

The validity of currently recognised sectional limits  
within *Combretum* Loefling, subgenus *Combretum*  
(Combretaceae) in southern Africa

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The practical work incorporated in this dissertation was conducted on the campus of the University of Durban-Westville from January 1989 to December 1990.

I hereby declare that this thesis, submitted for the degree of Master of Science, University of Durban-Westville, is the result of my own investigations, except where the work of others is acknowledged.

In all instances where the term “the writer” appears this refers to the author.

A handwritten signature in cursive script, reading "Rodman".

Sharon Rodman

December 1990

This work is dedicated to my mother and the memory of my father, in an attempt to express my gratitude to them for providing me with every possible opportunity to further my education.

## Abstract

Taxonomic confusion associated with *Combretum* Loefling, subgenus *Combretum* (Combretaceae) resulted in this investigation into the validity of sectional limits within the subgenus in southern Africa. Eight sections, together with their species and infraspecific taxa, totalling 29, are currently recognised in this region.

Light and scanning electron microscopy on herbarium samples representing the taxa concerned were used to observe a final total of 171 selected characters.

Data from individual specimens were collected numerically and processed to produce phenograms using Rohlf's NTSYS-pc program; also to produce descriptions in natural language format. A data processing program, TAXON, was specially designed and implemented to facilitate the desired processing and output.

With the possible exceptions of *Macrostigmaea* and *Ciliatipetala* which require further investigation before certainty is reached, currently recognised sections were found to be valid and the limits between them acceptable.

The main sources of confusion in this subgenus were found to lie in certain currently recognised species and their infraspecific taxa. These taxa were observed not to be distinct.

The status of non-distinct species has been changed whenever clear evidence exists in favour of these changes. Other changes to species and infraspecific taxa have been recommended, but only to be implemented if supportive evidence is found after further investigations.

Changes of status have been made in section *Angustimarginata* Engl. & Diels, where *C. caffrum* (Eckl. & Zeyh.) Kuntze and *C. woodii* Dümmer have become synonyms of *C. erythrophyllum* (Burch.) Sond., and *C. vendae* Van Wyk has become a subspecies of *C. erythrophyllum* (Burch.) Sond., i.e. ssp. *vendae* (Van Wyk) Rodman comb. & stat. nov. (ined.); and in section *Spathulipetala* Engl. & Diels, where *C. mkuzense* Carr & Retief (section *Macrostigmaea* Engl. & Diels) has become a synonym of *C. zeyheri* Sond.



*C. collinum* ssp. *gazense* (Swynn. & Bak.f.) Okafor, section *Metallicum* Fresen., has been changed to *C. collinum* ssp. *coriaceum* (Schinz) Rodman (ined.) in accordance with international botanical nomenclature.

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# 1

## Introduction

### 1.1 History of the subgenus *Combretum*

The Combretaceae is a family of trees, shrubs, climbers and lianas found in a wide variety of habitats throughout the tropics. The genus *Combretum* is one of 20 genera (Exell & Stace, 1966, pp. 5–25), 11 of these occurring in tropical Africa. The genus is spread throughout the tropics (except Australasia and Pacific Islands) and extending into the subtropics, with over 100 species in Africa (Exell & Stace, 1972, p. 309). The widest range of structure and most of the difficult taxonomic problems are found in Africa (Stace, 1969, p. 134). Stace (1980, p. 332) also maintains that all evidence points to Africa being the centre of diversity of the genus *Combretum*, with connections across both the Indian and Atlantic oceans.

Stace (1980, p. 329) predicts that the totals of 45 sections and approximately 224 species in the genus will probably be reduced as further data and collections accumulate; with the final total of species probably numbering around 200.

Three subgenera are recognised by Exell & Stace (1966, p. 10); viz. *Combretum*, *Cacoucia* (Aublet) Exell and Stace, and the Asian monotypic *Apetalanthum* Exell & Stace. Of these *Combretum* and *Cacoucia* are found in southern Africa.

Subgenus *Combretum* is separated from subgenus *Cacoucia* by having scales, but not microscopic stalked glands present. Scales are sometimes obscured by hairs (e.g. *Combretum erythrophyllum* ssp. *vendae*, Plate 2.5) or glutinous secretions/exudate

(e.g. *C. apiculatum* ssp. *apiculatum*, Plate 1.4). Subgenus *Cacoucia* has microscopic stalked glands, not scales, present; and has flowers which are 4- or 5-merous compared with *Combretum* which has flowers which are usually 4-merous. All species of *Combretum* are glandular and although the subgenus *Combretum* does not possess stalked glands, all species have scales with “markedly raised cuticular membranes enclosing copious secretions” (Stace, 1980, p. 330). Sometimes, particularly in young organs, this exudate partially or almost entirely covers the organ surface (e.g. lamina surface in *C. apiculatum* ssp. *apiculatum*, Plate 1.4); whereas at other times, scales seem to “break through” the exudate (e.g. *C. edwardsii*, Plate 1.6).

