

**A re-assessment of the species boundaries in  
*Merciera* A.DC. (Campanulaceae)**



*Merciera leptoloba*

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## ABSTRACT

Patterns of morphological variation were investigated in the genus *Merciera* A.DC. to re-assess the species boundaries. This study differs from previous studies in the genus because it employs multivariate statistical methods. Vegetative and floral characters obtained from herbarium specimens were analyzed. The results of the cluster analysis and principal coordinate analysis support the recognition of six species, *M. leptoloba*, *M. brevifolia*, *M. tenuifolia*, *M. eckloniana*, *M. azurea*, and *M. tetraloba*. *M. azurea* is re-instated as a species and a new species *M. tetraloba* is described. An infra-generic phylogeny for the genus is proposed for the first time. A key to the species, descriptions, and distribution of all the species are also provided.

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## Introduction

*Merciera* A. DC. (Campanulaceae) is a small genus of dwarf shrubs endemic to the Cape Floristic Region (Goldblatt, 1978) in South Africa. It occurs in the Bredasdorp, Caledon, Simonstown, Cape Town, and Worcester divisions of the southwestern Cape. Current records show that the highest concentration of species is found in the Caledon division. The genus is known to have occurred in the Cape Peninsula more than a century ago, but a record of Ecklon & Zeyher on the Steenberg mountains near Muizenberg however remains unconfirmed. *Merciera* grows mainly in open sandy, clay or rocky soil, often-disturbed habitats. The genus was named in honour of the botanist Philip Mercier by De Candolle (1830), who described the genus as "*genus incertae sedis*" (genus of uncertain position) because of the unusual structure of the ovary.

Four *Merciera* species are currently recognized, but the delimitation of the species in the genus was always uncertain. This is shown in the different number of taxa that have been previously recognized (Table 1). De Candolle (1830) recognized three species, *M. tenuifolia*, *M. leptoloba*, and *M. brevifolia*. Ecklon & Zeyher (1837) added two more species, *M. eckloniana* and *M. heteromorpha*, but *M. heteromorpha* was incorrectly placed in *Merciera*; belonging in the family Rubiaceae instead. Sonder (1865), reduced the number of species to two, *M. tenuifolia* (L.f.) A.DC. and *M. brevifolia* A.DC., and recognized six varieties, *M. tenuifolia* (L.f.) A.DC. var. *tenuifolia*, *M. tenuifolia* (L.f.) A.DC. var. *candolleana* Sonder, *M. tenuifolia* (L.f.) A.DC. var. *thunbergia* Sonder, *M. tenuifolia* (L.f.) A.DC. var. *eckloniana* (Buek ex Ecklon & Zeyher) Sonder, *M. brevifolia* A.DC. var. *brevifolia* and *M. brevifolia* A.DC. var. *leptoloba* (A.DC.) Sonder. He separated the varieties on the basis of leaf length, degree of leaf hairiness, the shape of the corolla lobes, and the length of the corolla in relation to the leaves. The taxa *M. eckloniana* Buek ex Ecklon & Zeyher and *M. leptoloba* A.DC., previously recognized by De Candolle (1830) and Ecklon & Zeyher (1837) as species were considered as varieties of *M. tenuifolia* (L.f.) A.DC. and *M. brevifolia* A.DC., respectively by Sonder (1865). At the end of the nineteenth century, Schlechter (1898) described a new species, *M. azurea*, from Sir Lowry's Pass. He distinguished this violet-blue-flowered species from the other violet-blue-flowered species, *M. tenuifolia* (L.f.) A.DC., by its shorter and less hairy leaves, and much

shorter and wider corolla. Adamson (1954) in his revision recognized five species, *M. tenuifolia* (L.f.) A.DC., *M. eckloniana* Buek ex Ecklon & Zeyher, *M. brevifolia* A.DC., *M. leptoloba* A.DC. and *M. vaginata* Adamson, with two varieties, *M. tenuifolia* (L.f.) A.DC. var. *tenuifolia* and *M. tenuifolia* (L.f.) A.DC. var. *azurea* (Schlechter) Adamson. He reduced *M. azurea* Schlechter to varietal rank, placing it under *M. tenuifolia* (L.f.) A.DC., claiming that it is only a smaller and stouter form of *M. tenuifolia* (L.f.) A.DC. The approach of Adamson and Ecklon & Zeyher in delimiting the species show similarity, in that both recognized the species *M. tenuifolia* (L.f.) A.DC., *M. eckloniana* Buek ex Ecklon & Zeyher, *M. leptoloba* A.DC. and *M. brevifolia* A.DC. Furthermore, very strangely, like Ecklon & Zeyher, Adamson placed *M. vaginata* Adamson, which belonged to the Rubiaceae, incorrectly in *Merciera*.

Table 1. List of taxa recognized by previous workers in *Merciera*.

Authors	Names of Taxa											
	<i>tenuifolia</i>	<i>tenuifolia</i> var. <i>tenuifolia</i>	<i>tenuifolia</i> var. <i>candolleana</i>	<i>tenuifolia</i> var. <i>thunbergiana</i>	<i>tenuifolia</i> var. <i>eckloniana</i>	<i>eckloniana</i>	<i>brevifolia</i>	<i>brevifolia</i> var. <i>brevifolia</i>	<i>brevifolia</i> var. <i>leptoloba</i>	<i>leptoloba</i>	<i>tenuifolia</i> var. <i>azurea</i>	<i>azurea</i>
De Candolle (1830)	•						•			•		
Ecklon & Zeyher (1837)	•					•	•			•		
Sonder (1865)		•	•	•	•			•	•			
Schlechter (1898)												•
Adamson (1954)		•				•	•			•	•	

*Merciera* is classified in the Campanulaceae subfamily Campanuloideae. The family Campanulaceae *sensu lato* comprises 82 genera and 2000 species (Mabberley 1997) of mostly herbaceous plants. Species from genera such as *Campanula*, *Symphyandra*, *Wahlenbergia*, *Lobelia* and *Monopsis*, are of great economic importance in the horticultural industry. The family has a worldwide distribution, but is mainly found in the North Temperate Zone. In the southern hemisphere, South Africa is particularly rich in members of the subfamily Campanuloideae or Campanulaceae *sensu stricto*, containing eight small endemic genera (*Merciera* A. DC., *Microcodon* A. DC., *Rhigiophyllum* Hochst., *Roella* L., *Prismatocarpus* L'Hérit., *Siphocodon* Turcz., *Theilera* Phillips, and *Treichelia* Vakte.). In the rest of southern Africa, only 15 genera are found. Taxonomically the genera are separated on account of the morphology of the ovary and capsule dehiscence. In South Africa the Campanulaceae *sensu stricto* contains mostly

herbs (annual, or perennial) or rarely small shrubs. The leaves are alternate, rarely opposite, simple, and without stipules. The flowers are actinomorphic, campanulate, funnelform or salverform and bisexual. They are borne singly or more often in inflorescences. The large showy flowers are predominantly blue in colour. The blue colour is particularly attractive to bees but there are a number of other pollen carriers. Petals, sepals and stamens are normally in fives. The petals are partially or completely fused and are inserted on an inferior or half inferior, or seldomly a superior ovary. There are as many stamens as corolla lobes. The style is simple with as many stigmas as carpels. The fruit is a capsule.

The circumscription of the Campanulaceae Juss. has always been disputed. Most disagreements concern the designation of taxonomic rank to the campanulad and lobeliad members of the family. The campanulads are characterized by actinomorphic flowers and free anthers, and the lobeliads by zygomorphic flowers and fused anthers. A group with zygomorphic flowers and free anthers, the cyphiads, is considered intermediate to the campanulads and lobeliads. Traditionally, three taxa have been recognized. Bentham & Hooker (1876) followed the classification of Sonder (1865) recognizing the three taxa as tribes of the Campanulaceae: Lobelieae, Cyphieae, and Campanuleae. Dahlgren (1980, 1983), De Candolle (1830), Fedorov (1972), Kovanda (1978), Lammers (1992), and Takhtajan (1987) preferred to recognize them as families, whereas Cronquist (1988), Schönland (1889), Thorne (1992), Wagenitz (1964), and Wimmer (1968) relegated the families to subfamilial rank. New evidence from morphology and *rbcL* sequencing contributed to the current recognition of five taxa: Campanuloideae, Cyphioideae, Lobelioideae, Cyphocarpoideae, and Nemacladiodeae (Lammers 1998). Authors such as Gustaffsson & Bremer (1995) and Takhtajan (1997) recognize the taxa as families: Campanulaceae, Cyphiaceae, Lobeliaceae, Cyphocarpaceae, and Nemacladaceae. Takhtajan (1997) further divided the Campanulaceae into four subfamilies: Cyananthoideae, Ostrowskioideae, Canarinoideae and the Campanuloideae. Until agreement is reached amongst campanulad systematists, the Campanulaceae can be taxonomically approached in two ways. The family can be considered as one large family (Campanulaceae *sensu lato*) that is divided into subfamilies or considered in a strict sense that is equivalent to the subfamily Campanuloideae of the

Campanulaceae *sensu lato*. Whether one considers the Campanulaceae *sensu lato* as one family or several separate families, is "purely a matter of taste" (p.986 Cronquist 1981). *Merciera* and its allies are placed in the Campanulaceae *sensu stricto*.

Adamson (1951, 1954) considered *Merciera*, *Roella*, and *Prismatocarpus* as closely allied genera. He also suggested that *Merciera* might have evolved from *Roella* series *Ciliatae* with which it shares a similar habit and leaf structure. From my personal field experience, I have found it difficult to assign some specimens of the two genera to one genus or the other during their vegetative phase. The flower structure of *Merciera* however differs from that of *Roella*. *Merciera* has a narrow tubular corolla, non-dilated filaments and four ovules, whereas, *Roella* has a bell-shaped corolla, dilated filaments and more than four ovules. The capsule in *Merciera* is indehiscent whereas in *Roella* it opens by a terminal pore. The narrow tubular corolla of *Merciera* has parallels in other genera in the family such as in *Rhigiophyllum*, *Siphocodon*, and *Prismatocarpus* subgenus *Afrotrachelium*. In *Rhigiophyllum* and *Siphocodon*, the tubular corolla is associated with epipetalous stamens whereas in *Prismatocarpus* it is not. Some species of *Prismatocarpus* like *Merciera* have non-dilated filaments. The capsule in *Prismatocarpus* is dehiscent and splits longitudinally into five strips. Evidence from chloroplast DNA sequencing (Raubeson et al. 1999) supported Adamson's concept of the alliance between the three genera. The cladogram based on the DNA sequencing showed that *Merciera*, *Prismatocarpus*, and *Roella* formed a clade supported by a bootstrap value of 100. *Prismatocarpus* is the sister genus to *Merciera* in the clade supported by a bootstrap value of 74.

The unconvincing separation of the species of *Merciera* by previous workers is contributing to the confusion in the number of taxa recognized, the designation of infraspecific ranks, and the misidentification of species. A sound taxonomy, which is the basis for all detailed biological studies, as well as for making informed conservation decisions, is clearly lacking for *Merciera*. A convincing species level taxonomy for *Merciera* is therefore imperative to unlock the largely unknown biology of the genus. This study aims at addressing this inadequacy by providing a sound species level taxonomy for *Merciera*, employing multivariate statistical

methods in delimiting taxa. Multivariate statistical methods provide an objective analysis of patterns of morphological variation within a taxon and are a suitable tool to systematists in making decisions on taxa delimitation. Examples of such studies in recent years are Aldasoro et al (1998), Baum & Bailey (1992), Brunnel & Whitkus (1999), Eakes & Lammers (1996), Eddie & Ingrouille (1999), Eriksen (1997), Matos (1995), Sepp & Paal (1998), Shaw (1998), Tyteca & Dufrene (1994), Verboom & Linder (1998) and Wilkin (1999). No infra-generic phylogeny exists for *Merciera*. This study will also determine the phylogenetic relationship among the species as well as their phylogenetic status.

This study has the following objectives. Firstly, to re-evaluate the patterns of morphological variation and determine the species limits within the genus, employing multivariate statistics. Secondly, to provide a complete taxonomic account of the genus based on the results obtained in the multivariate analysis.

## **Material and Methods**

### Sampling methods

This study is based on herbarium specimens from SAM, BOL, and NBG (abbreviations as in Holmgren et al., 1990). A set of 162 specimens was selected in order to obtain representative material from the known distribution range of the genus. From this set 127 specimens were selected as Operational Taxonomic Units (OTU's). The other specimens were not used because some floral characters were missing or the specimens were too brittle to remove plant parts. In addition to the herbarium specimens a further 8 specimens were collected and examined.

### Preparation and examination of study material

Floral morphology was examined using flowers at anthesis. One flower from each specimen was removed, boiled in water for 30 seconds and the floral parts dissected out. The floral parts were mounted on gummed cards and used in the subsequent measurements.

Nineteen characters representing reproductive and vegetative morphology were chosen for the investigation (Table 2). The characters included 12 quantitative- and 7 qualitative characters. Flower measurements, shown in Figure 1, include length of corolla tube, corolla lobe, calyx lobe, hypanthium, style, filament, and bract. Leaf measurements (Figure 1) were taken of the largest leaf from each specimen after the leaf was softened in boiling water and mounted on a gummed card. Leaf width was measured at the widest part of the leaf. All measurements were done using a Vernier caliper precise to 0.02 mm.

Table 2. List of characters used in the multivariate analysis.

