acute to obtuse. Sepals alternating with petals on hypanthium rim, triangular, 1.1-2.4 x 0.9-1.8 mm, hirsute, margins hirsute, apex acute and hooded. Petals white or pink, obovate to ovate, 2.5-5 x 1.8-3.8 mm, margins crisped, apex obtuse. Stamens erect inflexed, filament filiform, 1.1-1.6 x 0.1-0.2 mm; anthers ovate, 0.45-0.50 x 0.30-0.45 mm. Hypanthium 3-4 x 2-3.5 mm, hirsute; ovules 0.35-0.70 x 0.15-0.35 mm. Style 1-2.25 x 0.25-0.35 mm. Fruit

3.0-5.5 x 2-3 mm, glabrous or hirsute. Seeds 1-3, obovate 1.2-2.0 x 0.6- 1.0 mm; testa papillose, black to dark brown. Figure 4.

Distribution. Pericalymma spongiocaule occurs from Wellstead east of Albnay to Cataby near Jurien (Map 3).

Habitat. Occurring in type 1 and type 2 habitats with sandy peaty soils containing some lateritic gravel. In both of these habitats *Pericalymma spongiocaule* overtops most associated species displaying its larger and showier flowers above the surrounding plants. This suggests that this species is insect pollinated with little selfing occurring, possibly creating considerable genetic variation within and between populations.

Flowering period. October to January.

Conservation status. Widespread, not considered rare or endangered.

Etymology. Named from the Latin *spongiosus* (porous) and *caule* (stem) in reference to the soft, swollen stems.

Pericalymma megaphyllum Cranfield, sp. nov.
Type: Governor Broome Road, Scott River, 4 Nov. 1993, Cranfield 8996 (holo: PERTH)

Shrub to 0.35 m high. Stem erect, inflated and soft. Leaves alternate, scattered along branchlets; lamina broadly obovate, 4.0-11.8 x 2.1-5.0 mm, glabrous, flat, midrib visible adaxially, venation obscured, margins slightly undulate, apex obtuse to acuminate. Floral leaves 4 or absent, sessile, ovate, 2.1-3.3 x 0.2-0.7