The identification of sections in the subgenus *Combretum* is not a straightforward task, partly because there are a number of small sections currently recognised and “no system (other than entirely artificial ones) has yet been found for grouping them in larger units” (Exell, 1978, pp. 102–103). It would appear that 21 sections and 99 species are currently recognised in Africa (Stace, 1980, p. 329); of which eight sections are represented in the southern African region and examined in this study. These sections and the formally recognised species and subspecies they represented in southern Africa at the onset of this study are:

1. section *Hypocrateropsis* Engl. & Diels

*C. celastroides* Welw. ex Laws.

*C. celastroides* ssp. *celastroides*

*C. celastroides* ssp. *orientale* Exell

*C. imberbe* Wawra

*C. padoides* Engl. & Diels

2. section *Angustimarginata* Engl. & Diels

*C. caffrum* (Eckl. & Zeyh.) Kuntze

*C. erythrophyllum* (Burch.) Sond.

*C. kraussii* Hochst.

*C. nelsonii* Dümmer

*C. vendae* Van Wyk

*C. woodii* Dümmer

3. section *Macrostigmatea* Engl. & Diels

*C. engleri* Schinz

*C. mkuzense* Carr & Retief

4. section ***Metallicum*** Fresen.

*C. collinum* Fresen.

*C. collinum* ssp. *gazense* (Swynn. & Bak.f.) Okafor

*C. collinum* ssp. *ondongense* (Engl. & Diels) Okafor

*C. collinum* ssp. *suluense* (Engl. & Diels) Okafor

*C. collinum* ssp. *toborensis* (Engl.) Okafor

5. section ***Spathulipetala*** Engl. & Diels

*C. zeyheri* Sond.

6. section ***Ciliatipetala*** Engl. & Diels

*C. albopunctatum* Suesseng.

*C. apiculatum* Sond.

*C. apiculatum* ssp. *apiculatum*

*C. apiculatum* ssp. *leutweinii* (Schinz) Exell

*C. edwardsii* Exell

*C. moggii* Exell

*C. molle* R.Br. ex G. Don

*C. petrophilum* Retief

*C. psidioides* Welw.

*C. psidioides* ssp. *psidioides*

*C. psidioides* ssp. *dinteri* (Schinz) Exell

7. section ***Breviramea*** Engl. & Diels

*C. hereroënsis* Schinz

*C. hereroënsis* ssp. *hereroënsis* var. *hereroënsis*

*C. hereroënsis* ssp. *hereroënsis* var. *villosissimum* Engl. & Diels

8. section ***Elaeagnoida*** Engl. & Diels

*C. elaeagnoides* Klotzsch

This list of sections and species is based on the works of Exell, 1970; Wickens, 1973; Exell, 1978; Van Wyk, 1984, and Carr, 1988.

Species identification in the subgenus *Combretum* is notoriously difficult, frequently beset with much confusion. An indication of this is the substantial number of

incorrectly labelled specimens examined in this study, often determined previously by botanists of repute.

According to Exell (1978, p. 129), polymorphic aggregate species occur frequently in *Combretum*. In their areas of distribution, the incidence of these species seems to correlate with the occurrence of seasonal bush fires. Some problem complexes in our region are: *C. collinum* agg., *C. apiculatum* agg., *C. molle* agg., *C. hereroëense* agg. Whatever the effects the fires may have on genetic instability, the resulting problems are regarded as immense and difficult ones.

Hybridization could also be a possible factor in the confusion associated with some *Combretum* species.

The importance of scale characters at a microscopic level for species identification has often been overlooked, probably resulting in much of the confusion and misidentification. Stace (1969, p. 132) comments that scales are of the “greatest taxonomic value, and it is surprising that they have not been studied more closely.” Bachmann (1886) and Heiden (1893) examined scales from a number of species. Engler & Diels (1899) made some use of scale structure, but largely missed their taxonomic potential. After these earlier works and until Stace’s initial work on scale significance (1961), only Duvigneaud (1956) made a serious effort to regard scale structure as taxonomically important.

It is now generally accepted that scales show a wide range of structure and are extremely valuable in determining taxonomic relationships, at sectional and species levels: so much so that the degree of similarity between scales is often sufficient to determine whether specimens are members of the same or of different sections. The variation in structure of mature scales from each specimen or within each species is usually small.

The importance of scale characters is illustrated by the fact that they can be used to identify sterile as well as fertile material, and to match up flowering and fruiting specimens.

Scales (sometimes called peltate trichomes) are found on most epidermal surfaces of plants in the subgenus *Combretum*. A close correlation between scale and other characters usually exists in species of *Combretum*, and species with conspicuously

different scales are unlikely to be closely related. However, caution should be exercised in placing too much taxonomic emphasis on scale structure, particularly as detail is only visible with a light microscope not often available in the field or to non biologists. No weighting was placed on scale structure in the numerical taxonomy employed in this study.