<b>Characters</b>	<b>Units or states</b>
Habit	0= decumbent, 1= semi-erect
Corolla tube length	mm
Corolla lobe length	mm
Corolla lobes hairy on the back	0= absent, 1= present
Corolla lobe shape	0= linear-lanceolate, 1= ovate
Number of corolla lobes	count
Calyx lobe length	mm
Number of calyx lobes	count
Calyx lobe margins hairy	0= absent , 1= present
Bract length	mm
Hypanthium length	mm
Style length	mm
Number of stamens	count
Filament length	mm
Leaf length	mm
Leaf width	mm
Leaf orientation (old leaves)	0= spreading, 1= ascending
Leaf hairy on the adaxial surface	0= absent, 1= present
Flower colour	0= white, 1= violet-blue

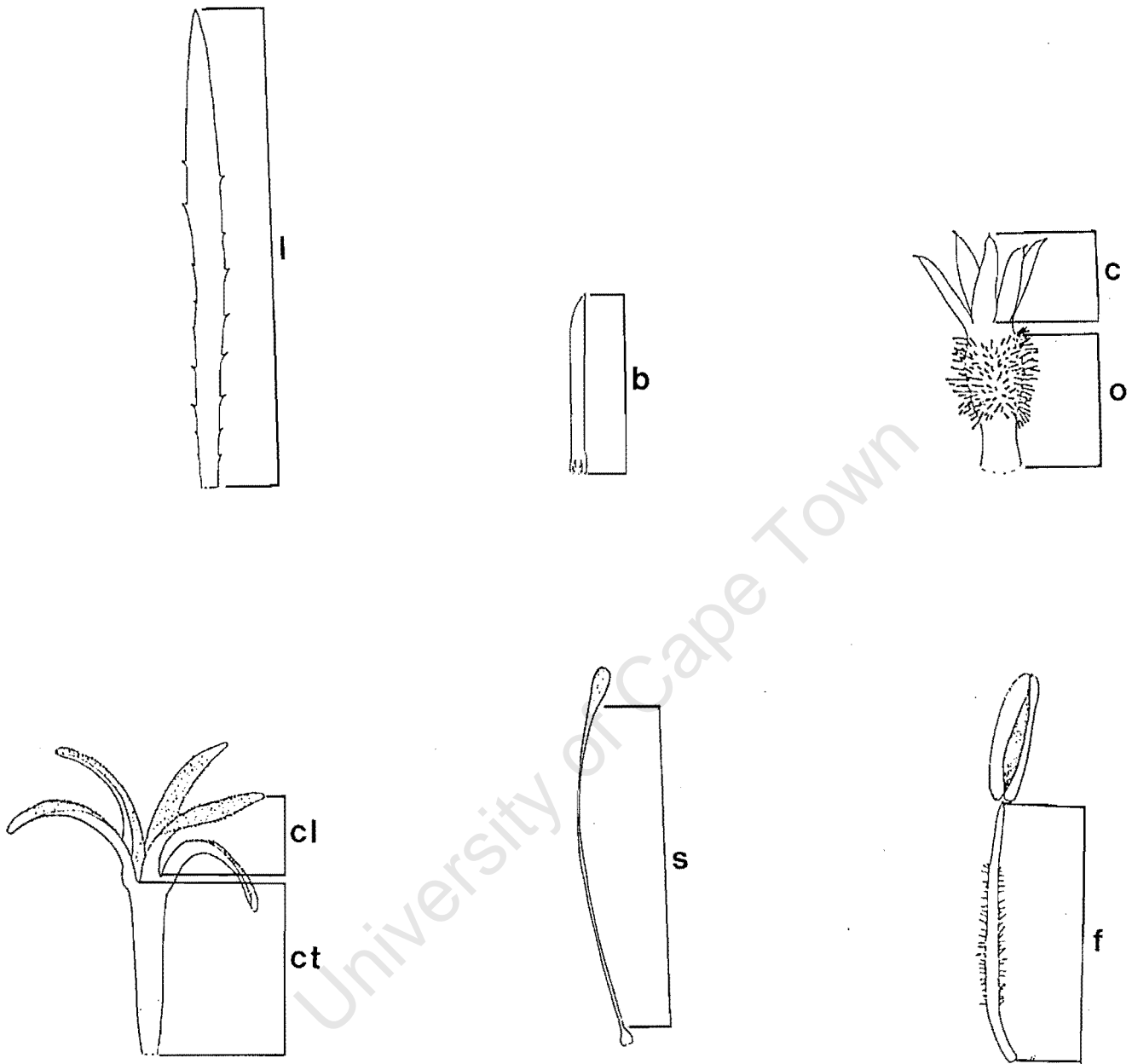


Figure 1. Illustrations depicting how floral parts and leaves were measured for the morphometric analysis.

l= leaf length, b= bract length, c= calyx lobe length, o= hypanthium length, ct= corolla tube length, cl= corolla lobe length, s= style length, f= filament length

Illustrations were done from FAA preserved material (Cupido 66, NBG) collected near Pringle Bay.

## Phenetic analysis

Data were entered onto a computerized spreadsheet program, Microsoft Excel version 7 (Appendix). The spreadsheet was later transformed into a file format suitable for phenetic analysis.

Principal coordinate analysis (PCO) and clustering analysis were carried out using NTSYS-pc version 2.02 (Rohlf 1993), with a matrix of standardized data. The data were standardized to eliminate the distorting effects of different scales of measurement on the output results. Standardization was performed by subtracting the character mean and dividing by the standard deviation. For PCO, a Manhattan distance matrix of standardized data was obtained. The Manhattan distance was used because the data set contained mixed (metric and binary) data. The distance matrix was double centered and the eigenvectors were calculated and plotted. The PCO gives the distances between OTU's, rather than the correlation between the characters. This method is therefore suitable for mixed character data, as it will not be distorted by binary characters as will PCA. It has the added advantage of handling missing data well. To test the repeatability of the phenetic groupings, the groupings obtained by ordination were compared to those obtained using the clustering algorithms, single linkage, complete linkage, WPGMA, and UPGMA. Each of the clustering algorithms was performed on a Manhattan distance matrix, resulting in a phenogram depicting similarity between the OTU's. A cophenetic correlation was then calculated to show the degree of relationship between the original distance matrix and the tree matrix. The highest cophenetic value was obtained using the UPGMA algorithm (Table 3).

Table 3. The cophenetic values obtained using different clustering methods

<b>Clustering methods</b>	<b>Cophenetic values</b>
Single linkage	0.77
Complete linkage	0.83
WPGMA	0.76
<b>UPGMA</b>	<b>0.85</b>

## Phylogenetic analysis

### Taxa

All the clusters revealed by the phenetic analysis were included in the analysis. Adamson (1951) recognized the two sub-genera, *Euprismatocarpus* and *Afrotrachelium* within *Prismatocarpus*. The sub-genus *Afrotrachelium* includes *Prismatocarpus diffusus* (L.f.) A.DC. which has a few characters in common with *Merciera*. The two taxa share the same corolla structure, number of locules and non-dilated filaments. *Prismatocarpus diffusus* is therefore a suitable outgroup.

### Characters

Sixteen characters representing vegetative and reproductive morphology were chosen for the analysis. The characters included four quantitative and twelve qualitative characters. The description of the characters and the distribution of the character states are listed in Table 4.

Table 4. List of characters and character states used in the phylogenetic analysis.

Taxa	Character states							
<i>Prismatocarpus diffusus</i>	00	00	00	00	00	00	00	00
<i>M. leptoloba</i>	1 0/1	00	00	01	00	01	10	00
<i>M. brevifolia</i>	0 0/1	10	10	01	00	10	11	00
<i>M. eckloniana</i>	0 0/1	10	10	00	00	10	01	01
<i>M. azurea</i>	1 0/1	00	00	00	0 0/1	10	01	00
<i>M. tenuifolia</i>	01	01	10	00	01	10	01	01
<i>M. tetraloba</i>	00	00	11	11	1 0/1	10	10	10

Characters states scored as 0/1 indicates that both states are found.

### Characters

#### 1. Stems: slender (0); stout (1)

This is a difficult character to quantify because in some specimens the older primary stem is thicker than that of the new growth. Only the stems of the new growth, which are more numerous on the plants, were used to quantify the

character. Stems with thickness of equal to or less than 1 mm were considered slender and above 1 mm were considered stout.

2. Leaves (abaxial surface): glabrous (0); hairy (1)

3. Leaves: crowded (0); scattered (1)

The distance between leaves varies within the genus. Leaves were considered as crowded when the stem between successive leaves could not be distinguished. In the case of scattered leaves, the stem was clearly visible.

4. Leaves: spreading (0); ascending (1)

5. Leaves (axillary clusters): not always present (0); always present (1)

The presence of smaller leaves in the leaf axil is consistent in all, except in 2 phenetic clusters. In these 2 clusters, the smaller axillary leaves are rarely present and when present are found only in a few lower leaf axils.

6. Calyx lobes: margins glabrous (0); margins hairy (1)

7. Number of calyx lobes: five (0); four (1)

8. Corolla tube length: >7 mm (0); <7 mm (1)

Two classes of corolla tube lengths are evident (Fig. 5a): less than 7 mm and more than 7 mm long.

9. Number of corolla lobes: five (0); four (1)

10. Corolla lobes (abaxial surface): glabrous (0); hairy (1)

11. Corolla lobe shape: elongate (0); not (1)

12. Corolla lobes: shorter than tube (0); as long or longer than tube (1)

The corolla lobe shape in the genus can be described as linear-lanceolate or ovate. Only a single phenetic cluster has linear-lanceolate corolla lobes, which are associated with corolla tubes that are shorter than or as long as the lobes.

13. Flower colour: violet-blue (0); white (1)

14. Flower buds: cylindrical (0); clavate (1)

15. Number of stamens: five (0); four (1)

16. Filaments: as long as or slightly shorter than corolla tube (0); shorter than (1)

Filaments more than 2 mm shorter than the corolla tube were considered shorter than the corolla tube, whereas those less than 2 mm shorter than the corolla tube were considered slightly shorter or as long as the corolla tube.

## *Analysis*

The computer programs *McClade* version 3.01 (Maddison & Maddison, 1992) and *PAUP\** version 4 (Swofford 1998) were used to find the most parsimonious tree from the data set. *McClade* was used to set-up the data matrix and to create a data file for *PAUP*. All the characters used in the analysis were given equal weight and all uninformative characters were removed before the analysis was performed. Eight characters were parsimony informative and were included in the analysis. The data set was analyzed using the branch-and-bound algorithm. The initial upper bound was computed via the 'stepwise' option and all of the most parsimonious trees retained. The strict consensus tree of the resulting trees was calculated. A bootstrap analysis (Felsenstein, 1985) using 100 replicates was performed. This was done to determine comparative support within the data set for the nodes retrieved by the analysis. Several limitations of the use of the bootstrap analysis have been listed by Kitching et al. (1998), but the bootstrap analysis is frequently used to show support for nodes in cladograms.

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## Results

### Phenetic analysis

Cluster analysis (Figure 2) produced two primary groupings of the OTU's: A and B. Group A included specimens from *M. leptoloba*, *M. brevifolia*, *M. tenuifolia* var. *tenuifolia*, *M. tenuifolia* var. *azurea* and *M. eckloniana*, and group B of specimens assigned to *M. brevifolia*. Group B shows no distinct internal structure, whereas group A does, separating into the sub-groups A1, A2, A3, A4 and A5. The PCO (Figure 3) revealed a similar grouping pattern of the OTU's as the CA.

CA and PCO therefore revealed six distinct groups within *Merciera*: 1. the *M. leptoloba* group (A1), 2. the *M. brevifolia* 1 group (A2), 3. the *M. eckloniana* group (A3), 4. the *M. tenuifolia* var. *azurea* group (A4), 5. the *M. tenuifolia* var. *tenuifolia* group (A5), and 6. the *M. brevifolia* 2 group (B). The specimens assigned to each group are listed in Table 5.

Analysis of the twelve quantitative characters (Figures 4 & 5) indicates that the value ranges of seven characters (bract length, hypanthium length, calyx lobe length, corolla lobe length, style length, leaf length and leaf width) overlap among the six groups. Corolla tube length (Fig. 5a) convincingly separates the white flowering groups, *M. leptoloba*, *M. brevifolia* 1 and *M. brevifolia* 2 from the violet-blue flowering groups, *M. eckloniana*, *M. tenuifolia* var. *azurea* and *M. tenuifolia* var. *tenuifolia*. Except for a slight overlap, the value ranges of the filament length (Fig. 5d) show a similar separation. The number of corolla lobes, calyx lobes, and stamens show a distinct difference between the *M. brevifolia* 2 group and the remaining groups (Table 6).

The seven qualitative characters coded (Table 6) show that some character states are unique to particular groups. Hairs on the calyx lobe margins are only present in the *M. brevifolia* 2 group, except for its presence in one specimen in the *M. leptoloba* group. The absence of hairs on the back of the corolla lobes is unique to the *M. leptoloba*, *M. brevifolia* 1, and *M. eckloniana* groups. The *M. leptoloba* group is the only group with elongated (linear-lanceolate) corolla lobes, whereas the remaining groups possess non-elongated (ovate) corolla lobes.

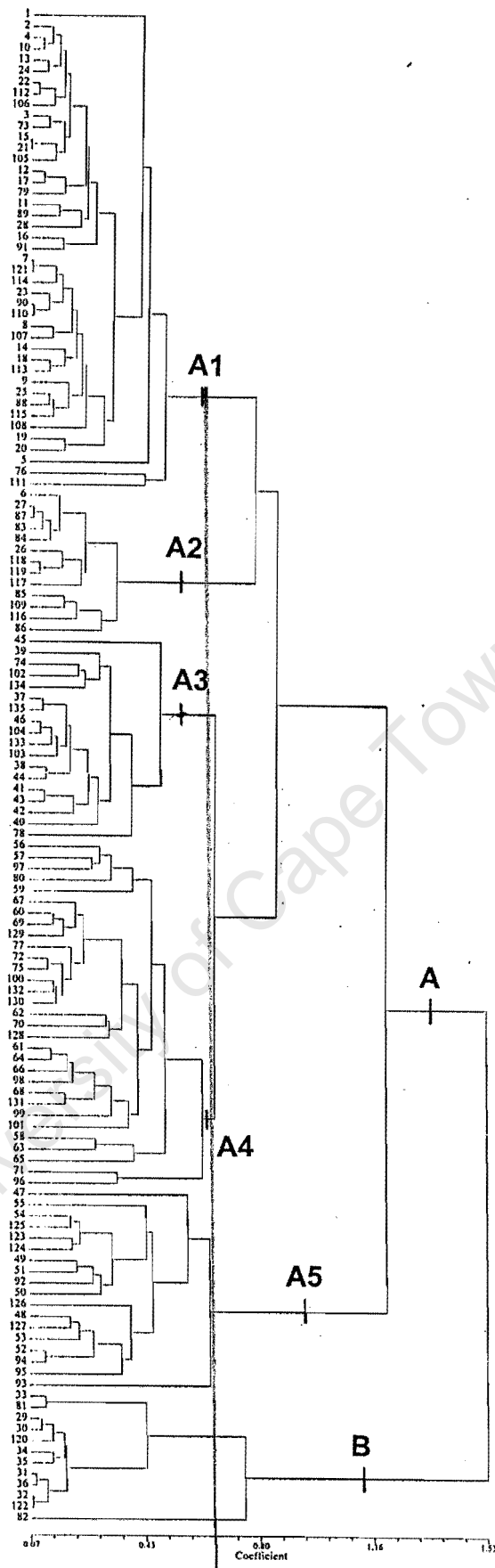


Figure 2. Phenogram depicting the groups within *Merciera* based on CA using all characters. The cophenetic correlation,  $r = 0.85$ . Group codes are as in Table 5.