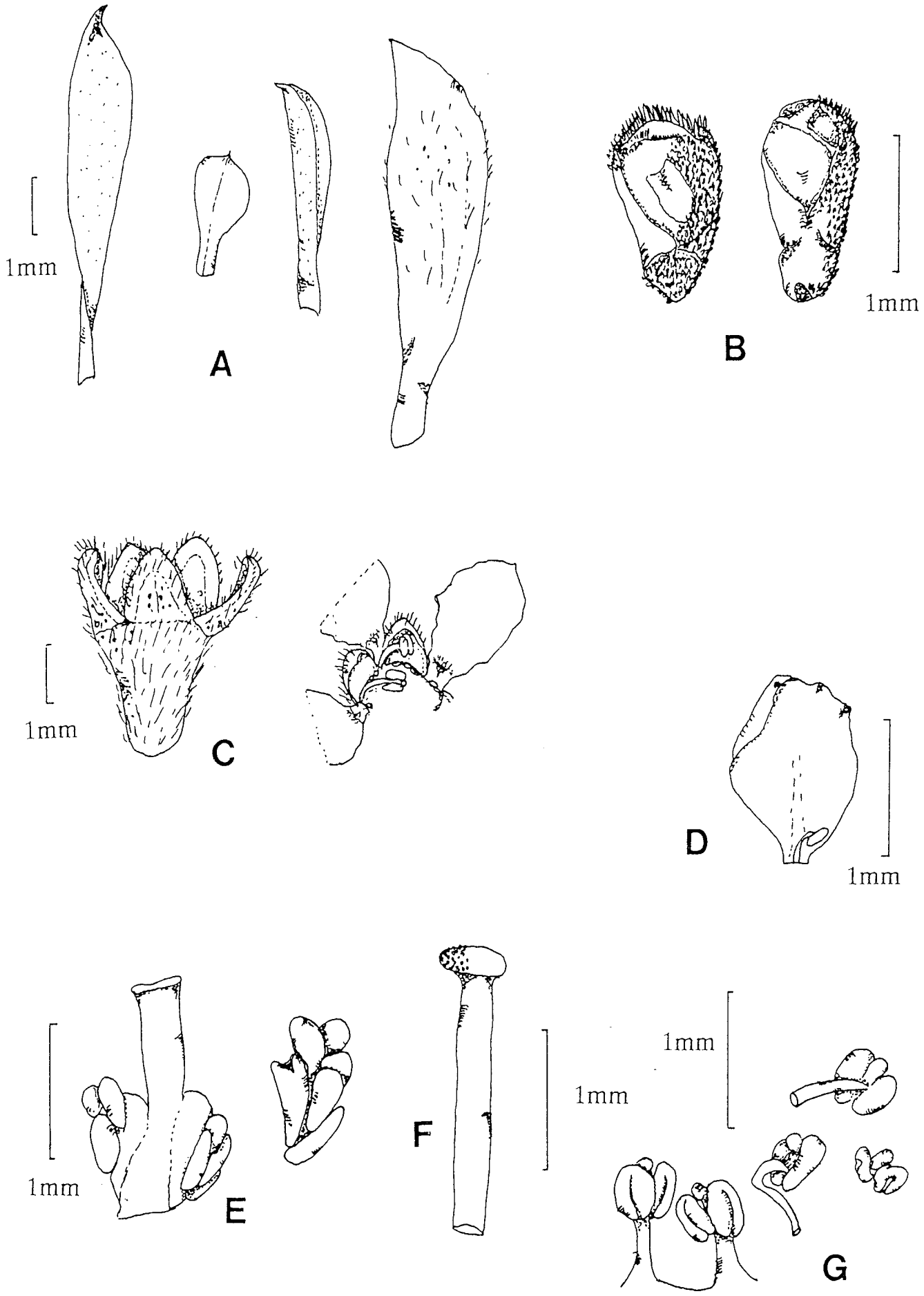
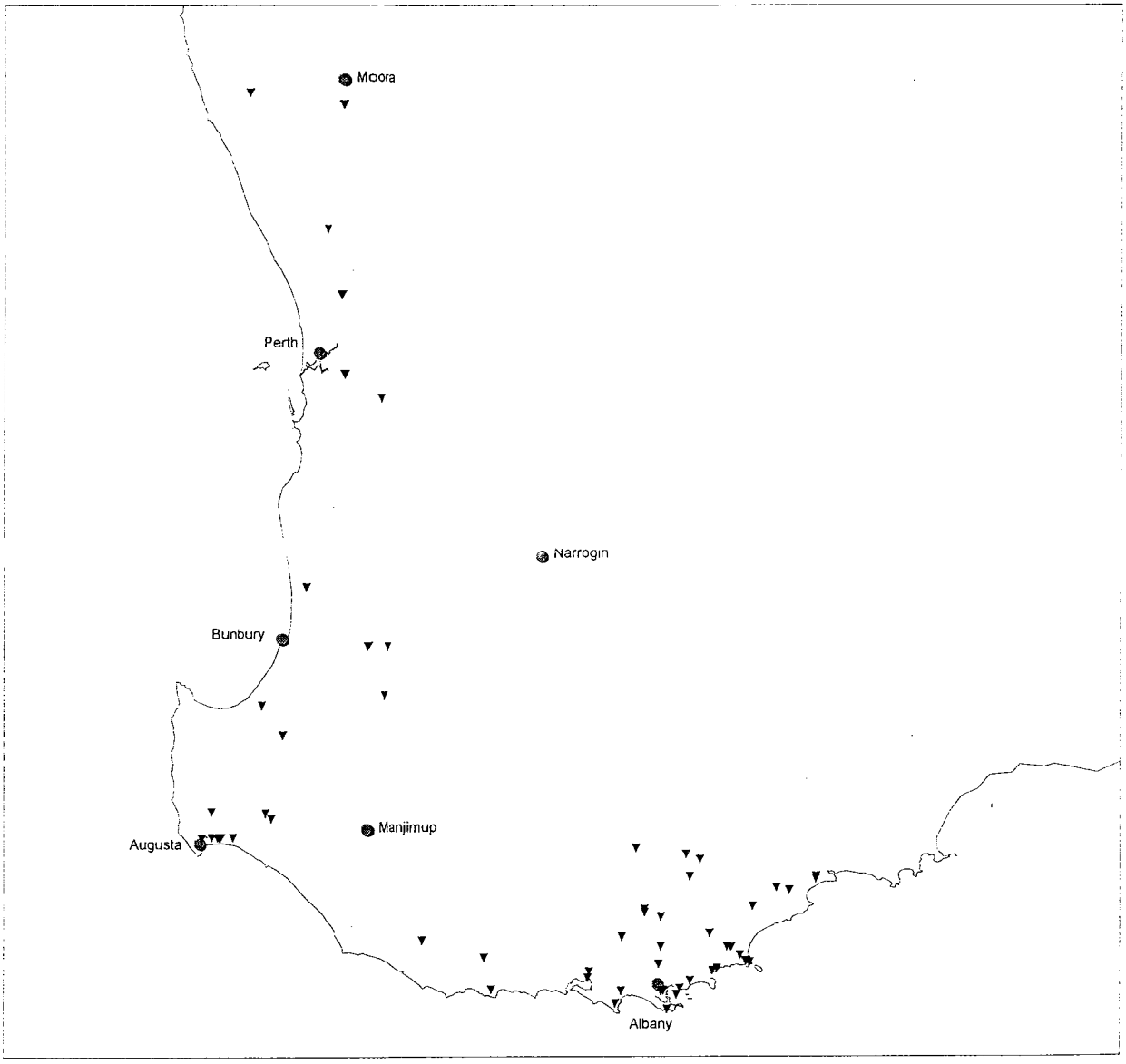