A scale is composed of a one-cell-thick cell-plate usually attached centrally by a short stalk (e.g., *C. edwardsii*, Plate 1.5), which is seldom visible, thereby making many scales appear sessile (e.g., *C. edwardsii*, Plate 1.6), and resulting in the structure being best observed in surface view. Scales are sometimes referred to as sessile when short stalks have not been observed. The cell-plate is more or less flat or disc-shaped (e.g. *C. imberbe*, Plate 4.3), concave or bowl-shaped (e.g. *C. padoides*, Plate 4.4), or, less frequently, dome-shaped (e.g. *C. celastroides*, Plates 4.1 & 4.2). Scales range in colour usually from silvery or translucent to rust-brown, or variations thereof, often consistently for each species. The simplest types have a cell-plate consisting usually of eight radially-arranged cells (Plate 5.6). It would seem that scales with greater complexity start developing from this primary pattern, with further divisions of radial and tangential walls occurring to form more complex structures (Fig. A.1.2). As remarked by Stace, who has probably done more research into *Combretum* epidermal structure than anyone else, it is difficult to ascertain whether the 8-celled scale kind is “primitive, advanced, or both, when compared with the complex types; the extent to which the eight-celled type is polyphyletic in origin; or what the evolutionary relationship is between the various complex types” (1969, p. 164). Stace then continues by stating that “virtually the only other character used to indicate evolutionary advancement in the genus is the shape of the upper hypanthium, and it is perhaps logical to assume that in general the more elongated hypanthia are derived from the less elongated ones. The African section with the least elongated upper hypanthium (*Hypocrateropsis*) possesses, however, the largest and most complex scales” and, “It is evident that the evolution of the scale-types has progressed along many divergent and convergent pathways, and that there is little likelihood of eight-celled scales being consistently more primitive or advanced than more complex types, or of there being a constant evolutionary relationship between one complex type and another”. Stace briefly refers again to these relationships in his subsequent publication on the conclusions of his work on the significance of leaf epidermis in the taxonomy of the Combretaceae, 1980, (p. 331). Apart from the above comments on evolutionary relationships, phylogenetic pathways in the subgenus *Combretum* have not been studied further in this work.

Stace (1980) recommends that apart from the cellular delimitation of the scales, the general appearance should be considered. This includes colour, thickness of cell walls, opacity of cells, quantity of secretions and the extent to which the cuticular membrane is raised from the cell-plate. In this work, apart from cellular delimitation and dimension, colour, opacity of cells and quantity of secretions were examined. As epidermal and scale cells were often shrivelled, it was difficult to determine the extent to which the cuticular membrane was raised from the cell-plate.

Most scales examined by taxonomists are obtained from lamina surfaces. On these surfaces, scales are often less densely distributed over veins (e.g. *C. molle*, Plate 3.1).

Stace in 1969 (p. 164) and 1980 (p. 332) recognised six and eight scale groups respectively, based on the delimitation of cells in the cell-plates. These do not always, however, assist greatly with separation into sections. For example, the section *Ciliatipetala* appears in four, and *Breviramea* in two out of six groups (1969).

Other epidermal structures of *Combretum* of relatively less taxonomic importance than scales, particularly below the genus level, are the shape and distribution of trichomes in the form of microscopically visible, compartmented hairs. These are found in the family Combretaceae and only elsewhere in the distant family Cistaceae and in a few species of the Myrtaceae (Stace, 1965, pp. 233–234).

According to Stace (1961, p. 10), compartmented or combretaceous hairs have been found in every species of the Combretaceae examined by him thus far, and that these are rarely accompanied by other types of hairs. Combretaceous hairs are very peculiar in that they possess a double wall (Fig. A.1.1): the protoplast of the originally long, pointed, simple, unicellular hair shrinks during development, and when it has been confined to a relatively small region at the base of the hair, it secretes a second, internal wall. The original, external wall often becomes very thick owing to continued deposition of cellulose by the shrinking protoplast, but even so it hardly ever becomes cutinised and hence is not, or is only fragmentarily represented, in cuticular preparations. The second internal wall, however, is usually cutinised and, according to Stace, forms a fairly typical feature of the cuticular preparations of the *Combretum* genus: the shape of the second internal cell-wall frequently providing a diagnostic feature, both generically and specifically. However, Stace and other taxonomists do not usually apply the characters of second internal walls of hairs in keys below the genus level in *Combretum*.

## 1.2 Aim & Scope of this dissertation

The main purpose of this study was to examine species and infraspecific taxa from the subgenus *Combretum* in southern Africa, in an objective manner, for as many characters as were feasible in the time available: then to assess the validity of those taxa as separate entities so that the validity of the currently recognised sectional limits could be determined. It was hoped that much of the confusion surrounding the sections and taxa of the subgenus could be reduced, and that the results could be used in the revision of the Combretaceae for the Flora of southern Africa (FSA).

Wherever possible in this study, specimens from the southern African region were examined. However, sometimes type material came from outside this region (e.g. isoelectotype of *C. celastroides* ssp. *celastroides*, Welwitsch 4370, from Angola), or material available came from a more central region of Africa (e.g. *C. collinum* ssp. *taborense*, Greenway 6197, from Zambia). Emphasis in this work was not placed on geographical location (except that all taxa were present in the FSA region), but rather on characters observed from each specimen.

Because specimens from as many as eight sections were examined, time limitations have meant that the study gives only an overall perspective of the subgenus *Combretum*. No more than 12 specimens of any one previously recognized taxon have been examined. *C. moggii* Exell, *C. petrophilum* Retief and *C. psidioides* Welw., section *Ciliatipetala*, have not been studied much further than attempts at determining scale and certain flower characters owing to limitations in time. Only the type of *C. nelsonii* Dümmer, section *Angustimarginata*, has been examined because, based on scale structure, other specimens labelled *C. nelsonii* were found not to be authentic. Only the type of *C. padoides* Engl. & Diels, section *Hypocrateropsis*, and a few flower characters of *Thorncroft* 22210 were examined owing to time restraints.