Leaf hairs are only absent in the *neo-brevifolia* group, and ascending leaves are present in only the *M. tenuifolia* var. *tenuifolia* group. Flower colour splits the groups into two. The one comprising the white flowered *M. leptoloba*, *M. brevifolia* and *neo-brevifolia* groups, and the other comprising the violet-blue *M. tenuifolia* var. *azurea*, *M. eckloniana* and *M. tenuifolia* var. *tenuifolia* groups.

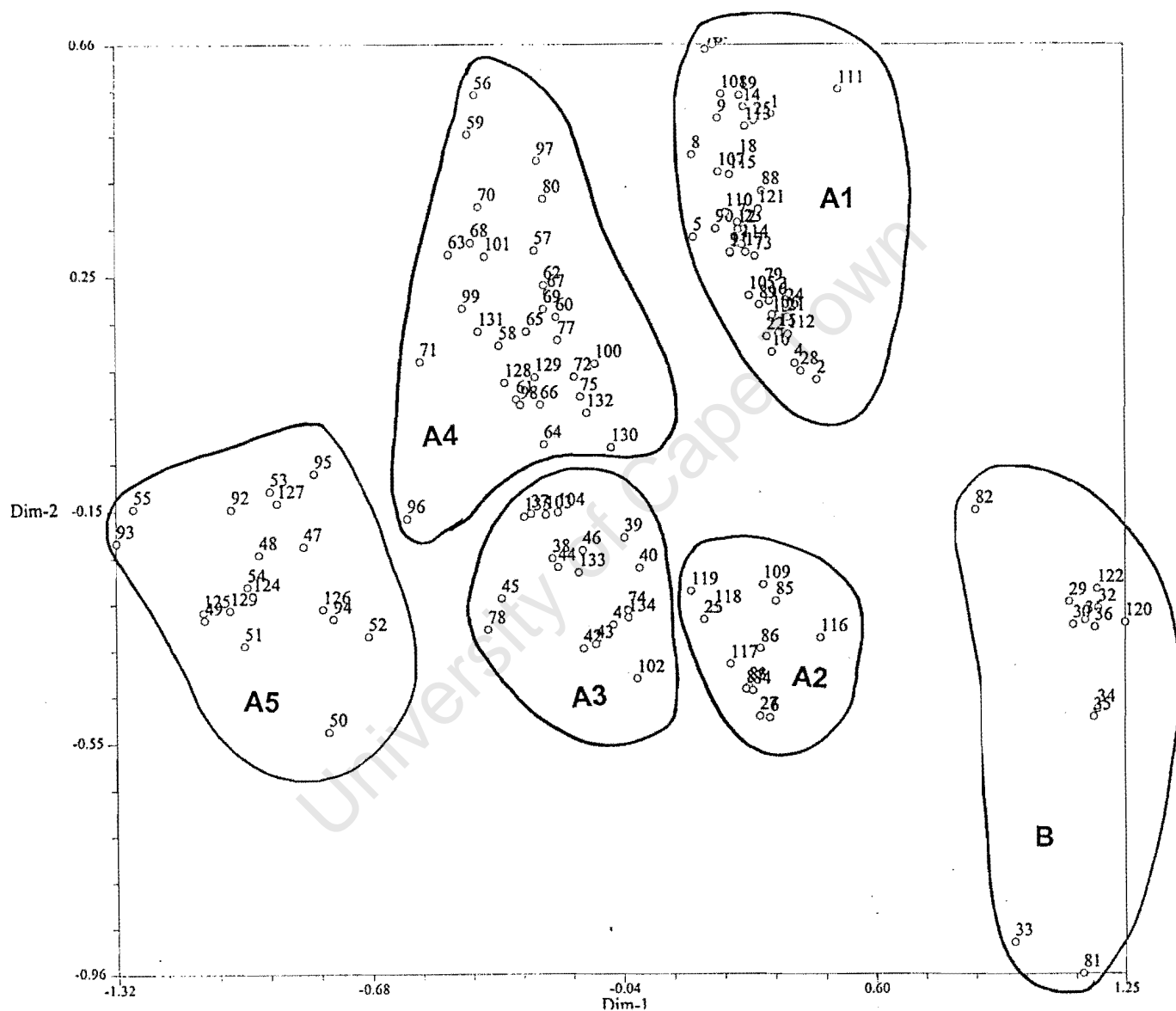


Figure 3. The phenetic groupings obtained from Principal coordinate analysis (PCO) using all characters. Group codes are as in Table 5.

Table 5. Specimens examined for the multivariate analysis. The number preceding the specimen identity and herbarium where the specimen is housed is that of the corresponding OTU on the phenogram (Fig. 2.) and ordination (Fig. 3).

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Group A1 (*M. leptoloba*)

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105- Adamson 4773 (BOL), 106- Adamson 4774 (BOL), 89- Adamson 4781 (SAM), 121- Adamson 4898 (BOL), 11- Barker 7776 (NBG), 22- Boucher 1769 (NBG), 8- Boucher 932 (NBG), 24- Brenan 14048 (NBG), 16- Burger 2859 (NBG), 115- Burman 1255 (BOL), 3- Compton 10223 (NBG), 1- Compton 14225 (NBG), 7- Compton 18951 (NBG), 5- Compton 19016 (NBG), 12- Compton 23238 (NBG), 4- Compton 6116 (NBG), 73- Cupido 66 (NBG), 76- Cupido 69 (NBG), 79- Cupido 72 (NBG), 9- De Vos 475 (NBG), 108- Esterhuysen 19594 (BOL), 114- Esterhuysen 33722 (BOL), 28- Esterhuysen 4954 (NBG), 15- Forsyth 394 (NBG), 90- Geopotts 5054 (SAM), 2- Guthrie s.n. (NBG), 110- Kensit 13469 (BOL), 17- Kruger 91 (NBG), 113- Leighton 2465 (BOL), 107- Leighton 2587 (BOL), 112- Levyns 11265 (BOL), 111- Levyns 4046 (BOL), 91- Lewis 3194 (SAM), 18- Orchard 341 (NBG), 20- Rycroft 3149 (NBG), 88- Stokoe 58444 (SAM), 14- Taylor 3793 (NBG), 21- Taylor 9557 (NBG), 19- Thompson 3872 (NBG), 10- Walters 1048 (NBG), 13- Walters 51 (NBG), 23- Williams 2949 (NBG), 25- Williams 3389 (NBG).

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Group A2 (*M. brevifolia* 1)

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26- Barker 8802 (NBG), 109- Bolus 5105 (BOL), 118- Bolus 7402 (BOL), 117- Bolus 4679 (BOL), 6- Compton 10603 (NBG), 85- Ecklon & Zeyher 3154 (NBG), 83- Ecklon & Zeyher s.n. (SAM), 27- Gillet s.n. (NBG), 84- Lewis 3532 (SAM), 116- Salter 5136 (BOL), 87- Schlechter 7372 (BOL, SAM), 86- Stokoe 58445 (SAM), 119- Zeyher 3154 (BOL).

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Group A3 (*M. eckloniana*)

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38- Barker 286 (NBG), 102- Bolus 634 (SAM), 39- Compton 21897 (NBG), 74- Cupido 67 (NBG), Cupido 71 (NBG), 134- Esterhuysen 11424 (BOL), 135- Esterhuysen 14361 (BOL), 45- Gillet 670 (NBG), McDonald 1735 (NBG), 37-

McDonald 603 (NBG), 133- Pillans 6749 (BOL), 104- Stokoe 64365 (SAM), 103- Stokoe 67099 (SAM), 41- Taylor 3016 (NBG), 44- Taylor 3877 (NBG), 42- Thompson 2303 (NBG), 46- v Jaarsveld & Bean 6411 (NBG), 43- Viviers 775 (NBG).

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Group A4 (*M. tenuifolia* var. *azurea*)

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96- Adamson 4904 (SAM), 99- Barnard 40469 (SAM), 70- Boucher 167 (NBG), 69- Boucher 1781 (NBG), 130- Burman 1079 (BOL), 72- Compton 14234 (NBG), 71- Compton 16835 (NBG), 75- Cupido 68 (NBG), 77- Cupido 70 (NBG), 80- Cupido 73 (NBG), 62- de Vos 1161 (NBG), 128- Esterhuysen 10007 (BOL), 129- Esterhuysen 4229 (BOL), 65- Jordaan 18402 (NBG), 64- Jordaan 832 (NBG), 68- Kruger 90 (NBG), 131- Leighton 906 (BOL), 132- Levyns 5372 (BOL), 97- MacOwan 3103b (SAM), 58- Martin sn (NBG), 60- Orchard 358 (NBG), 63- Orchard 524 (NBG), 100- Schlechter 7263 (SAM), 59- Steiner 2445 (NBG), 101- Stokoe 64366 (SAM), 98- Stokoe 65581 (SAM), 56- Taylor 10251 (NBG), 61- Taylor 4401 (NBG), 67- v.d Merwe 1787 (NBG), 66- Viviers 81 (NBG), 57- Williams 2937 (NBG).

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Group A5 (*M. tenuifolia* var. *tenuifolia*)

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123- Adamson 4098 (BOL), 125- Bolus 6948 (NBG), 50- Bolus 6948 (BOL), 54- Bond 1684 (NBG), 55- Boucher 5279 (NBG), 48- Compton 16832 (NBG), 93- Ecklon & Zeyher 2417 (SAM), 124- Gill s.n. (BOL), 49- Guthrie 2275 (NBG), 53- Haynes 1543 (NBG), 52- Le Maitre 177 (NBG), 92- MacOwan 3103 (SAM), 47- Rourke 998 (NBG), 94- Stokoe 58443 (SAM), 95- Stokoe 69735 (SAM), 126- Stokoe 8653 (BOL), 127- Stokoe 9113 (BOL), 51- Zeyher 3152 (NBG).

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Group B (*M. brevifolia* 2)

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120- Adamson 4895 (BOL), 33- Barker 8865 (NBG), 31- Bayliss 4089 (NBG), 122- Bolus sn (BOL), 29- Boucher 3447 (NBG), 34- Compton 10372 (NBG), 82- Drege 17297 (SAM), 35- Guthrie 2792 (NBG), 32- Jordaan sn (NBG), 30- Markotter 8639 (NBG), 36- Parker 3550 (NBG), 81- Tyson 899 (SAM).

Table 6. The distribution of the states of the seven qualitative characters and one quantitative character across the six phenetic groups. A1= the *M. leptoloba* group, A2= the *M. brevifolia* 1 group, A3= the *M. eckloniana* group, A4= the *M. tenuifolia* var. *azurea* group, A5= *M. tenuifolia* var. *tenuifolia* group, B= *M. brevifolia* 2 group.

Characters	A1	A2	A3	A4	A5	B
Habit	0	1	1	0	1	0
Corolla lobes hairy on the back	0	0	0	1	1	1
Corolla lobe shape	0	1	1	1	1	1
Calyx lobe margins hairy	0	0	0	0	0	1
Leaf orientation	0	0	0	0	1	0
Leaf hairy on abaxial surface	1	1	1	1	1	0
Flower colour	0	0	1	1	1	0
Number of corolla lobes	5	5	5	5	5	4
Number of calyx lobes	5	5	5	5	5	4
Number of stamens	5	5	5	5	5	4

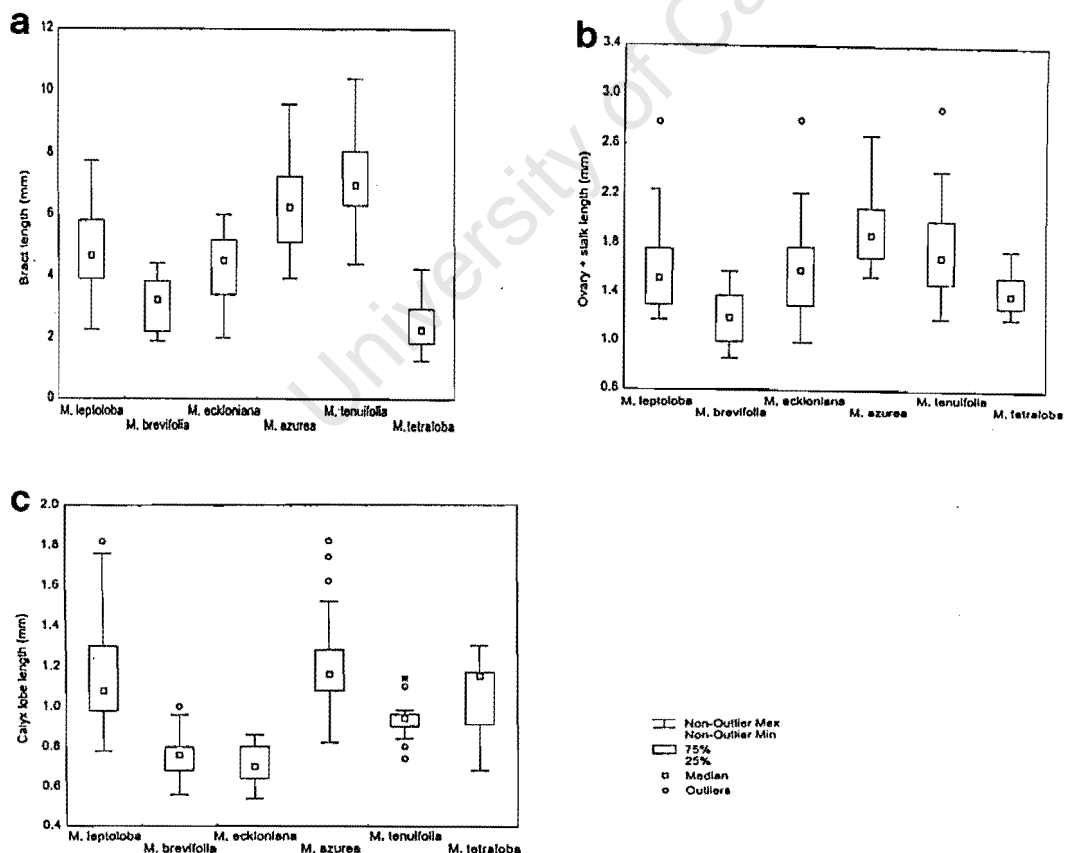


Figure 5. Box and whisker plots depicting the character variation ranges in the six phenetic groups. (a) bract length, (b) hypanthium length, and (c) calyx lobe length.