Figure 4. Pericalymma spongiocaule. A-Leaf. B-Seed. C-Flower. D-Petal. E-Ovules. F-Style. G-Anther.



Map 3 Pericalymma spongiocaule distribution.

mm, with membranous basal wings, apex acute and reflexed. Bracteoles 4, 2 lower and 2 upper, opposite and alternating, sessile, ovate, 1.7-2.8 x 0.6-1.4 mm, light brown, glabrous, margins ciliated, apex acute. Sepals alternating with petals on hypanthium rim, triangular, 1.0-1.4 x 1.1-1.6 mm, glabrous to sparsely hirsute, margins sparsely ciliated, apex acute and hooded. Petals white or pink, ovate, 2.1-3.8 x 2.0-3.8 mm, margins crisped, apex obtuse. Stamens erect and inflexed, filament filiform, 0.4-0.5 x 0.15-0.16 mm; anthers ovate, topped with a gland, 0.4-0.5 x 0.40-0.45 mm. Hypanthium 1.5-2.0 x 1.7-2.5 mm, glabrous to sparsely hirsute; ovules 0.4-0.6 x 0.15-0.20 mm. Style 1.0-2.0 x 0.25 mm. Fruit 3.0-3.5 x 2.0-2.5 mm, glabrous. Seeds obovate, testa papillose. Figure 5.

Distribution. Known only from type location. Map 4.

Habitat. Only known to occur on a Type 3 habitat in an elevated washed area with red brown, lateritic, clayey sand.

Flowering period. November.

Conservation status. Further surveys and collections are required to determine the conservation status of this species.

Etymology. Named from Greek *mega* (large) and *phyllum* (leaf) in reference to the relatively large broad leaves.

Further surveys and studies of this species is required to establish any relationships to other species and to determine its ranking.