Difficulty was experienced in locating flowering material for *C. apiculatum* Sond ssp. *leutweinii* (Schinz) Exell, section *Ciliatipetala*, but as literature (Exell, 1970; Exell, 1978; Carr, 1988) records no differences between inflorescences of the two subspecies of *C. apiculatum* studied, the same characters for inflorescence structure were used for *C. apiculatum* ssp. *leutweinii* as for *C. apiculatum* ssp. *apiculatum* in the numerical data base.

All data were collected numerically to facilitate the use of numerical taxonomy programs and for programs assisting in description and key formation. The principles behind numerical taxonomy have largely been taken from the work of Sneath & Sokal (1973) as it would seem that the principles and recommendations as given by Sneath and Sokal are generally accepted as fundamental assumptions for modern taxonomic research. It is, however, acknowledged that other numerical taxonomists sometimes hold opinions different from those of Sneath and Sokal on some of the issues regarding numerical taxonomy.

Numerical Taxonomy can be defined as “the grouping by numerical methods of taxonomic units into taxa on the basis of their character states” (Sneath & Sokal, 1973, p. 4). Numerical taxonomy usually requires character lists to be compiled phenetically (Sneath & Sokal, 1973, p. 5). The term phenetic can be defined as “the arrangement by overall similarity, based on all available characters without any weighting” (Cain & Harrison, 1960, p. 3).

One of the fundamental views of numerical taxonomy is that “the greater the content of information in the taxa of a classification and the more characters on which it is based, the better a given classification will be” (Sneath & Sokal, 1973, p. 5). Sneath & Sokal also recommend that no fewer than 60 characters should be used, although they cannot justify this requirement on empirical or theoretical grounds (1973, p. 106). Furthermore, these authors see the proper selection of characters as a critical issue in the application of numerical taxonomy (Sneath & Sokal, 1973, p. 103). It is hoped that the final character list produced in this work will serve as a guide to other research into the subgenus.

Numerical taxonomy is used in this study as a tool to show differences and similarities between specimens and between taxa.

Advantages of numerical taxonomy are listed in Sneath & Sokal (1973, p. 11). From these given advantages the following are particularly useful in this study: numerical taxonomy has the power to integrate data from a variety of sources, in this case from light microscopy and scanning electron microscopy; greater efficiency is promoted through the automation of large portions of the taxonomic process in data processing; data coded in numeric form can be integrated with existing electronic data processing systems in taxonomic institutions and used for the creation of descriptions and keys; the methods, being quantitative, provide greater discrimination along the spectrum of



taxonomic differences and are more sensitive in delimiting taxa than classifications obtained by more conventional methods; and the creation of explicit data tables for numerical taxonomy force the use of well-described characters.

In order to facilitate the compilation and analysis of data for this work, a computer database program, TAXON, was designed and implemented using specifications given by the writer. In this TAXON format, data could be more easily edited, manipulated and adapted for a variety of other computer programs and uses.

Concepts incorporated into numerical taxonomy theory are described when they are mentioned in the methodology employed in character list formation.

# 2

## Materials & Methods

### 2.1 Plant material

#### 2.1.1 Source of specimens

Most material examined consisted of dried herbarium specimens on loan from Bolus Herbarium, University of Cape Town (BOL); Compton Herbarium, National Botanical Institute, Kirstenbosch (NBG and SAM); C.E. Moss Herbarium, University of the Witwatersrand (J); Natal Herbarium, Botanical Research Unit, Durban (NH); National Herbarium, Botanical Research Institute, Pretoria (PRE); University of Durban-Westville (UDW) and University of Natal, Pietermaritzburg (NU). Permission was obtained from the curator of each herbarium to detach small pieces of leaf material for scanning electron microscopy to view scale structure, and to reconstitute inflorescence material for clearer examination of flowers.

Some fresh material was collected and examined, but all characters used for numerical taxonomy were obtained from dried material in order to reduce variation between specimens. This has resulted in the omission from the data base of many characters of habit which are not present on herbarium sheets.

Some species were represented by specimens with leaf scales which were sometimes difficult to see clearly: they can be obscured by hairs, lie flat against the epidermal surface, and/or are often covered with exudate. For example, considerable or dense hair distribution on the abaxial lamina surfaces of *C. collinum* ssp. *coriaceum* (Plate

2.4) and *C. erythrophyllum* ssp. *vendae* (Plate 2.5) obscure clear viewing of scales: scales from *Moll 5632* of *C. apiculatum* ssp. *apiculatum* (Plate 1.4) are occluded by glutinous exudate, and the scales of members of the section *Angustimarginata* (Plate 5) lie flat against the epidermis.

Whole specimens and reconstituted inflorescence parts were examined using a stereomicroscope, whereas detailed scale structure was examined using scanning electron microscopy and sometimes by light microscopy.