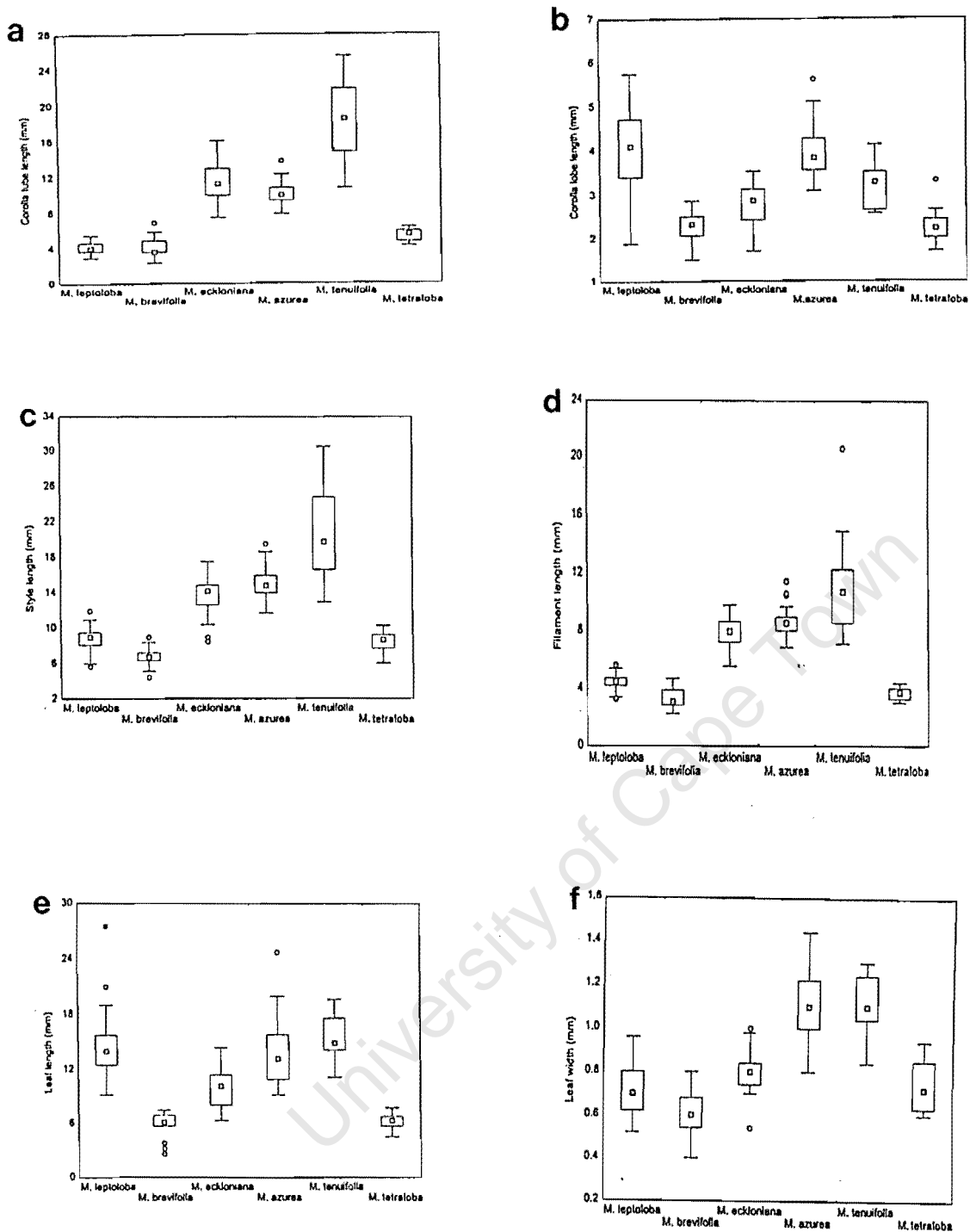


Figure 6. Box and whisker plots depicting the character variation ranges in the six phenetic groups. (a) corolla tube length, (b) corolla lobe length, (c) style length, (d) filament length, (e) leaf length, and (f) leaf width.

## Phylogenetic analysis

The parsimony analysis produced four trees each with a length of 13 steps, consistency index of 0.62 and a retention index of 0.58. The trees differ in the position of *M. tetraloba* sp. nov. In the first tree, it is the sister taxon to *M. leptoloba* in the second and fourth trees the sister taxon to *M. brevifolia*. In the third tree it is placed below *M. azurea* and is a sister lineage to it. One of the most parsimonious trees is shown in Figure 6. In the strict consensus tree (Figure 7) most of the nodes collapsed, creating polytomies.

The contribution of qualitative characters in the resolution of the cladogram in Figure 6 is significant whereas only a single quantitative character, corolla tubes length contributed to the resolution of the cladogram. Three characters, corolla lobe shape, filament length in relation to the corolla tube and the presence/absence of axillary clusters of leaves have consistency indices of 1, whereas the remaining five characters have consistency indices of 0.5.

In the consensus tree, only a single clade with a bootstrap value of 67% was revealed (Figure 7).

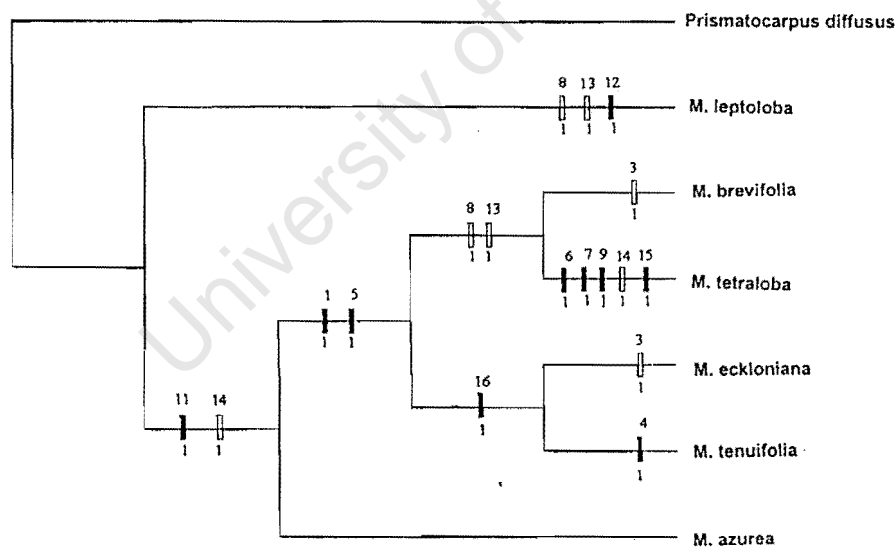


Figure 6. One of the four most parsimonious trees of the species in *Merciera*. Apomorphies are indicated with solid bars and homoplasies are indicated with hollow bars. Character numbers appear above boxes and character states appear below.

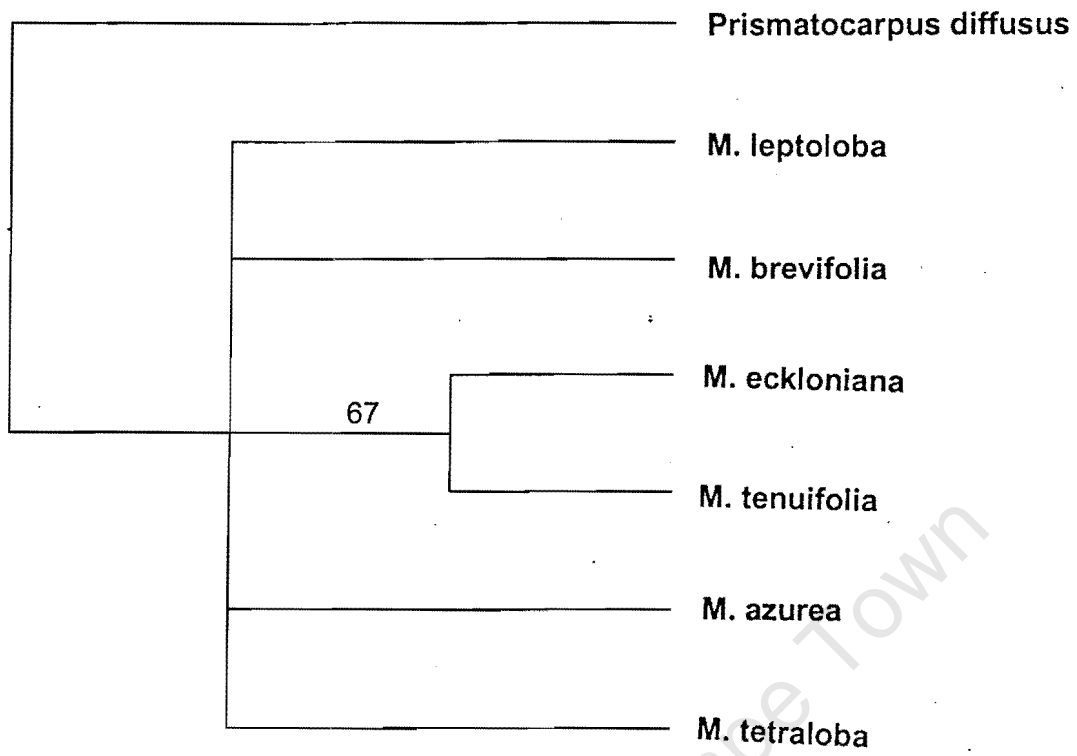


Figure 7. Strict consensus tree of the four most parsimonious trees of species in *Merciera*. Bootstrap value of the single clade is indicated above the line.

## Discussion

### Taxon delimitation

The value of phenetic methods in systematics lies in the translation of results into defensible taxonomic decisions. In the absence of agreement among biologists on a universally acceptable species concept, it is up to the individual taxonomist to define species level taxa. Various authors have used different criteria to define species, such as reproductive compatibility (Paterson, 1985, Mayr and Ashlock, 1991), ecological adaptation (Van Valen, 1976), overall similarity (Sneath and Sokal, 1973), and minimal diagnosability (Nixon and Wheeler, 1990). These criteria were formulated into the biological -, ecological -, phenetic -, and phylogenetic species concepts and are based on process or pattern to define species. The biological and ecological species concepts are process related and include criteria concerning the origin and function of species, whereas the phenetic and phylogenetic species concepts are pattern related. The pattern-related species concepts are feasible for practicing taxonomists because they use criteria that are based on observed patterns of character variation to delineate species. Three pattern related species concepts, the phenetic, phylogenetic and autapomorphic are briefly discussed.

The phenetic species concept (Sneath and Sokal, 1973) is an empirical approach that considers distinct phenetic clusters as species without making assumptions about speciation. The formation of clusters is produced by overall similarity between objects as a function of their individual similarities in each of the many characters in which they are being compared. Phenetic clusters may not include a fixed character, but are recognized by the possession of a particular minimum number of characters in common.

Sometimes the phenetic species concept is combined with the phylogenetic species concept, under which phenetic clusters accompanied by fixed character differences are considered species. A quantitative character in which there are intervals in values could be used to delineate phylogenetic species, but one that shows differences only in mean values could not in the phylogenetic species

concept. However, populations or phenetic groups that differ by differences in mean values would be recognized as subspecies or varieties (Luckow 1995). The recognition of infraspecific taxa is in conflict with the phylogenetic species concept, which does not recognize infraspecific taxa, but the smallest diagnosable groups as species (Eldredge and Cracraft, 1980 and Nixon & Wheeler, 1990). Crowe (1999), an advocate of the phylogenetic species concept defended the use of the rank of subspecies in taxonomy, stating that: "species cannot always be delineated unambiguously and the goals of 100% diagnosability and precise character congruence are not always achieved". The use of the subspecies rank will therefore allow the taxonomist to assign a taxon not accorded species status under the phylogenetic species concept to the subspecies rank. An extreme view on the recognition of infraspecific taxa comes from Brunell & Whitkus (1999). They argued that if infraspecific taxa are to be recognized they should be delimited from other taxa by non-overlapping discontinuity in one or more characters and have a geographical basis. Most practitioners of the phylogenetic species concept would assign specific ranks to taxa when using the Brunell & Whitkus criteria for delimiting infraspecific taxa.

The phenetic species concept differs from the phylogenetic species concept, which searches for fixed differences or gaps in continuously varying characters in order to distinguish species. The phylogenetic species concept is equivalent to the taxonomic species concept used in the majority of taxonomic publications surveyed by McDade (1995). Under the phylogenetic species concept, a unique or diagnostic character may be either apomorphic or pleisomorphic, and a group diagnosed only by pleisomorphic features is not monophyletic. Phylogenetic species could therefore be either paraphyletic or monophyletic. Mishler and Donoghue (1982), Donoghue (1985) and De Queiroz and Donoghue (1988) are amongst the authors who have based a species concept on the idea that species are monophyletic units that are supported by at least one autapomorphy. The approach to find autapomorphies to delimit species became known as the autapomorphic species concept. One of the shortcomings of this species concept is the inability of the practitioners thereof to recognize species that do not possess autapomorphies. This shortcoming is overcome by assigning those assemblages that lack autapomorphies to an entity outside any species, called a metataxon

(Donoghue, 1985 and De Queiroz and Donoghue 1988). Under this approach distinct clusters accompanied by an autapomorphy would be assigned to species and those lacking autapomorphies are considered metasppecies.

The criteria used to choose between species concepts are various. Rojas (1992) suggests that the choice of species concept used depends on what is to be studied and explained. An example of this approach is found in a study by Pedersen (1998) on the applicable taxonomic concepts in *Dactylorhiza*. This study found that in *Dactylorhiza* the following taxonomic concepts should apply: 'species' should comply with the biological species concept, 'subspecies' with the ecological species concept and 'varieties' with the phenetic species concept. According to Luckow (1995), the species concept employed depends on the method used to delimit species. It would therefore be inappropriate, for example, to promote a monophyletic species concept and then use phenetic analysis to delimit species. If Luckow's approach is followed then the use of phenetic analysis almost compels the taxonomist to use of the phenetic species concept to delimit species. This approach is rigid and limiting.

Phenetic and phylogenetic analyses suggest that the groups within *Merciera* satisfy the three species concepts differently. Under the autapomorphic species concept three groups, *M. leptoloba*, *M. tenuifolia* var. *tenuifolia*, and *M. brevifolia* 2 will be true species, because they are clearly monophyletic as indicated by their respective possession of autapomorphies. In contrast, the other three groups, *M. brevifolia* 1, *M. tenuifolia* var. *azurea* and *M. eckloniana* would be metasppecies because they lack autapomorphies. The *M. tenuifolia* var. *tenuifolia* and *M. brevifolia* 2 groups satisfy the phylogenetic species concept because both groups can be distinguished from each other and all other groups by unique characters that do not overlap among the groups. Ascending leaves are unique to *M. tenuifolia* var. *tenuifolia* and hairy calyx lobes, 4 corolla lobes, 4 calyx lobes, 4 stamens, and the absence of hairs on the adaxial surface of the leaves are unique to the *M. brevifolia* 2 group. The other four groups could be considered as subspecies or varieties of the two phylogenetic species. Under the phenetic species concept which looks for discrete clusters in multidimensional space all six groups as revealed by the phenetic analysis should be recognized as species. This is the approach followed in this study.