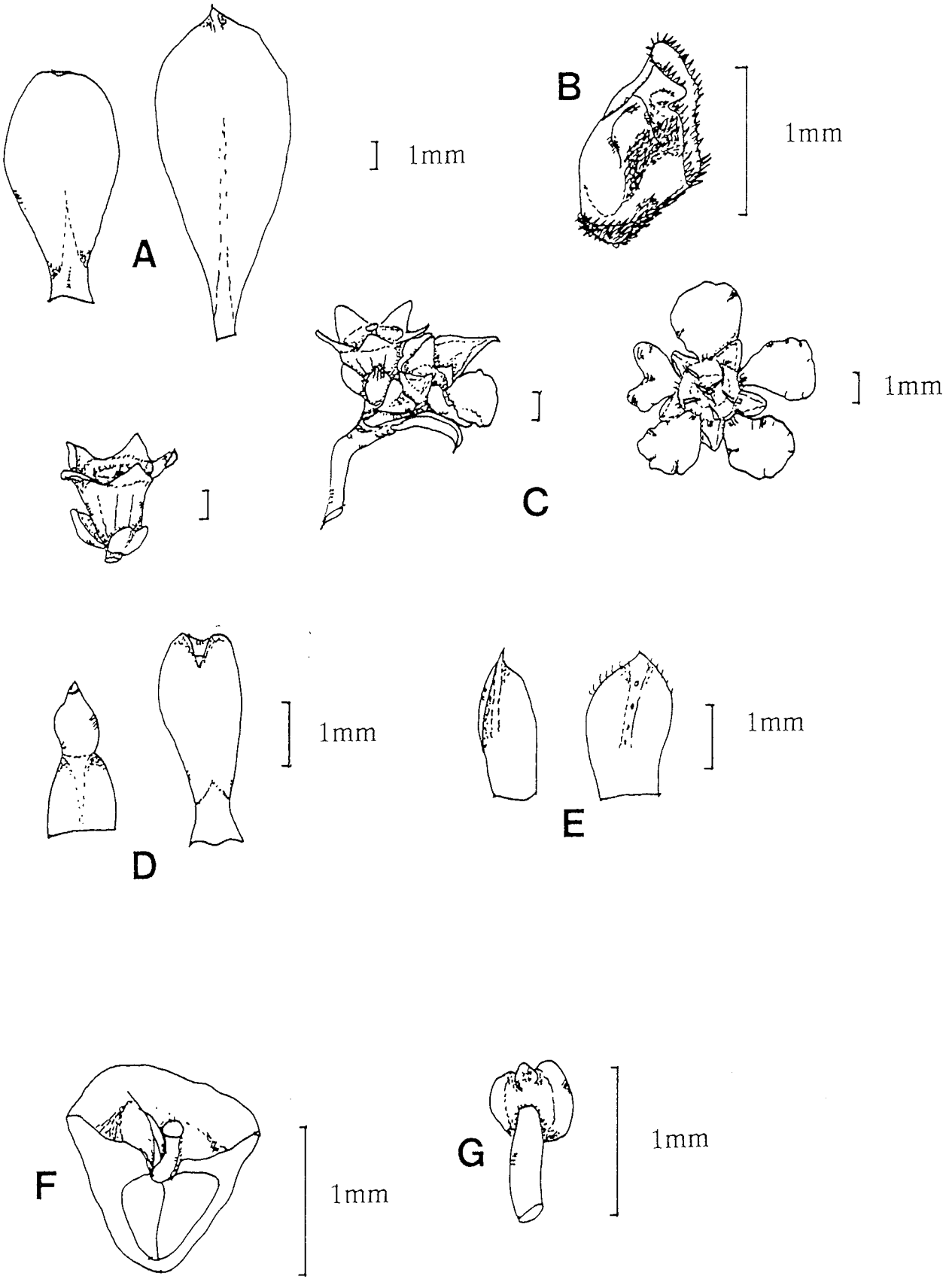


Figure 5. Pericalymma megaphyllum. A-Leaf. B-Seed (immature). C-Flower. D-Floral leaf. E-Floral bract. F-Hypanthium. G-Anther.

Map 4 Pericalymma megaphyllum distribution.

Pericalymma ellipticum (Endl.) Schauer Plantae Preissianae 1. (1844) 120. Type: King Georges Sound, 1837, Hugel. (holo: Wien not sighted).