### **2.1.2 Reconstitution of inflorescences**

Whole or parts of inflorescences, detached from dry material by the edge of a blade from a small paper-cutter or scalpel, were reconstituted by soaking for five to eight days in 25% aqueous ammonia, followed by rinsing in tap water and storing in 50% aqueous ethanol (E.F. Hennessy, pers comm.).

## **2.2 Microscopy**

### **2.2.1 Light Microscopy**

1. Entire herbarium or fresh specimens:

Dried and, on occasion, fresh material was viewed using a WILD Heerbrug M5A stereomicroscope, with a Volpi Intralux 5000 cold light source attachment, up to a magnification of  $\times 50$ . Beco callipers were used for measurements up to 14 mm.

2. Scale structure:

Using the aforementioned stereomicroscope, scales were prised off adaxial and/or adaxial leaf surfaces with the edge of a razor or scalpel blade. With a dissecting needle, the scales were placed into a drop of glycerol on a glass slide and viewed with a light microscope  $\times 100$ –400.

Difficulty was sometimes experienced in obtaining scales from leaves of dry material as they tended to “shoot” out and become lost. Reconstituted material usually appeared too dark for scales to be clearly visible, hence difficulty in obtaining these scales was also experienced.

### 2.2.2 Scanning Electron Microscopy

1. Small portions of leaf material, preferably from mature leaves in an attempt to obtain fully-developed scales and to eliminate excess exudate, were cut from dry material using a scalpel blade edge or the edge of a small paper-cutter. (Lamina surfaces from immature leaves often have much epidermal exudate which obscures scale structure). The leaf material was further cut in half and stuck on to brass stubs with double-sided Sellotape; one adaxial surface uppermost and one abaxial surface uppermost.
2. The stubs were coated with gold in a Polaron E 5000 Sputter Coating Unit in the following manner:
  - i. the stubs were placed on the plate in the chamber and the Allen screws tightened.
  - ii. the lid of the chamber was closed.
  - iii. the pump was switched on until the pressure gauge read between 0,2 and 0,1 torr.
  - iv. the valve on top of the argon cylinder was opened to give a flow at 20 kPa.
  - v. the chamber was flushed twice with argon gas by rotating the argon leak valve anticlockwise about one turn, immediately returning to zero.
  - vi. the HT was set at approximately 1,1 kV and switched on.
  - vii. the argon leak valve was rotated anticlockwise to keep the needle between 0,1 and 0,2 torr on the pressure gauge, and to give a voltage reading of 10–20 mAmp.
  - viii. discharging was started and continued for a period of five minutes
  - ix. the leak valve, HT control and operation switches were returned to zero or turned off.
  - x. the valve on top of the chamber was opened to release the vacuum.
  - xi. the coated specimens were removed and placed in a desiccator.
3. The specimens were viewed using a Philips PSEM 500 electron microscope from a magnification of x 40–1250.

## **2.3 Data collection**

### **2.3.1 Character list & Operational Taxonomic Units**

A character may be defined as “a single basis for comparison among homologous parts within a given set of organisms”, (homologous parts referring to the notion of homology, the idea that like must be compared with like) (Abbott et al., 1985, p. 42). Features of plants are regarded as the product of interactions between the plant genotype and the environment. Taxonomists make observations of these features and decide which are homologous and what character states or values to compare (Abbott et al., 1985, p. 122).

A character is usually one of three kinds; quantitative multistate, qualitative multistate or binary. Quantitative characters are lengths or numbers of elements or organs; binary characters contain two states to choose from, often a choice between absent or present; and multistate characters have more than two states, either ordered or unordered, to choose for each character. The choice of character kind is usually important in the subsequent analytical methods used. In the methods employed in this study, multistate characters were not required to be ordered as only one character state was selected for each character.

The character list used in this study was constructed in a format which could be run (or be easily adapted to run) on most numerical taxonomic programs, although no one program in particular was in mind at the start. Sneath & Sokal, 1973, and Abbott et al., 1985, were the main works initially consulted for background information and guidelines.

Some numerical taxonomists have mentioned restrictions to be placed on the use of certain characters in phenetic studies. Sneath & Sokal (1973, p. 103) call these disqualifying characters “inadmissible” characters. According to Sneath & Sokal (1973, pp. 103–105), these include (a) meaningless characters: those that do not reflect the inherent nature of the organisms; (b) logically correlated characters: those that are a logical consequence of other characters; (c) partially logically correlated characters: those which are correlated only partially to other characters; (d) invariant characters: those that are invariant over the entire sample of specimens; and (e)

empirically correlated characters: those where one of a pair may be eliminated unless it can be shown that there is some independent source of variation in those characters.

An initial character list was constructed using as many characters and character states as was feasible from dried herbarium specimens of a few species. No bias or preconceived ideas were formed in the compilation of the character list although literature was consulted in order to include characters previously found to be of taxonomic significance. In an attempt not to miss any important leaf characters, as many lamina epidermal features as seemed possible in theory (e.g. shape and size of epidermal cells; shape and size of guard cells; hair complexity) were listed. Scanning electron microscopy was used to establish which lamina features were visible and appeared to have taxonomic potential (lamina features were thought to be of importance because all specimens examined usually included leaves). Although many characters were not rejected until later when they were shown not to be taxonomically meaningful, care was taken to try and avoid using characters regarded as unsuitable for numerical taxonomic analysis. After the initial character list construction, more characters and character states were added as further material was examined and different characters observed.