## Phenetic groups

Five of the six groups revealed by CA and PCO correspond with previously described taxa within *Merciera*. The five groups constitute group A1-A5: *M. leptoloba*, *M. brevifolia* 1, *M. tenuifolia* var. *azurea*, *M. eckloniana*, and *M. tenuifolia* var. *tenuifolia*. The other group B (*M. brevifolia* 2) constitutes a new taxonomic entity within the genus.

### the *M. leptoloba* (A1) and *M. brevifolia* 1 (A2) groups

De Candolle (1830), Ecklon & Zeyher (1837), and Adamson (1954) considered *M. leptoloba* and *M. brevifolia* as distinct species, whereas Sonder (1865) treated *M. leptoloba* as a variety of *M. brevifolia*. This study has found no support for Sonder's concept of taxon delimitation within the genus. Specimens of *M. leptoloba* (Fig. 2, A1) do form a subgroup distinct from specimens of *M. brevifolia* 1 (Fig. 2, A2). This separation of the taxa appears weak as they show continuous variation in all but one quantitative character, leaf length (Fig. 6h). Furthermore, the two taxa co-occur on the Houwhoek Mountains, which makes sub-division on geographical grounds inappropriate. The qualitative characters, corolla lobe shape, and habit (Table 6) support the recognition of two distinct taxa. *M. leptoloba* and *M. brevifolia* 1 are distinct from all other groups, except the *M. eckloniana* (A3) group by the absence of hairs on the back of the corolla lobes, and from the *M. brevifolia* 2 group by the number of calyx lobes, corolla lobes, stamens, and geographical distribution.

### the *M. eckloniana* (A3) and *M. tenuifolia* var. *azurea* (A4) groups.

The association between specimens of *M. eckloniana* and *M. tenuifolia* var. *azurea* is surprising. The specimens of *M. eckloniana* (Fig. 2, A3) form a distinct subgroup from specimens of *M. tenuifolia* var. *azurea* (Fig. 2, A4) within the *M. tenuifolia* var. *azurea*-*M. eckloniana* group. *M. eckloniana* is separated from *M. tenuifolia* var. *azurea* by the absence of hairs on the back of the corolla lobes, difference in habit (Table 6), and a distinct geographical distribution. Ecklon & Zeyher (1837) and Adamson (1954) considered *M. eckloniana* a species; Sonder

(1865) on the other hand relegated the species to a variety of *M. tenuifolia*. Schlechter (1898), who described *M. azurea*, regarded it as a distinct species, whereas Adamson (1954) regarded it as a variety of *M. tenuifolia*. CA and PCO indicate a clear division between *M. tenuifolia* var. *azurea* and *M. eckloniana*.

#### the *M. tenuifolia* var. *tenuifolia* (A5) group

Specimens from *M. tenuifolia* var. *tenuifolia* constitute this group. No single quantitative character (Figures 4 & 5) separates this group from the other violet-blue flowering groups, (A3 and A4). However, the distinctly ascending leaves separate this group from all the other groups. Geographically, this group occurs in sympatry with the *M. tenuifolia* var. *azurea* group but does differ from it in having a habit that is more erect. According to Adamson (1954), *M. azurea* is only a smaller and stouter form of *M. tenuifolia* and he accordingly assigned to varietal status. The distance between the *M. tenuifolia* var. *azurea* and *M. tenuifolia* var. *tenuifolia* clusters revealed by CA and PCO do not support Adamson's concept of the taxa boundaries.

#### the *M. brevifolia* 2 group

This group is a well-defined entity separated by CA and PCO. It is characterized by a reduction in the number of calyx lobes, corolla lobes and stamens, the presence of hairs on the calyx lobe margins, and the absence of leaf hairs on the adaxial surface. In addition to the floral and leaf characters, it also occupies a distinct geographical range, west of the Hottentots Holland Mountains in the Western Cape.

All previous workers considered specimens here assigned to the *M. brevifolia* 2 group as belonging to *M. brevifolia*. Sonder (1865) described *M. brevifolia* as having 4-5 corolla lobes, but did not recognize the 4 corolla lobed specimens taxonomically. The type specimen of *M. brevifolia*, Masson in herb. BM (a scanned image seen by myself) does not resemble any of the specimens in the *M. brevifolia* 2 group, but rather suspiciously, specimens in the *tenuifolia* var.

tenuifolia group. In the light of the substantial evidence favouring the recognition of the *M. brevifolia* 2 group, it should be given formal taxonomic status.

### Phylogeny

The cladogram produced by the parsimony analysis is unresolved. This may be due to too few informative characters. The clade formed by *M. eckloniana* and *M. tenuifolia* is supported by a unique synapomorphy, which is reflected in the bootstrap value of greater than 50% retrieved by 100 bootstrap replicates. The other nodes have bootstrap values of less than 50% and collapsed. *M. tenuifolia* possess a unique character state suggesting that it has undergone the most evolutionary modification in the clade. Similarly, *M. tetraloba* has several autapomorphies, implying that it has undergone the most evolutionary change in the genus, probably as a consequence of adaptation to a unique set of environmental factors.

*M. leptoloba*, *M. tenuifolia* and *M. tetraloba* are monophyletic taxa because of their respective possession of autapomorphies. *M. brevifolia*, *M. eckloniana*, and *M. azurea* on the other hand are clearly distinguishable as species, but they lack autapomorphies and are considered metataxa (Donoghue, 1985; De Queiroz & Donoghue, 1990). Metaspecies are unresolved entities (Rieseberg & Brouillet, 1994) with monophyletic species embedded within them. For example, the metaspecies *M. eckloniana* would most likely have *M. tenuifolia* embedded in it. Metaspecies are afforded species status and are considered the ancestors of monophyletic species.

## Taxonomy

*Merciera* A. DC.

A. De Candolle, *Monographie des Campanulées*: 369 (1830)

Type: *M. tenuifolia* (L.f.) A. DC. (lectotype, designated by Pfeiffer (1874)).

(=*Trachelium tenuifolium* L.f.)

Subshrubs, hispidulous to hispid. Stems decumbent or semi-erect, branched. Leaves scattered or crowded, sessile, glabrous or hairy, alternate, linear, subulate, entire, often with axillary clusters of smaller glabrous leaves, margins more or less ciliated. Flowers actinomorphic, sessile or subsessile, solitary or occasionally with 2 rudimentary flowers, axillary or on reduced side branches. Bracts 2 or 3, when 2 then absent in the terminal flower or when 3 then one subtends the developed flower and the other two subtend each of the rudimentary flowers, with hyaline tips, entire or serrated glabrous or hairy, abaxial surface occasionally warty near apex. Hypanthium obconical, hispid. Calyx 4-5 lobed, glabrous or hairy, entire or serrated, with hyaline tips, often with 2 hairs on hyaline tips. Corollas narrowly tubular with spreading limb, white, or violet-blue, limb 4-5 lobed, lobes occasionally unequal, glabrous, or hairy on back. Stamens 4-5, free, inserted at the base of the corolla tube, opposite the calyx lobes, filaments flattened, wider and pilose about the middle, becoming very narrow, anthers linear, basifixed. Ovary inferior, 1-locular, or incompletely 2-locular, containing 4 erect ovules situated at the base of the ovary. Style filiform, often exserted, glabrous, swollen at base. Stigmas bifid, glabrescent. Fruit a hispid capsule, crowned with persistent calyx, 1-2 seeded, indehiscent.

A genus of six species endemic to the southwestern parts of the Cape Floristic Region. Grows in open sandy, clayey or rocky soil, often-disturbed habitats. Fire is important in the growth and survival of the genus. After fire, the plants resprout from the base and a period of 4 to 6 years of vigorous vegetative growth and flowering follows. After six years, the plants start to die and start disappearing when the veld remains unburnt for very long periods. Flowering is from October to April.

Phillips (1951) cited *M. leptoloba* as the type whereas Pfeiffer (1874) cited *Trachelium tenuifolium* under the new genus *Merciera*. According to Stafleu & Cowan (1983), Pfeiffer frequently indicates type species for generic names, which constitute in numerous instances the first selection of a lectotype. Single species are mentioned only when they serve as a type of new genera or sections, as was done with *Merciera*. Article 9.17 of the Code (Greuter et al., 2000) is applied here. It states that the author who first designated a lectotype or a neotype must be followed. The species designated by Pfeiffer is therefore cited as the type.

### Key to the species

1. Corolla tube less than 7 mm long; flowers white occasionally with purple tips; calyx lobes, corolla lobes & stamens 4 or 5.

2. Calyx lobes, corolla lobes & stamens 4; calyx lobe margins hairy; plants growing in clayey soil; distributed west of the Hottentots Holland mountains

***M. tetraloba***

2. Calyx lobes, corolla lobes & stamens 5; calyx lobe margins glabrous; plants growing in sandy or stony soil; distributed south-east of the Hottentots Holland mountains

3. Lower leaves more than 8 mm long, very crowded; plants decumbent, stout; corolla lobes long (2-6 mm), linear-lanceolate; flower buds cylindrical

***M. leptoloba***

3. Lower leaves less than 8 mm long, scattered; plants semi-erect, slender; corolla lobes short (2-3 mm), ovate; flower buds clavate

***M. brevifolia***

1. Corolla tube more than 7 mm long; flowers blue, violet or purple rarely white; calyx lobes, corolla lobes & stamens 5.

4. Plants slender (stem equal to or less than 1 mm thick); leaves scattered; corolla lobes glabrous on the back; distributed from the Groenlandberg northwards to Tulbagh.

***M. eckloniana***

4. Plants stout (stem more than 1 mm thick); leaves crowded; corolla lobes hairy on the back; distributed south of the Groenlandberg.

5. Stems semi-erect; leaves ascending, abaxial surface hairy, axillary clusters of smaller 'leaves' always present; corolla tube long (11-26 mm).

***M. tenuifolia***

5. Stems decumbent; leaves spreading, abaxial surface glabrescent, axillary clusters of smaller 'leaves' occasionally present on the lower parts of the stem; corolla tube short (6-14 mm).

***M. azurea***

***Merciera leptoloba*** A.DC., Monographie des Campanulées: 371 (1830); Ecklon & Zeyher: 387 (1837); Adamson: 162 (1954). *Merciera brevifolia* A.DC. var. *leptoloba* (A.DC.) Sonder: 596 (1865). Type: Cape of Good Hope: "Bonae-Spei", Hooker s.n. (K).

Stems decumbent with groups of branches at the end of a year's growth. Leaves scattered to crowded, lower leaves more than 8 mm long, glabrous to hairy on abaxial surface, with an axillary cluster of smaller leaves. Bracts 2-8 mm long. Calyx lobes 5, 0.7-1.8 mm long, with hairs on the hyaline tips, rarely on the back. Corolla white, tube 3-5.5 mm long, occasionally shorter than the lobes, lobes 5, 2-6 mm long, linear, glabrous on the back, Stamens 5, filaments 3-5 mm long. Hypanthium 1-3 mm long. Style 4-12 mm long.

***Distribution***

*M. leptoloba* is a common species on the Cape south-east coast from Kogelberg to Elim, with a range outlier to Tulbagh Suurvlakte (Figure 8). This species is found on sandy or stony flats and hills at altitudes ranging between sea level and 400 m. It flowers from November to March.

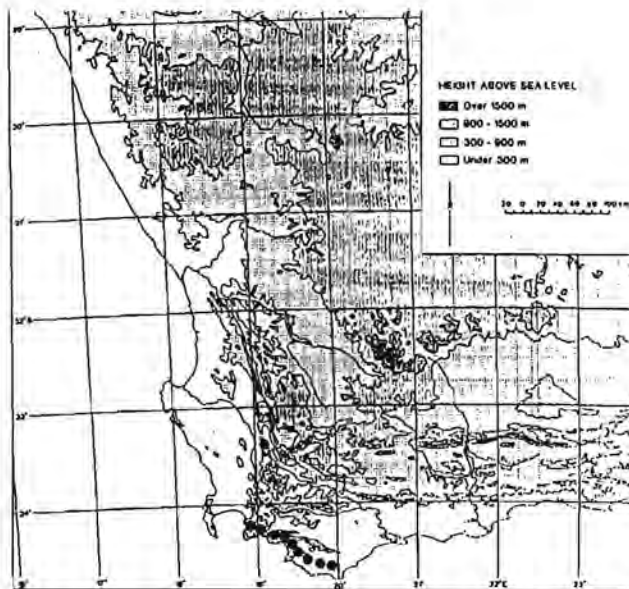


Figure 8. Distribution of *M. leptoloba* in the Cape Floristic Region.

#### *Specimens examined*

Adamson 4773 (BOL), Adamson 4774 (BOL), Adamson 4781 (SAM), Adamson 4898 (BOL), Barker 7776 (NBG), Boucher 1769 (NBG), Boucher 932 (NBG), Brenan 14048 (NBG), Burger 2859 (NBG), Burman 1255 (BOL), Compton 10223 (NBG), Compton 14225 (NBG), Compton 18951 (NBG), Compton 19016 (NBG), Compton 23238 (NBG), Compton 6116 (NBG), Cupido 66 (NBG), Cupido 69 (NBG), Cupido 72 (NBG), De Vos 475 (NBG), Esterhuysen 19594 (BOL), Esterhuysen 33722 (BOL), Esterhuysen 4954 (NBG), Forsyth 394 (NBG), Geopotts 5054 (SAM), Guthrie s.n. (NBG), Kensit 13469 (BOL), Kruger 91 (NBG), Leighton 2465 (BOL), Leighton 2587 (BOL), Levyns 11265 (BOL), Levyns 4046 (BOL), Lewis 3194 (SAM), Orchard 341 (NBG), Rycroft 3149 (NBG), Stokoe 58444 (SAM), Taylor 3793 (NBG), Taylor 9557 (NBG), Thompson 3872 (NBG), Walters 1048 (NBG), Walters 51 (NBG), Williams 2949 (NBG), Williams 3389 (NBG).

***Merciera brevifolia*** A.DC., Monographie des Campanulées: 371 (1830); Ecklon & Zeyher: 387 (1837); Adamson: 161 (1954). Type: s. loc. Masson s.n. (Herb. BM!)

Stems semi-erect, slender with groups of branches at the end of a year's growth. Leaves scattered to crowded, less than 8 mm long, glabrous to hairy on abaxial surface, with an axillary cluster of smaller leaves. Bracts 2-4 mm long. Calyx lobes 5, 0.5-1 mm long, with hairs on the hyaline tips, rarely on the back. Corolla white, tube 3-6 mm long, lobes 5, 1.5-3 mm long, ovate, glabrous on the back. Stamens 5, filaments 2-4 mm long. Hypanthium 0.8-1.6 mm long. Style 4-8.5 mm long.