Shrub to 3 m high. Stems erect, multi-stemmed not obviously inflated and hard to firm. Leaves alternate, scattered to dense on branchlets; Lamina oblanceolate to narrowly obovate, 3.5-11.3 x 0.6-4.6 mm, glabrous to sparsely hairy, flat to shallowly folded, venation obscured, apex acute sometimes reflexed. Floral leaves 4, sessile, oblanceolate to ovate, 2.0-6.6 x 0.2-1.5 mm, glabrous with basal membranous wings, apex acute to obtuse. Bracteoles 4, 2 lower and 2 upper, opposite and alternating, sessile, ovate, 2.0-4.6 x 1.2-4.0 mm, greenish brown to light brown, glabrous to sparsely hirsute, margins glabrous to sparsely ciliated, apex acute to obtuse. Sepals alternating with petals on hypanthium rim, triangular, 1.2-2.6 x 1.0-2.5 mm, glabrous to hirsute with simple white hairs, margins ciliated sometimes inrolled, apex acute to obtuse, hooded. Petals white to pink, ovate, 2.3-6.0 x 2.0-5.5 mm, glabrous, margins crisped, apex obtuse. Stamens erect inflexed, filament filiform, 1.0-2.1 x 0.10-0.30 mm; Anthers ovate, 0.20-0.50 x 0.20-0.30 mm. Hypanthium 1.5-4.0 x1.75-3.0 mm, glabrous to sparsely hirsute; Ovules 0.2-0.3 x 0.18-0.50 mm. Style 1.5-3.5 x 0.20-0.50 mm. Fruit 2.0-5.0 x 2.0-3.5 mm, glabrous. Seeds obovate to ovate, 1.3-2.0 x 0.50-1.5 mm, testa papillose, black. Figure 6.

Distribution. Pericalymma ellipticum occurs from Jurien in the north to east of Albany in the south.

Habitat. Occurs mainly on type 3 and elevated edges of types 1 & 2 habitats. Mainly on drier leached lateritic sands with fine layer of peat or other organic matter.

Flowering period. October to January.

Conservation status. Not considered rare or endangered.