Care was also taken throughout the study to check previously examined specimens for the presence of characters or states perhaps overlooked earlier, but added later. The first working list comprising 271 characters (branch, 23 characters; branchlet, 22; leaf, 89; inflorescence, 101; fruit, 36) is shown in Appendix A.2.

It soon became apparent that to examine as many as 271 characters, too much time would be taken up on each specimen, especially as 29 taxa at or below species level were to be studied, and some of the characters were obtained from scanning electron microscopy, a time consuming activity. Efforts were therefore made to refine the list by identifying and keeping characters of taxonomic value (intrinsic information) and recognising and rejecting characters of little or no taxonomic value (extrinsic information). (Information structure of little taxonomic value may be termed extrinsic as compared with intrinsic information structure which has significant taxonomic value (Legendre & Rogers, 1972)). The following list serves to summarise the refinement process.

1. After 30 specimens from various species had been examined for which characters they possessed out of a possible 271, the data obtained was analysed

as described under the heading **Data processing** following later in this chapter. The data was then run a second time, but with branch and branchlet characters omitted. These omissions did not alter the results in any significant way. Most branch and branchlet characters were thus regarded as extrinsic/superfluous and removed from the character list.

2. All characters with character states common to all specimens were removed as these would serve no purpose in separating taxa: e.g. all flowers were sessile; all fruits stipitate; no specimens had bullae in axils along the midrib of lamina abaxial surfaces.
3. All characters for colour, except for scale colour, were removed as it became evident that colour was often dependent on the age (level of organ maturity or time after collection) of the specimen. As dried herbarium specimens with differing levels of maturity and chronological ages were used in observations, colour generally varied considerably within each species and could not be regarded as a consistent taxonomic character. However, it was observed that the colour of scales did not usually vary much with age within each species: thus scale colour was regarded to be of intrinsic value and retained.
4. All characters from immature leaves and fruits were disregarded as it was felt that one cannot validly compare immature with mature structures.
5. As far as possible, character states were combined and preferably simplified to give fewer states for each character: e.g. for hair presence; “pubescent” was combined with “tomentose” and “hirsute” to give a character state of hairs “considerably to densely distributed”; “puberulose” was combined with “tomentulose”, “pilose”, “sparse to pubescent”, “sparse to tomentose”, “sparse to hirsute”, “sparse to puberulose” and “tomentulose or pilose” to give a character state of hairs “moderately distributed”. Great care was taken in the numerical analysis to ensure that characters states were combined accurately. It was felt that fewer and more simplified character states would lead to an improved comparison of generalized characters between specimens, particularly as some character states, e.g. lamina hair distribution, are tremendously variable within a single specimen, specimens from the same taxon, or between taxa. A more general description could thus be more accurate overall.

The final version of the character list contained 171 characters (branch, 5 characters; branchlet, 3; leaf, 70; inflorescence, 67; fruit, 26) and is shown in Appendix A.3.

The basic unit used in a numerical phenetic study is termed the Operational Taxonomic Unit (OTU). In this study each specimen was initially regarded as an OTU. At the end of the raw data collection and after establishing beyond reasonable doubt that each specimen was correctly named, character lists for each currently recognised species were averaged to give a general character list for each species; thus creating a new set of OTUs. Phenetic analyses were used to cluster and rank these OTUs to assist in determining which species were in fact distinct. Data from species that were considered synonyms of other species were then combined with those other species and a final set of OTUs was determined. Phenetic analyses were again used to group and rank these final OTUs to help determine the validity of currently recognised sections.

### **2.3.2 Computer database**

The computer programs used in this study for taxonomic analysis (NTSYS-pc) and for processing descriptions (DELTA) require data in fairly rigid numerical format. In this form the data is difficult to enter and edit. Furthermore, the programs require the same data in differing formats, which normally implies duplication of the data. To process subsets of the data also requires a massive amount of effort and data manipulation, all of which is prone to error.

For this reason a computer database program (TAXON) was devised to make the data collection, storage, and subsequent processing easier. Since both the NTSYS-pc and DELTA programs require an IBM-PC, or compatible, personal computer to operate, the TAXON program was implemented on this type of computer. The program is described in more detail in Appendix A.5.

The data was initially captured to a form corresponding to the character list (Appendix A.4). Once the data had been collected in this format it was entered into the TAXON computer database. The database was set up to accept and edit the data in the same format as it was defined in the character lists, thus removing the need to convert the data to some numerical form. In addition, the TAXON program could check the data on input to ensure that only valid character states or numerical values were entered.



## **2.4 Data processing**

### **2.4.1 Descriptions**

In an attempt to obtain species descriptions, data captured to the TAXON database were extracted and processed to create data files readable by the DELTA program (Dallwitz & Paine, 1986). The only changes made to the character list were in the modification of the wording of characters and character states in order for the species descriptions to read and flow correctly. This was done in the TAXON database program. Most negative character states were edited out of the DELTA descriptions to enable the descriptions to flow in a more conventional natural language output.