## Distribution

This is a mountain species occurring on the Babylons Tower, Bot River Mountains, Houwhoek Mountains, Shaw's Mountains, and the Caledon Swartberg (Figure 9). Flowering is from November to February.

## Notes

On the Houwhoek mountains where this species occur in sympatry with *M. leptoloba* possible hybrids between the two species are formed.

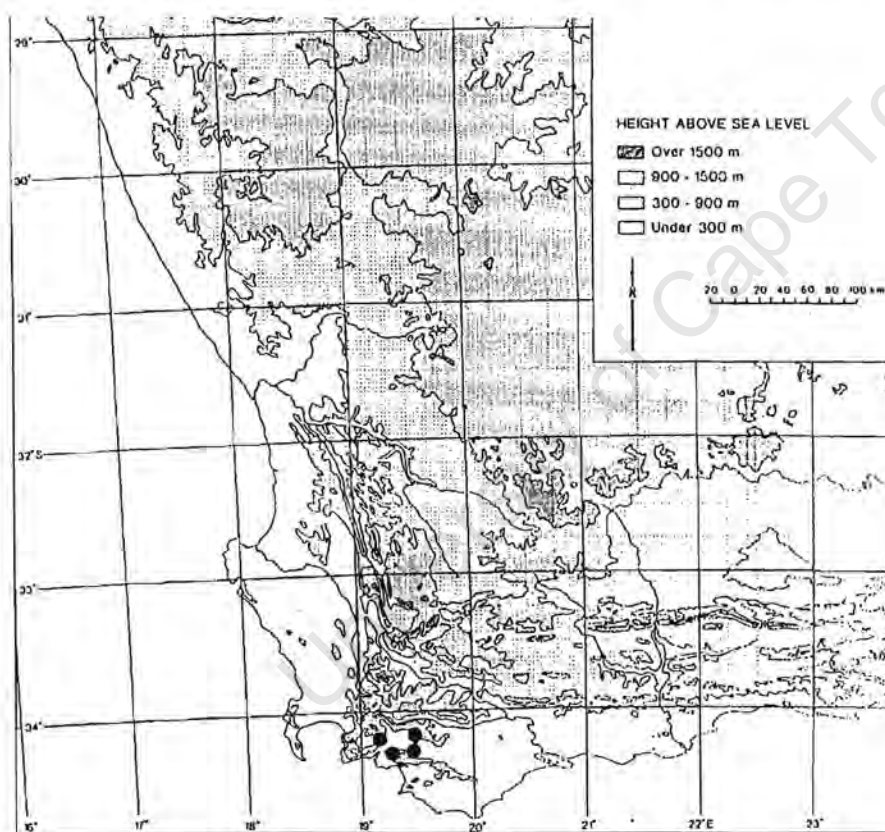


Figure 9. Distribution of *M. brevifolia* in the Cape Floristic Region.

## Specimens examined

Barker 8802 (NBG), Bolus 5105 (BOL), Bolus 7402 (BOL), Bolus 4679 (BOL), Compton 10603 (NBG), Ecklon & Zeyher 3154 (NBG), Ecklon & Zeyher s.n. (SAM), Gillet s.n. (NBG), Lewis 3532 (SAM), Salter 5136 (BOL), Schlechter 7372 (BOL, SAM), Zeyher 3154 (BOL).

*Merciera tenuifolia* (L. f.) A. DC., Monographie des Campanulées: 370 (1830); Sonder: 596 (1865); Adamson: 159 (1954). *Trachelium tenuifolium* L.f: 143 (1781); Thunberg: 38 (1800). *Roella tenuifolia* (L.f.) Thunb.: 174 (1823). Type: s.loc., Thunberg 4773 & 4774, (UPS-THUNB.!).

*Merciera tenuifolia* (L.f.) A.DC. var. *candolleana* Sonder: 596 (1865). Type: South Africa, Western Cape, Houwhoek Mountains, Ecklon & Zeyher 2417 (SAM!).

*Merciera tenuifolia* (L.f.) A.DC. var. *thunbergiana* Sonder: 596 (1865). Type: Cap, Thunberg 4773. (UPS-THUNB.!).

Stems semi-erect, sparsely or profusely branched, occasionally with group of branches at the end of a year's growth. Leaves crowded, ascending, hairy on the abaxial surface, axillary cluster of smaller leaves occasionally present. Bracts 4-10 mm long. Calyx lobes 5, 0.8-1 mm long, with hairs on the hyaline tip. Corolla violet-blue, rarely white, tube 10-25.5 mm long, narrow; lobes 5, 2.5-4 mm long, ovate, hairy on the back. Stamens 5, filaments 7-21 mm long. Hypanthium 1-3 mm long. Style 13-30.5 mm long.

#### *Distribution*

The distribution of *M. tenuifolia* (Figure 10) is limited to Bot River, Houwhoek and Kogelberg where it is found on stony soil at altitudes ranging between 110 and 600 m. This species flower during December and January.

#### *Notes*

The locality of the specimen MacOwan 3103 collected at Tulbagh Nuwekloof is suspect. It has the same locality, collecting date, and number as a specimen from *M. azurea*. No recent collections of *M tenuifolia* have been made in the Tulbagh area.

## Specimens examined

Adamson 4098 (BOL), Bolus 6948 (NBG), Bond 1684 (NBG), Boucher 5279 (NBG), Compton 16832 (NBG), Ecklon & Zeyher 2417 (SAM), Gill s.n. (BOL), Gutherie 2275 (NBG), Haynes 1543 (NBG), Le Maitre 177 (NBG), MacOwan 3103 (SAM), Rourke 998 (NBG), Stokoe 58443 (SAM), Stokoe 69735 (SAM), Stokoe 8653 (BOL), Stokoe 9113 (BOL), Zeyher 3152 (NBG).

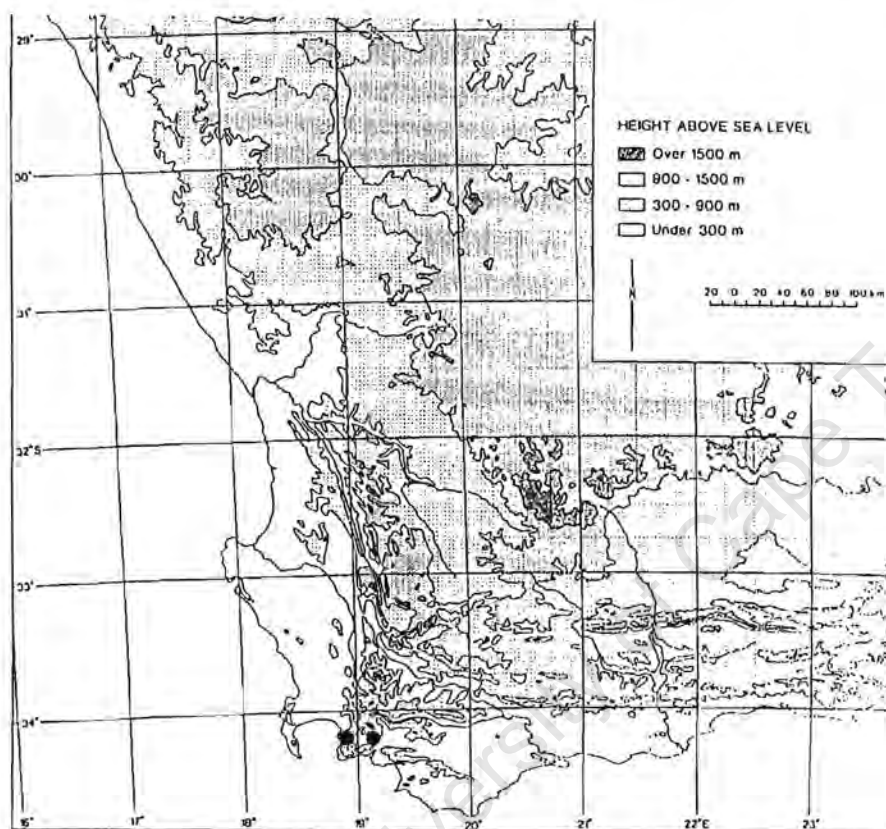


Figure 10. Distribution of *M. tenuifolia* in the Cape Floristic Region.

*Merciera azurea* Schlechter, *Botanische Jahrbücher* 24:447 (1898). *Merciera tenuifolia* (L.f) A.DC. var. *azurea* (Schlechter) Adamson: 160 (1954). Type: South Africa, Western Cape, Sir Lowry's Pass, Schlechter 7263 (SAM!)

Stems decumbent, stout, occasionally with group of branches at the end of a year's growth. Leaves crowded, spreading, glabrous or hairy on the abaxial surface, alternate, axillary cluster of smaller leaves occasionally present. Bracts 4-9.5 mm long. Calyx lobes 5, 1-1.9 mm long, with hairs on the hyaline tip. Corolla

violet-blue, rarely white, tube 7-14 mm long, wide; lobes 5, 3-5.5 mm long, ovate, glabrous, or hairy on the back. Stamens 5, filaments 7-11.5 mm long. Hypanthium 1.5-2.7 mm. Style 12-19.5 mm long.

### *Distribution*

*M. azurea* ranges from Sir Lowry's Pass to Bredasdorp (Figure 11) and occurs on sandy or stony soil at altitudes ranging between 100 and 650 m. This species flowers from November to February.

### *Notes*

The locality of the specimen MacOwan 3103b collected at Tulbagh Nuwekloof is suspect. It has the same locality, collecting date, and number as a specimen from *M. tenuifolia*. No recent collections of *M. azurea* have been made in the Tulbagh area. During 1896 MacOwan made several collecting trips to Tulbagh, Caledon, Houwhoek and the Hottentots Holland mountains (Gunn & Codd, 1981) and it could have happened that specimens from the different localities were unknowingly mixed up resulting in incorrect locality information.

### *Specimens examined*

Adamson 4904 (SAM), Barnard 40469 (SAM), Boucher 167 (NBG), Boucher 1781 (NBG), Burman 1079 (BOL), Compton 14234 (NBG), Compton 16835 (NBG), Cupido 68 (NBG), Cupido 70 (NBG), Cupido 73 (NBG), de Vos 1161 (NBG), Esterhuysen 10007 (BOL), Esterhuysen 4229 (BOL), Jordaan 18402 (NBG), Jordaan 832 (NBG), Kruger 90 (NBG), Leighton 906 (BOL), Levyns 5372 (BOL), MacOwan 3103b (SAM), Martin sn (NBG), Orchard 358 (NBG), Orchard 524 (NBG), Schlechter 7263 (SAM), Steiner 2445 (NBG), Stokoe 64366 (SAM), Stokoe 65581 (SAM), Taylor 10251 (NBG), Taylor 4401 (NBG), v.d Merwe 1787 (NBG), Viviers 81 (NBG), Williams 2937 (NBG).

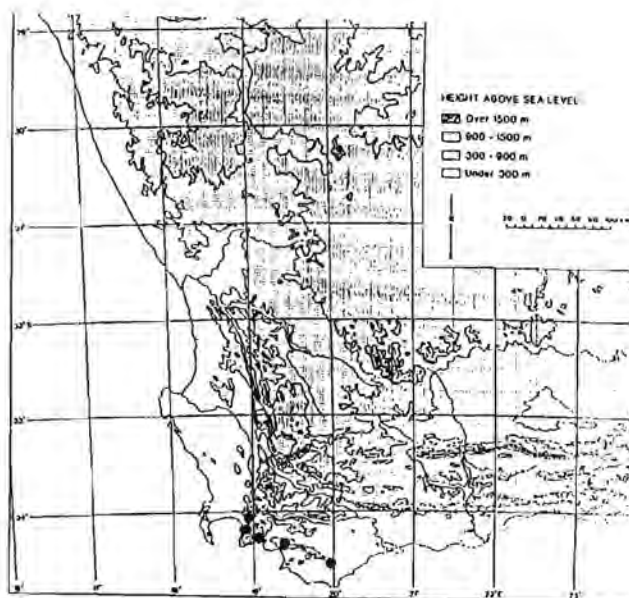


Figure 11. Distribution of *M. azurea* in the Cape Floristic Region.

***Merciera eckloniana*** Buek ex Ecklon & Zeyher, Enumeratio plantarum Africae Australis Extratropicae: 387 (1837); Adamson: 160 (1954). *Merciera tenuifolia* (L.f.) A.DC. var. *eckloniana* (Buek ex Ecklon & Zeyher) Sonder: 596 (1865). Type: South Africa, Western Cape, Tulbagh, Waterfall, Ecklon & Zeyher 2420 (SAM!)

Stems semi-erect, slender, occasionally with group of branches at the end of a year's growth. Leaves scattered, spreading, glabrous, or hairy on the abaxial surface, axillary cluster of smaller leaves occasionally present. Bracts 2-6 mm long. Calyx lobes 5, < 1 mm long, with hairs on the hyaline tip. Corolla violet-blue, rarely white, tube 7.5-16 mm long, narrow; lobes 5, 1.5-3.5 mm long, ovate, glabrous on the back. Stamens 5, filaments 5.5-10 mm long. Hypanthium 1-2.8 mm long. Style 8.5-17.5 mm long.

## Distribution

This species is distributed from the Groenlandberg northwards to Tulbagh (Figure 12). It is found on sandy or stony soil at altitudes ranging between 450 to 1500 m. Flowering time is from October to February.

## Specimens examined

Barker 286 (NBG), Bolus 634 (SAM), Compton 21897 (NBG), Cupido 67 (NBG), Cupido 71 (NBG), Esterhuysen 11424 (BOL), Esterhuysen 14361 (BOL), Gillet 670 (NBG), McDonald 1735 (NBG), McDonald 603 (NBG), Pillans 6749 (BOL), Stokoe 58445 (SAM), Stokoe 64365 (SAM), Stokoe 67099 (SAM), Taylor 3016 (NBG), Taylor 3877 (NBG), Thompson 2303 (NBG), v Jaarsveld & Bean 6411 (NBG), Viviers 775 (NBG).