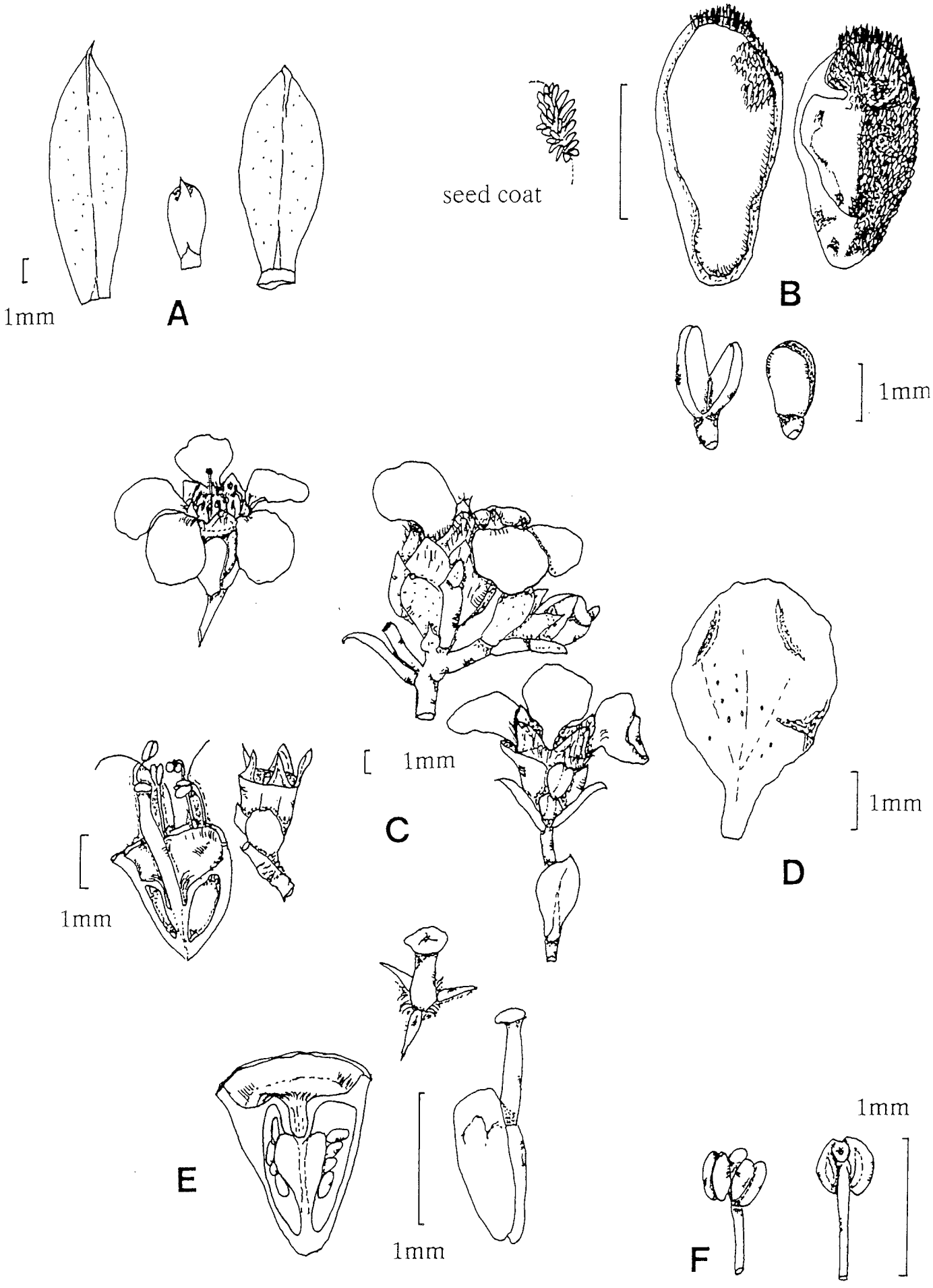


Figure 6. Pericalymma ellipticum. A-Leaf. B-Seed and embryo. C-Flower. D-Petal. E-Hypanthium showing style insertion. F-Anther.

6.10 Key to the varieties of *Pericalymma ellipticum*

A. Petals 2-4mm long ..... *P. ellipticum* var. *ellipticum*

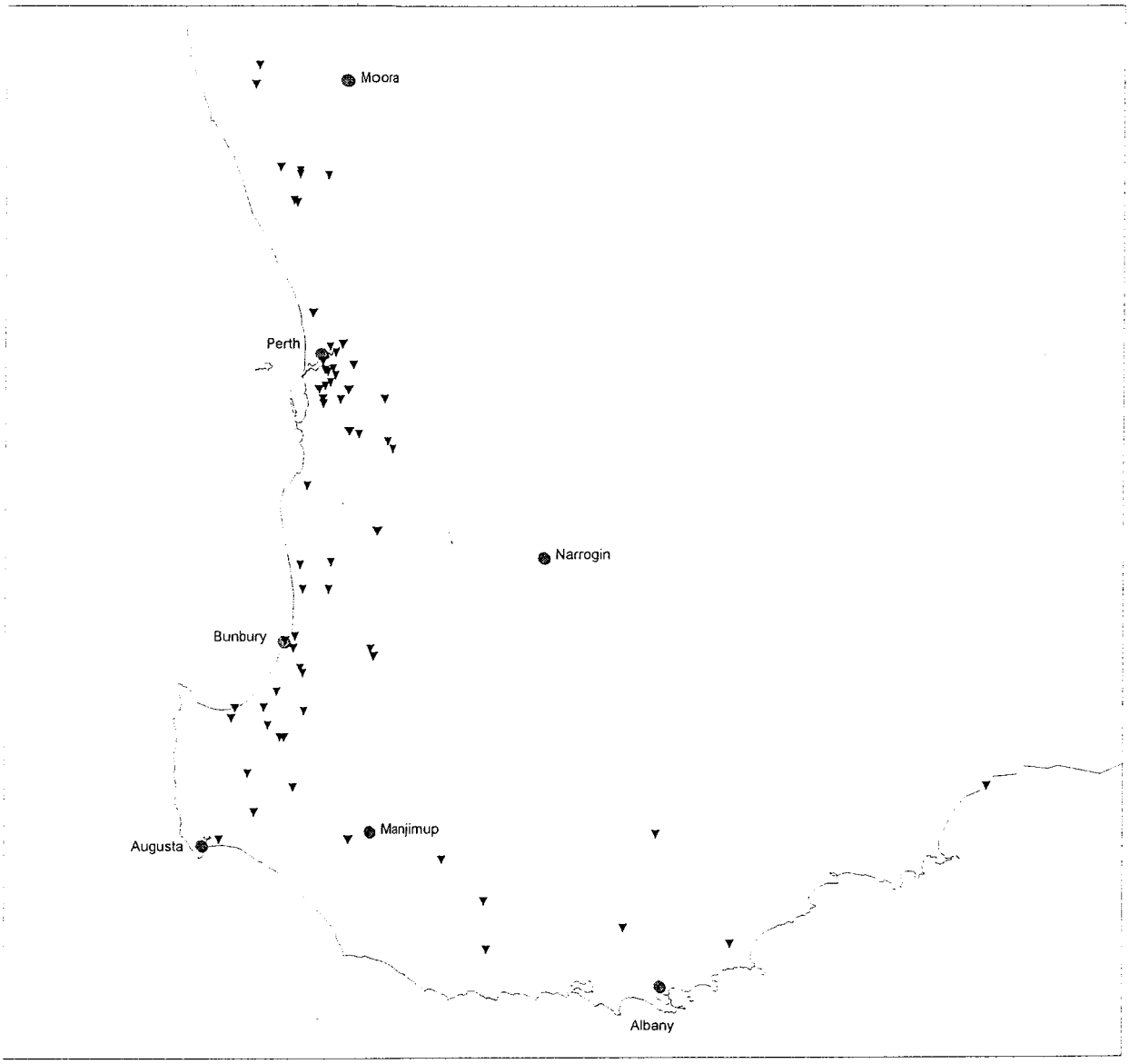
A. Petals 3.5-6mm long ..... *P. ellipticum* var. *floridum*