The DELTA program was found unsuitable for the following reasons: all unlinked characters come out with capital letters on characters, often when lower case letters are preferred); all linking is done with semi-colons and cannot be changed to have commas where preferred; no capacity for italics is included; and it is difficult to enable and disable characters and negative character states not required in descriptions. These several points would result in too much editing to be done if using the DELTA program for descriptions, especially when dealing with many species (22 in this study) and many characters (171 in this case). The DELTA program cannot be altered unless by changes to the source code, unavailable to the user.

The TAXON program was extended, again to the author's specification, to produce descriptions in a more conventional form from the information in the TAXON database. These descriptions were used, with few modifications, in the formal taxonomy descriptions given in Chapter 6.

### **2.4.2 Keys**

Consideration was given to using the DELTA System (Dallwitz & Paine, 1986) for constructing identification keys, but it was decided not to use this method of key construction mainly because it would require too much time to construct the 30 directives (Dallwitz & Paine, 1986, pp. 86–98) needed for the 171 characters observed. Key formation in the DELTA System is controlled by means of directives. One of these requires that “reliabilities” of characters be specified: characters are given high reliabilities if their state values can be easily and accurately assigned to any specimen. Characters selected by the program for inclusion in the key are those

which have high reliability, divide the taxa into evenly sized subgroups, and are not too variable within taxa. The program user also needs to specify the character to be used at any position in the key. Besides any of the other 29 directives, reliabilities alone would have taken more than a small amount of time to work out. It was thus decided to construct keys without using a computer program.

After observing 135 OTUs while working with a list of 171 characters, it became apparent that some characters remained more or less constant within a given taxon while others showed more variation. Separate tables (Tables A.7.1–A.7.4) were constructed for scales, fruits, inflorescences and leaves, with characters observed to be taxonomically predictable, or of possible taxonomic potential, for each of these four structures compared against the taxa examined. It was observed that many leaf characters were sometimes variable within one specimen and/or between specimens of the same taxon. For this reason, leaf apex and leaf base were characters not included in keys. Lamina hair distribution was also found to be variable and thus not used much in keys above subspecies level.

Combinations of characters regarded as taxonomically predictable were used to construct keys to sections, keys to species within sections, and keys to infraspecific taxa.

### **2.4.3 Numerical Taxonomy**

There was only one suitable numerical taxonomy program available to the writer to perform phenetic taxonomic analysis, namely Rohlf's NTSYS-pc Numerical Taxonomy System for the IBM-PC microcomputer (and compatibles) (1986, version 1.2). This system of programs performs various kinds of multivariate statistical analyses typically required in the field of numerical, especially phenetic, taxonomy. This program is described further in Appendix A.6.

The TAXON database program was designed to extract specified subsets of characters and/or OTUs and convert them to a data file format usable by NTSYS-pc. In this way it was possible to extract rapidly and process information, and produce representations such as phenograms.

The character data was largely unordered multistate data, with a few characters having numerical values. Such numerical characters were converted to unordered

multistate characters by the TAXON program before the data was used by the NTSYS-pc program.

To decide which similarity/dissimilarity measures and clustering methods to use, the TAXON program was used to compute the cophenetic correlation coefficients for all possible combinations of similarity/dissimilarity measure and clustering techniques. These coefficients represent a measure of “optimality” as far as subsequent phenograms are concerned. A value of zero represents totally random data, with no possible clustering of species, whereas a value of one indicates that the resulting phenogram is a perfect reflection of OTU/OTU relationships. In practise, values between 0.3 and 0.95 can be expected (Sneath & Sokal, 1973).

From the tables of coefficients, the one with the largest value was taken as representing the best similarity/dissimilarity measure and clustering technique, which was then used to produce a phenogram from the same data.

The NTSYS-pc program produces graphical phenograms, but these were not thought to be of high enough quality to include in this thesis. Furthermore it was not possible to import the phenograms into the thesis document from the NTSYS-pc program. The TAXON program was extended to produce more detailed phenograms on the screen which could then be exported directly into a format readable by the word processing program (Microsoft Word 4.0) on the Macintosh computer.

Phenograms were produced for currently recognised species, together with their infraspecific taxa, that had completed sets of character lists; one using all 171 of the final characters, and one using 64 characters regarded as probably having consistency within a taxon.

Another set of phenograms was produced of species considered valid in this study (i.e. after synonyms recognised by the writer had been combined with their respective species). As for currently recognised species; one phenogram was obtained by using all 171 final characters, and one from using 64 characters regarded as probably having consistency within a taxon.

# 3

## Results

### 3.1 Microscopy

Characters viewed with the scanning electron microscope are represented by micrographs in the form of plates (Plates 1–9). Evidence of fungal infection was found on a few specimens, sometimes even on type material, viewed using scanning electron microscopy. It will be recommended to the curators of the herbaria concerned that they treat the affected specimens with fungicide.

#### **Scales:**

If not absent or obscured by glutinous secretions (e.g. *C. apiculatum* ssp. *apiculatum*, Plate 1.4) or hairs (e.g. *C. erythrophyllum* ssp. *vendae*, Plate 2.5), scale distribution was found to be sparse, considerable or dense (Plates 1.1–1.3). If considerable or dense, scales were apart; apart to contiguous or overlapping; contiguous or overlapping (Plates 1.2–1.4). Scale stalks were not usually visible in surface view although a stalk from a scale of *C. edwardsii* is shown in Plate 1.5.