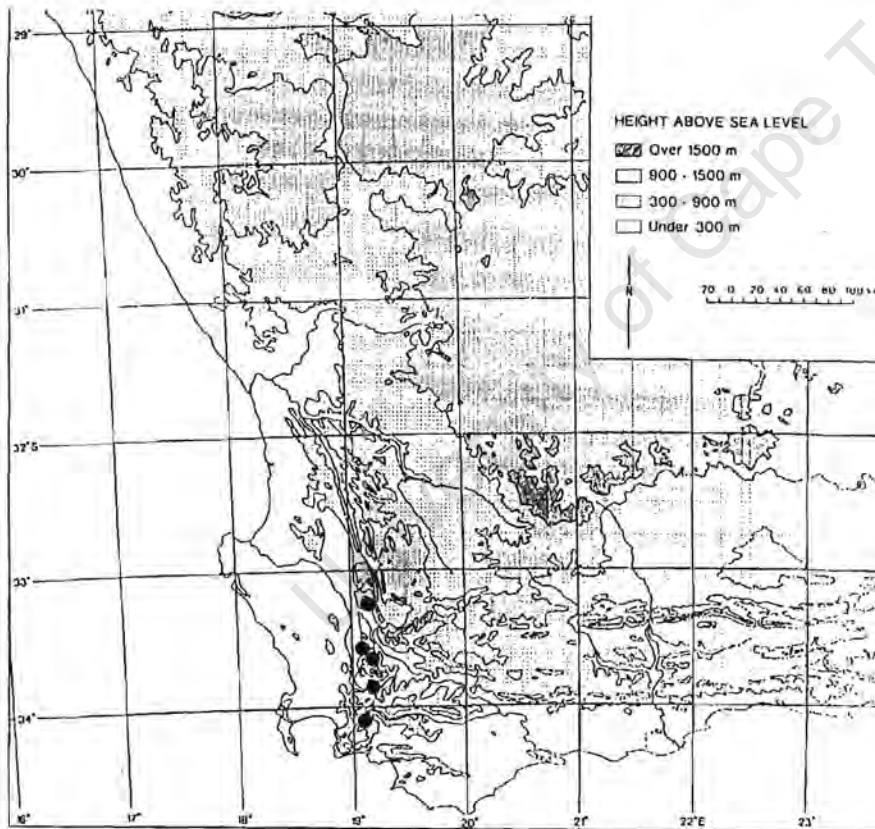


Figure 12. Distribution of *M. eckloniana* in the Cape Floristic Region.

***Merciera tetraloba* C.N.Cupido sp. nov.**

Ex affiniatē *M. brevifolia* A.DC. et specierum affinum folia glabra in pagina abaxiale, calyx 4 lobis et ciliatis margines, corolla alba, interdum purpureus apice, lobis 4 ovatis, stamina 4 distinguenda

Type: South Africa, Western Cape, Gordon's Bay, mountain slopes, Bayliss 4089 (NBG)

Stems decumbent, slender, branched, occasionally with group of branches at the end of a year's growth. Leaves scattered, ascending, the older spreading, glabrous on the abaxial surface, axillary cluster of smaller leaves present. Bracts 1-4 mm long. Calyx lobes 4, 0.6-1.2 mm long, hairs on the hyaline tips and margins. Corolla white, occasionally with purple tips, tube 4-6 mm long; lobes 2-3 mm long, ovate, glabrous or hairy on the back. Stamens 4; filaments 3-4.5 mm long. Hypanthium 1-2 mm long. Style 6-10 mm long.

*Notes*

This species occur on lower mountain slopes and lowland areas, which are sought after for urban development. Large areas of the habitat of this species in the Helderberg and Stellenbosch have already been destroyed. On the Harmony Flats in Strand, the few existing populations are under serious threat of extinction.

*Distribution*

This species is found in Faure, Gordon's Bay, Sir Lowry's Pass, Somerset West, Strand, Dal Josaphat, Du Toitskloof and Stellenbosch (Figure 13) on flats and lower mountain slopes at altitudes ranging between 30 and 65 m, It grows in clayey soil and flowers from November to January.

*Specimens examined*

Adamson 4895 (BOL), Barker 8865 (NBG), Bayliss 4089 (NBG), Bolus sn (BOL), Boucher 3447 (NBG), Compton 10372 (NBG), Drege 17297 (SAM), Gutherie 2792 (NBG), Jordaan sn (NBG), Markotter 8639 (NBG), Parker 3550 (NBG), Tyson 899 (SAM).

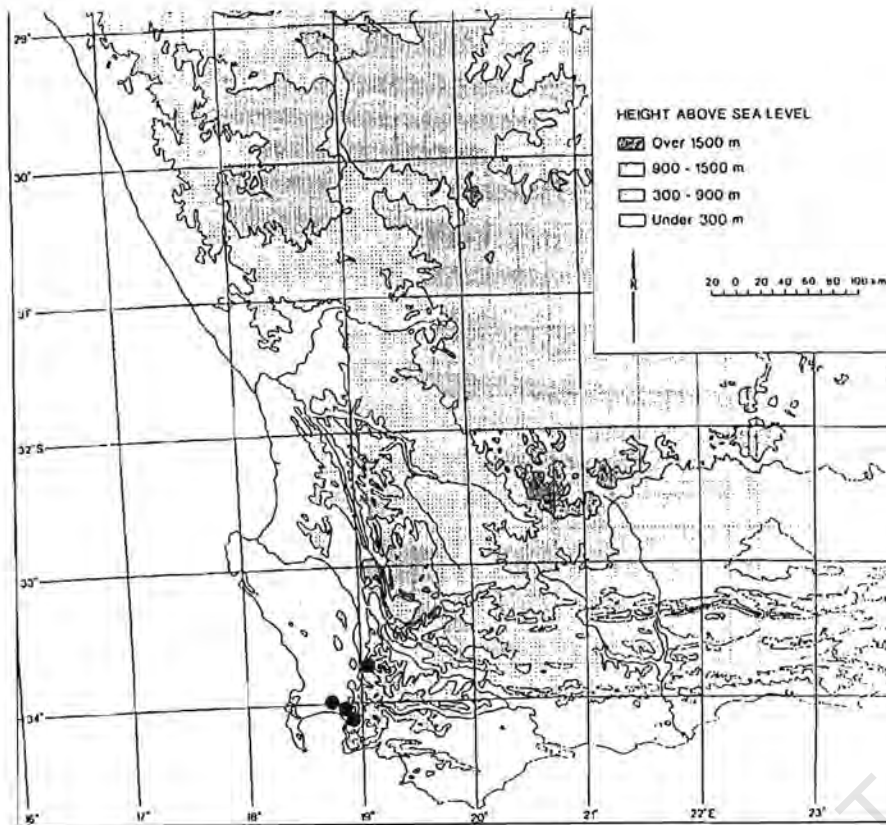


Figure 13. Distribution of *M. tetraloba* sp. nov. in the Cape Floristic Region.

#### Excluded species

***Merciera heteromorpha*** Buek ex Ecklon & Zeyher, Enumeratio plantarum Africae Australis Extratropicae: 387 (1837)

=*Carpacoce heteromorpha* (Buek ex Ecklon & Zeyher) L. Bolus: 25 (1896)

When Ecklon & Zeyher described the species, they noted that it mostly likely constitutes a distinct genus. Sonder (1865) considered it a Rubiaceae, but did not recognize it taxonomically. A few decades after Sonder, Bolus (1896) transferred the species to the genus *Carpacoce* in the Rubiaceae where it is currently classified.

***Merciera vaginata*** Adamson, The journal of South African Botany: 162 (1954)

=*Merciera heteromorpha* Buek ex Ecklon & Zeyher, Enumeratio plantarum Africae Australis Extratropicae: 387 (1837)

=*Carpacoce heteromorpha* (Buek ex Ecklon & Zeyher) L. Bolus: 25 (1896)

Adamson erroneously thought that Stokoe s.n. from the Somerset Snееukop is a new species of *Merciera* and consequently described it as such. After it has been

brought to his attention that the plant described as *M. vaginata* appears to be the same as certain specimens in the herbarium of the South African Museum he re-examined the specimen. He conceded that the plant was the same as Zeyher 2421, the type of *M. heteromorpha* (Adamson, 1955) and is therefore *Carpacoce heteromorpha*.

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## Appendix

Data matrix used in the multivariate analysis.

1= bract length, 2= hypanthium length, 3= calyx lobe length, 4= number of calyx lobes, 5= calyx lobe margins hairy (0= absent, 1= present), 6= corolla tube length, 7= corolla lobe length, 8= number of corolla lobes, 9= corolla lobes hairy (0= absent, 1= present), 10= style length, 11= filament length, 12= number of stamens, 13= leaf length, 14= leaf width, 15= leaf hairs on abaxial surface (0= absent, 1= present), 16= flower colour (0= white, 1= violet-blue), 17= habit (0= decumbent, 1= semi-erect), 18= corolla lobe shape (0= linear-lanceolate, 1= ovate), 19= leaf orientation (0= spreading, 1= ascending). ?= missing data. Length in mm.

OTU's	Characters																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Compton 14225	4.92	1.8	1.44	5	0	3.8	3.28	5	0	5.64	4.32	5	27.52	0.64	0	0	0	0	0
Gutherie sn	2.84	1.24	0.98	5	0	3.92	2.3	5	0	8.1	4.68	5	12.36	0.6	0	0	0	0	0
Compton 10223	3.84	1.18	1	5	0	3.74	4.08	5	0	7.1	4.5	5	12.42	0.74	0	0	0	0	0
Compton 6116	3.92	1.28	1	5	0	3.16	2.82	5	0	8.56	4	5	11.32	0.7	0	0	0	0	0
Compton 19016	5.8	1.3	0.98	5	0	4.8	5.62	5	0	11.9	4.54	5	13.28	0.54	1	0	0	0	0
Compton 10603	1.9	1.24	0.76	5	0	2.4	1.78	5	0	5.12	2.24	5	3.8	0.6	1	0	1	1	0
Compton 18951	5.5	1.66	1.26	5	0	5.1	4.02	5	0	9.02	5.4	5	12.78	0.64	0	0	0	0	0
Boucher 932	6.5	1.92	1.12	5	0	4.62	4.36	5	0	10.4	4.92	5	17.64	0.78	0	0	0	0	0
De Vos 475	4.6	2.24	1.26	5	0	4.14	5.1	5	0	9.9	4.92	5	14.2	0.9	0	0	0	0	0
Walters 1048	3.34	1.28	1	5	0	5	3.22	5	0	9.22	5.62	5	11.9	0.68	0	0	0	0	0
Barker 7776	4.9	1.38	0.8	5	0	3.88	4.2	5	0	8.58	4.74	5	18.22	0.86	0	0	0	0	0
Compton 23238	4.24	1.88	1.2	5	0	3.74	3.34	5	0	8.06	4.2	5	17.2	0.84	0	0	0	0	0
Walters 51	3.26	1.52	1.08	5	0	5.1	3.2	5	0	9.82	4.1	5	14.1	0.62	0	0	0	0	0
Taylor 3793	6.44	1.46	1.48	5	0	4.04	5.14	5	0	9.24	4.96	5	15.7	0.56	0	0	0	0	0
Forsyth 394	4.42	1.32	0.9	5	0	4.08	3.7	5	0	9.08	4.42	5	10.52	0.6	0	0	0	0	0
Burger 2859	4.06	1.32	0.84	5	0	4.78	4.8	5	0	8.8	4.4	5	9.2	0.92	0	0	0	0	0
Kruger 91	4.6	1.64	1.3	5	0	4.14	3.3	5	0	8.7	4	5	14.6	0.84	0	0	0	0	0

OTU's	Characters																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Orchard 341	6.4	1.96	1.4	5	0	4	4.3	5	0	9.4	4.5	5	11.12	0.66	0	0	0	0	0
Thompson 3872	4.9	2.78	1.38	5	0	4	4.12	5	0	8.54	4.7	5	15.26	0.72	0	0	0	0	0
Rycroft 3149	5.82	2.78	1.3	5	0	5.5	5	5	0	11	5.08	5	15.76	0.56	0	0	0	0	0
Taylor 9557	4.64	1.38	0.98	5	0	3.7	3.86	5	0	8.7	4	5	9.38	0.6	0	0	0	0	0
Boucher 1769	3	1.5	0.9	5	0	3.92	3.42	5	0	7.86	3.82	5	13.82	0.84	0	0	0	0	0
Williams 2949	4.86	1.68	1	5	0	4.64	4.52	5	0	9.22	4.8	5	14	0.54	0	0	0	0	0
Brenan 14048	4.08	1.26	1.1	5	0	3.5	3.24	5	0	8.1	3.3	5	14.6	0.62	0	0	0	0	0
Williams 3389	4.64	1.64	1.32	5	0	4	5.32	5	0	8.9	4.6	5	19	0.7	0	0	0	0	0
Barker 8802	4.42	1.26	0.8	5	0	5	2.86	5	0	8.4	4	5	6.92	0.6	1	0	1	1	0
Gillet sn	2.16	0.86	0.68	5	0	3.6	2.06	5	0	6.74	3.06	5	5.7	0.68	1	0	1	1	0
Esterhuysen 4954	3.4	1.38	0.78	5	0	4.1	1.88	5	0	7.66	3.42	5	17	0.76	0	0	0	0	0
Boucher 3447	2.92	1.38	1.24	4	1	5.9	2.64	4	0	9.32	3.76	4	4.46	0.9	0	0	0	1	0
Markotter 8639	2.3	1.4	1.18	4	1	5.32	2.24	4	0	8.64	3.82	4	6.7	0.94	0	0	0	1	0
Bayliss 4089	3.08	1.34	1.14	4	1	6	2.44	4	0	9.9	4.3	4	6.22	0.64	0	0	0	1	0
Jordaan sn	2.22	1.7	1.16	4	1	5.56	1.96	4	0	8.64	3.7	4	6.1	0.72	0	0	0	1	0
Barker 8865	1.26	1.24	0.74	4	1	5	2.4	4	1	8.6	3.14	4	5.56	0.62	0	1	0	1	0
Compton 10372	2	1.38	0.9	4	1	5.78	2.18	4	0	9.1	3.84	4	5.48	0.74	0	0	0	1	0
Gutherie 2792	1.64	1.4	1	4	1	4.22	2.1	4	0	6.68	3.38	4	7.68	0.82	0	?	0	1	0
Parker 3550	2.36	1.48	1.16	4	1	6.36	2	4	0	10.2	4.4	4	6.28	0.6	0	0	0	1	0
McDonald 603	5	2	0.78	5	0	13.2	3.12	5	0	15.8	8.72	5	11.38	0.74	0	1	1	1	0
Barker 286	5.4	1.46	0.64	5	0	13.3	3.14	5	0	14.7	7.92	5	10	0.82	0	1	1	1	0
Compton 21897	3.5	1.4	0.64	5	0	10.9	3.28	5	0	8.5	6	5	14.38	0.72	0	1	1	1	0
McDonald 1735	4.9	1.78	0.6	5	0	7.5	2.26	5	0	10.4	5.56	5	9	0.8	0	1	1	1	0
Taylor 3016	3.16	1.68	0.7	5	0	11.3	2.42	5	0	14	7.74	5	8.16	0.54	0	1	1	1	0
Thompson 2303	3.64	1.34	0.68	5	0	10.6	2.72	5	0	15.2	8.24	5	6.3	0.98	0	1	1	1	0
Viviers 775	3.4	1.6	0.66	5	0	13	2.3	5	0	13.7	8.8	5	7.9	0.74	0	1	1	1	0
Taylor 3877	6	1.16	0.7	5	0	12.7	2.84	5	0	14.8	7.22	5	11.28	0.8	0	1	1	1	0
Gillet 670	4.24	2.8	0.68	5	0	11.8	2.06	5	0	14.4	7.64	5	13.7	0.7	1	1	1	1	0
v Jaarsveld & Bean 6411	5.2	1.74	0.8	5	0	9.36	2.96	5	0	13.3	8	5	8	0.8	0	1	1	1	0