Pericalymma ellipticum (Endl.) Schauer. var. ***ellipticum*** Plantae Preissianae 1. (1844) 120. Type: King Georges Sound, 1837, Hugel. (holo: Wien not sighted).

This variety has similar floral characters and is usually found in association with *P. ellipticum* var. *floridum.* The main differance is in the smaller size of the petals. Map 5 shows the distribution of *P. ellipticum* var. *ellipticum.*

Pericalymma ellipticum (Endl.) Schauer. var. ***floridum*** Schauer Plantae Preissianae 1. (1844) 121. Type: Guildford 1839 Preiss No 131. (holo: Lund).

Shrub to 2 m high. Stems erect multi-stemmed not obviously inflated, hard sometimes soft. Leaves alternating, sparse to clustered on branchlets; Lamina obovate to narrowly obovate, 4.5-11.2 x 1.1-4.6 mm, glabrous, flat or slightly folded, venation obscured, apex acute reflex occasionally twisted. Floral leaves 3 to 5, sessile, ovate to oblanceolate, 2.0-5.4 x 0.3-1.5 mm, glabrous to hirsute with membranous basal wings, apex acute. Bracteoles 2 to 4, 2 upper 2 lower, opposite and alternating, sessile, ovate, 2.1-4.6 x 1.4-4.0 mm, light brown, hirsute to glabrous, margins ciliated, apex acute to obtuse. Sepals alternating with petals on hypanthium rim, triangular, 1.2-2.6 x 1.0-2.3 mm, hirsute to glabrous, margins ciliated. apex obtuse to acute hooded. Petals white or pink, ovate, 3.5-6.0 x 2.7-



Map 5 Pericalymma ellipticum var. ellipticum distribution.

5.5 mm, glabrous except for row of basal hairs on back, margins crisped, apex obtuse. Stamens erect inflexed, filament filiform, 1.0-2.1 x 0.1-0.3 mm; anthers ovate topped with gland, 0.2-0.5 x 0.2-0.3 mm. Hypanthium 2.0-4.0 x 2.0-3.0 mm, hirsute to sparsely hirsute with some ribbing; ovules 0.25-0.50 x 0.15-0.30 mm. Style 1.5-3.5 x 0.2-0.5 mm. Fruit 3.0-5.0 x 2.0-3.5 mm, glabrous to sparsely hirsute. Seeds 1.3-2.0 x 0.5-1.5 mm, testa papillose, dark brown to black. Figure 7.

Distribution. Pericalymma ellipticum var. *floridum* appears to occur in two populations with a disjunct scattering between populations. The two populations occur north of Perth and around the Busselton area in the south (Map 6).

Flowering period. August to November.

Conservation status. Not considered rare or endangered.

The varietal ranking requires further investigation. Location of the type material to establish the exact identity of *Pericalymma ellipticum* is required . Confused species concepts have prevented the clear understanding of *P. ellipticum* and *P. floridum* and resulted in the adoption of varietal rank here until further information is available.