OTU's	Characters																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Rourke 998	5.9	2.9	0.8	5	0	16.1	3.3	5	1	18.4	10	5	14.8	1.08	1	1	1	1	0
Compton 16832	6.08	2	0.9	5	0	16.6	3.3	5	1	18.5	9.22	5	15.98	1.26	1	1	1	1	1
Gutherie 2275	7.48	1.7	0.88	5	0	22.5	2.6	5	1	22.8	11.7	5	16.76	1.3	1	?	1	1	1
Bolus 6948	4.4	1.68	0.92	5	0	18.7	2.56	5	1	20.6	10.6	5	11.1	1.08	1	?	1	1	1
Zeyher 3152	6.92	1.94	0.9	5	0	20.9	2.6	5	1	25	11.9	5	13.1	1	1	?	1	1	1
Le Maitre 177	7.28	1.44	0.94	5	0	12	2.64	5	1	13.7	8.06	5	14.64	1	1	1	1	1	1
Haynes 1543	8.5	2.2	1.1	5	0	13.9	3.34	5	1	15.1	8.14	5	14.82	1.24	1	1	1	1	1
Bond 1684	6.58	1.56	0.96	5	0	19.3	3.5	5	1	22.4	12.5	5	14.1	1.1	1	1	1	1	1
Boucher 5279	10.4	2.4	0.84	5	0	19.4	3.66	5	1	21.4	10.8	5	17.6	1.24	1	1	1	1	1
Williams 2937	6.76	1.86	1.46	5	0	10	4.1	5	0	15.8	8	5	15.2	1	0	1	0	1	0
Martin sn	8	2	1.08	5	0	9.9	5.1	5	0	16.2	8	5	9.14	0.92	1	1	0	1	0
Steiner 2445	7.26	1.7	1.74	5	0	10.8	4.22	5	0	16.7	9.7	5	24.7	1.28	0	1	0	1	0
Orchard 358	4.94	2.1	1	5	0	9.88	4.94	5	0	13.5	8.68	5	10.86	1.16	0	1	0	1	0
Taylor 4401	6.24	1.76	1.1	5	0	10.8	4	5	1	14.9	8.38	5	9.6	1	0	1	0	1	0
de Vos 1161	5.7	1.7	1.18	5	0	12.4	3.94	5	0	18.6	11.5	5	16.28	0.8	0	?	0	1	0
Orchard 524	9.56	1.74	1.1	5	0	10.6	4.94	5	0	14.6	8	5	18.38	1.16	1	1	0	1	0
Jordaan 832	4.18	1.64	1.08	5	0	10	3.54	5	1	14.6	8.24	5	11.76	1	0	1	0	1	0
Jordaan 18402	5.74	1.6	1.3	5	0	5.52	3.82	5	0	13.1	9	5	15.78	1.16	1	1	0	1	0
Viviers 81	7.24	1.78	1	5	0	9.4	3.74	5	1	13.2	7.5	5	11.22	0.82	0	1	0	1	0
v.d Merwe 1787	7.08	2	1.16	5	0	8.5	3.88	5	0	12.7	8	5	12.3	1.32	0	1	0	1	0
Kruger 90	6.62	2	1.52	5	0	9.7	4.62	5	1	14	8.94	5	12.48	1.22	0	1	0	1	0
Boucher 1781	6.38	2	1.14	5	0	10	4.6	5	0	14.8	9.12	5	10.08	1.08	0	1	0	1	0
Boucher 167	5.28	2.24	1.28	5	0	11.7	4.14	5	0	17.5	10.6	5	19.96	1.26	0	1	0	1	0
Compton 16835	6	2.2	1.16	5	0	9.14	3.7	5	0	15	8.64	5	17.22	1.12	0	1	1	1	1
Compton 14234	5.1	1.68	1.06	5	0	8.54	3.4	5	0	14	8	5	14.22	1.1	0	1	0	1	0
Cupido 66	4.38	1.28	1.16	5	0	4.64	4.1	5	0	8.94	4.5	5	14.54	0.78	0	0	0	0	0
Cupido 67	2	1.22	0.62	5	0	10	3.52	5	0	12.1	6.98	5	7.86	0.84	0	1	1	1	0
Cupido 68	4.12	1.7	1.2	5	0	11.4	3.36	5	0	14	8.1	5	11.5	1.14	0	1	0	1	0
Cupido 69	6.4	1.3	1.76	5	0	5	4.72	5	0	10	5.22	5	21	0.96	0	0	0	0	0

OTU's	Characters																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Cupido 70	4.2	2	1.24	5	0	12	3.76	5	0	15.2	8.88	5	13.24	1	0	1	0	1	0
Cupido 71	4.52	1.3	0.8	5	0	14.2	3.12	5	0	17.4	9.08	5	11	0.88	1	1	1	1	0
Cupido 72	4.16	1.3	1.14	5	0	2.96	3	5	0	6.78	3.4	5	17.16	0.9	0	0	0	0	0
Cupido 73	8	2	1.82	5	0	8.4	3.66	5	0	11.7	6.86	5	15.1	1.22	0	1	0	1	0
Tyson 899	1.3	1.2	0.68	4	1	5.86	1.7	4	1	6	3.12	4	6.72	0.64	0	?	0	1	0
Drege 17297	4.24	1.6	0.92	4	0	4.4	3.3	4	0	7.76	4.2	4	6.92	0.72	0	0	0	0	1
Ecklon & Zeyher sn	3	1.08	0.78	5	0	3.9	2.3	5	0	4.44	2.84	5	6.23	0.62	1	0	1	1	0
Lewis 3532	3.24	1	0.74	5	0	3.5	2.38	5	0	6.32	2.72	5	2.58	0.56	1	0	1	1	0
Ecklon & Zeyher 3154	3.56	1.2	0.74	5	0	3.1	2.32	5	0	6.64	2.82	5	7.4	0.68	0	0	1	1	0
Schlechter 7372	2.24	1.06	0.78	5	0	3.6	2.4	5	0	7.24	3.24	5	6.18	0.68	1	0	1	1	0
Stokoe 58444	4.68	1.5	1.34	5	0	4.58	4.88	5	0	9.22	4.66	5	13.1	0.7	0	0	0	0	0
Adamson 4781	3.5	1.26	0.8	5	0	3.58	3.84	5	0	6	5.4	5	15.86	0.8	0	0	0	0	0
Geopotts 5054	6.82	1.76	1	5	0	4.64	4.12	5	0	9.2	4.4	5	13.72	0.7	0	0	0	0	0
Lewis 3194	3.5	1.78	0.9	5	0	4.52	4.68	5	0	10.3	4.92	5	12.9	0.9	0	0	0	0	0
MacOwan 3103	7.6	1.9	0.94	5	0	18.4	3.24	5	1	18.9	11.2	5	19.2	1.1	1	?	1	1	1
Ecklon & Zeyher 2417	8.88	1.5	1.14	5	0	25.5	3.36	5	1	30.5	20.6	5	14.92	1.1	1	?	1	1	1
Stokoe 58443	6.76	1.7	0.94	5	0	13.5	2.6	5	1	16	8.22	5	14.54	1.1	1	1	1	1	1
Stokoe 69735	9.12	2	0.98	5	0	14.9	3.1	5	1	16.6	9.32	5	17.6	1.04	0	1	1	1	1
Adamson 4904	6.3	1.8	1.12	5	0	11	3.7	5	0	16.5	8.56	5	9.46	1	1	1	1	1	1
MacOwan 3103b	8	2.68	1.22	5	0	10.2	4.72	5	0	14.2	7.38	5	15.1	1	0	?	0	1	0
Stokoe 65581	6.52	1.54	0.94	5	0	7.86	3.7	5	1	14.4	7.22	5	13.14	1.16	0	1	0	1	0
Barnard 40469	7.66	1.82	1.2	5	0	11	3.08	5	1	16.5	9.4	5	15.8	1.32	0	?	0	1	0
Schlechter 7263	5.42	1.86	1.2	5	0	9.98	3.18	5	0	14	8.6	5	11	1	0	?	0	1	0
Stokoe 64366	3.94	2.14	1.44	5	0	8.9	4	5	1	13.7	8.96	5	18	1.44	0	1	0	1	0
Bolus 634	3	1	0.54	5	0	9.2	1.7	5	0	13	8	5	7.8	0.76	0	1	1	1	0
Stokoe 67099	5.18	2.22	0.86	5	0	11.3	2.96	5	0	14.4	8.64	5	9.84	0.76	0	1	1	1	0
Stokoe 64365	5.94	1.74	0.8	5	0	11.2	2.88	5	0	12.7	8	5	11.96	0.76	0	1	1	1	0
Adamson 4773	5.1	1.62	0.94	5	0	3.04	3.7	5	0	7.9	4.16	5	12.2	0.74	0	0	0	0	0
Adamson 4774	2.28	1.52	0.9	5	0	3.64	3.6	5	0	9.8	4.2	5	15.54	0.68	0	0	0	0	0

OTU's	Characters																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Leighton 2587	6.64	1.7	1	5	0	3.52	4.64	5	0	9.52	4.38	5	18.04	0.64	0	0	0	0	0
Esterhuysen 19594	7.76	1.72	1.28	5	0	5	5.74	5	0	10.3	4.2	5	15.38	0.64	0	0	0	0	0
Bolus 5105	3.68	1	0.86	5	0	5.9	2.5	5	0	8.36	3.9	5	7.44	0.46	0	0	1	1	0
Kensit 13469	7.2	1.74	1	5	0	4.28	4.14	5	0	8.5	4.68	5	13.26	0.52	0	0	0	0	0
Levyns 4046	7.1	1.48	1.82	5	1	4.22	4.78	5	0	9	4.6	5	13.26	0.64	0	0	0	0	0
Levyns 11265	2.76	1.24	1	5	0	3.18	3.4	5	0	7.72	3.9	5	13.46	0.78	0	0	0	0	0
Leighton 2465	6.16	1.76	1.52	5	0	3.64	4.4	5	0	9.2	4.38	5	13.8	0.54	0	0	0	0	0
Esterhuysen 33722	5.08	1.96	1.08	5	0	4.3	4	5	0	9.46	4.64	5	10.92	0.7	0	0	0	0	0
Burman 1255	5.36	1.64	1.2	5	0	3.7	5.08	5	0	9.6	4.74	5	14.1	0.82	0	0	0	0	0
Bolus 4679	3.84	1.54	0.6	5	0	4.9	1.5	5	0	6.9	3.94	5	6.16	0.54	1	0	1	1	0
Bolus 7402	4.1	1.42	1	5	0	3.6	2.68	5	0	6.08	2.92	5	6.04	0.72	1	0	1	1	0
Zeyher 3154	3.98	1.58	0.96	5	0	4.28	2.8	5	0	7.16	3.42	5	7.48	0.8	1	0	1	1	0
Adamson 4895	2.12	1.24	1.3	4	1	4.32	2	4	0	7.64	3	4	6.48	0.88	0	0	0	1	0
Adamson 4898	5.16	1.66	1.32	5	0	3.2	4.08	5	0	8.24	4.6	5	12.48	0.66	0	0	0	0	0
Bolus sn	2.96	1.76	1.16	4	1	5.42	2.24	4	0	8.78	3.64	4	5.72	0.62	0	0	0	1	0
Adamson 4098	5.9	1.2	0.98	5	0	23.2	4.12	5	1	25.7	14.4	5	13.2	1	1	1	1	1	1
Gill sn	6.3	1.32	0.94	5	0	21.9	3.72	5	1	24.8	12.3	5	17.56	0.84	1	1	1	1	1
Bolus 6948	6.94	1.48	0.92	5	0	23.4	3.14	5	1	26.2	14.9	5	15.54	1.1	1	?	1	1	1
Stokoe 8653	8.06	1.3	0.74	5	0	10.8	3.18	5	1	13	7.1	5	19.6	1.3	1	1	1	1	1
Stokoe 9113	6.98	2.1	0.94	5	0	14.8	4.08	5	1	17.2	8.54	5	12.9	1.14	1	1	1	1	1
Esterhuysen 10007	4	2.1	0.82	5	0	13.8	3.8	5	0	19.5	10.5	5	14.08	1.08	0	1	0	1	0
Esterhuysen 4229	7.22	2.06	0.94	5	0	10.2	3.46	5	0	14.9	8.72	5	11	1.06	0	1	0	1	0
Burman 1079	4.1	1.88	0.96	5	0	9.42	3.12	5	0	13.6	7.96	5	10.18	0.9	0	1	0	1	0
Leighton 906	6.22	2.1	1.12	5	0	10.3	4.26	5	1	15	8.58	5	10.76	1.3	0	1	0	1	0
Levyns 5372	5.88	1.7	1.08	5	0	10.1	3.32	5	0	16	8.36	5	9.84	0.84	0	1	0	1	0
Pillans 6749	5.12	1.58	0.78	5	0	11.4	2.46	5	0	14.9	7.7	5	10.22	0.7	0	1	1	1	0
Esterhuysen 11424	3.22	1.06	0.72	5	0	8.72	2.46	5	0	8.96	7	5	10.68	1	0	1	1	1	0
Esterhuysen 14361	4.5	1.98	0.82	5	0	15.9	3.2	5	0	17.5	7.46	5	11.68	0.8	0	1	1	1	0
Stokoe 58445	2.2	1.38	0.58	5	0	6.92	1.82	5	0	9	4.7	5	3.18	0.54	0	?	1	1	0

OTU's	Characters																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Taylor 10251	8.08	2.26	1.62	5	0	10.3	5.6	5	0	15.9	8	5	18.32	1.16	0	1	0	0	0
Salter 5136	2.06	0.9	0.56	5	0	3.64	2.26	5	0	6.72	2.32	5	6.36	0.4	0	0	1	1	0

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