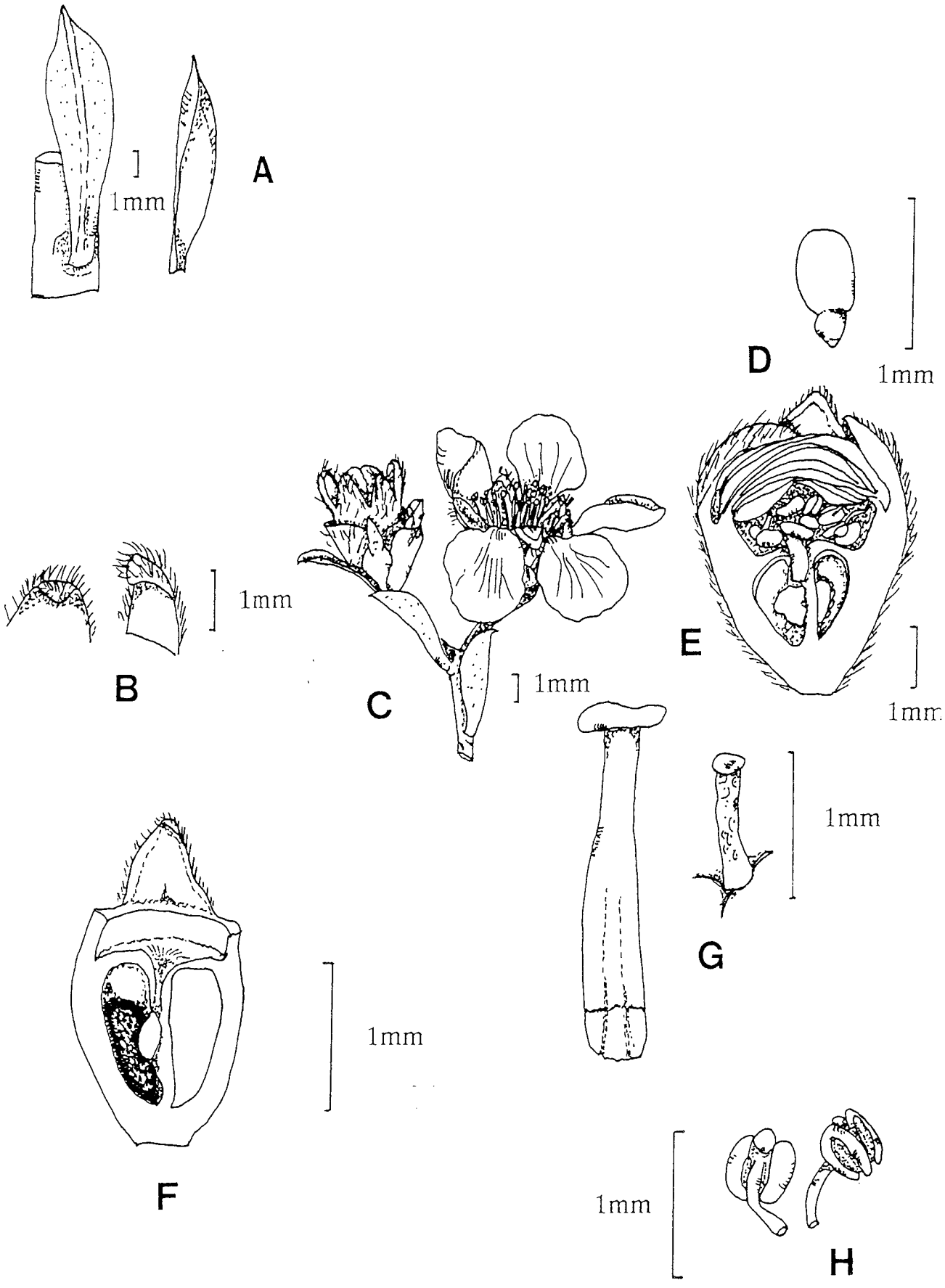


Figure 7. Pericalymma ellipticum var. floridum, A-Leaf. B-Sepal apex. C-Flower. D-Seed embryo. E-Bud. F-Seed in ovary. G-Style. H-Anther.

Map 6 Pericalymma ellipticum var. floridum distribution.

6.11 REFERENCES

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