Clear examples of one or more scales from each currently recognised species and its infraspecific taxa, if relevant, from each section is shown in the form of micrographs in plates 4–9. (section *Hypocrateropsis*, Plate 4; *Angustimarginata*, Plate 5; *Macrostigma* and *Metallicum*, Plate 6; *Spathulipetala*, Plate 7; *Ciliatipetala*, Plate 8; *Ciliatipetala*, *Breviramea* and *Elaeagnoida*, Plate 9).

### **Combretaceous hairs:**

if not absent or obscured by glutinous secretions or scales, hair distribution was found to be sparse, moderate, considerable or dense (e.g. on lamina surfaces, Plates 2.2–2.5; 3.1–3.3). No clear differences besides length and concentration between combretaceous hairs of different taxa were observed in this study. Hairs were usually striated, often twisted and/or slightly hooked; bases often bulbous (e.g. *C. molle*, Plate 2.1). Hairs were often more densely distributed along the veins (e.g. *C. edwardsii*, Plate 3.2).

## **3.2 Descriptions**

Descriptions of all recommended species are given in the formal taxonomy (Chapter 6). These were created by the TAXON program as described in Appendix A.5.

## **3.3 Keys**

Keys to sections and species within those sections are given as part of the formal taxonomy (Chapter 6).

## **3.4 Numerical Taxonomy**

These results represent the cophenetic correlation coefficient tables and resultant phenograms, obtained using the methods described in Appendix A.6. The various measures and techniques quoted are described in more detail in Rohlf (1986) and Sneath and Sokal (1973).

### **Clustering method notation:**

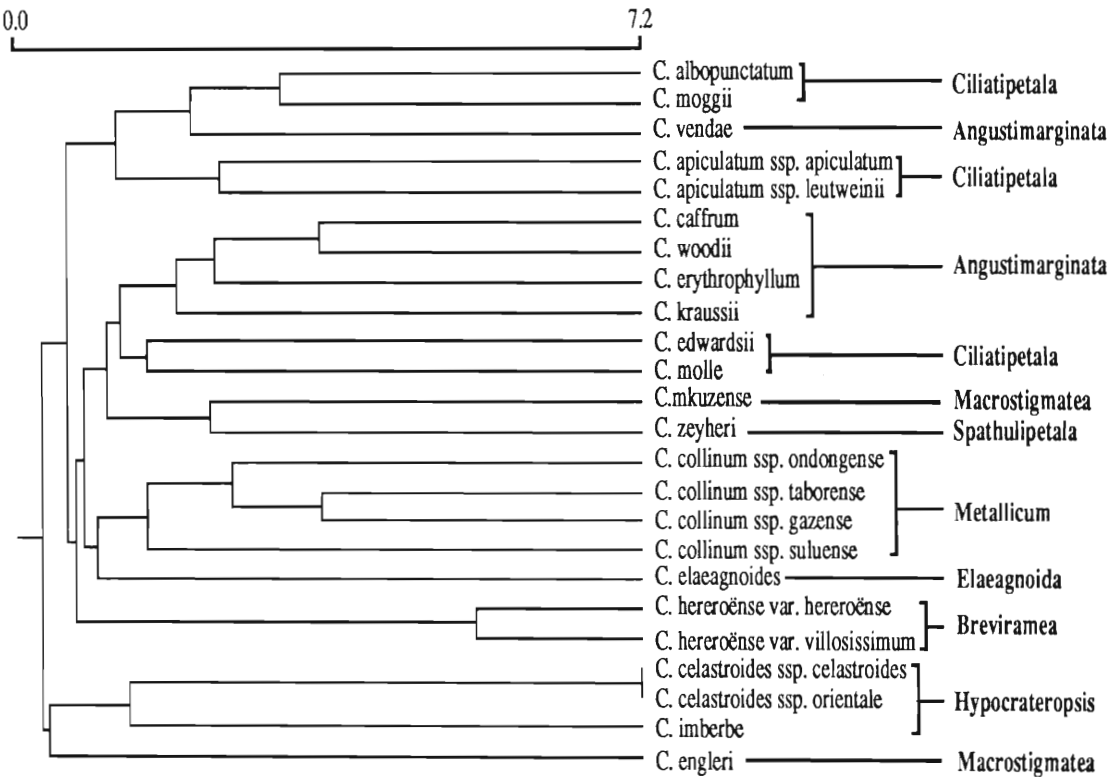
UPGMA:	Unweighted pair-group method, arithmetic averages
WPGMA:	Weighted pair-group method, arithmetic averages
WPGMS:	Weighted pair-group method, Spearman's average
SINGLE:	Single-link method
COMPL:	Complete-link method
FLEXI:	Flexible clustering ( $\beta = 0$ )

### **Similarity coefficient notation:**

$m$  = no. of matches  
 $u$  = no. of mismatches  
 $n$  = total number of characters ( $n = m + u$ )

**Table 3.4.1** Cophenetic correlation for various similarity coefficients vs. clustering methods for currently recognised taxa in subgenus *Combretum* using 64 relatively consistent characters (averaged for taxa with completed sets of character lists)

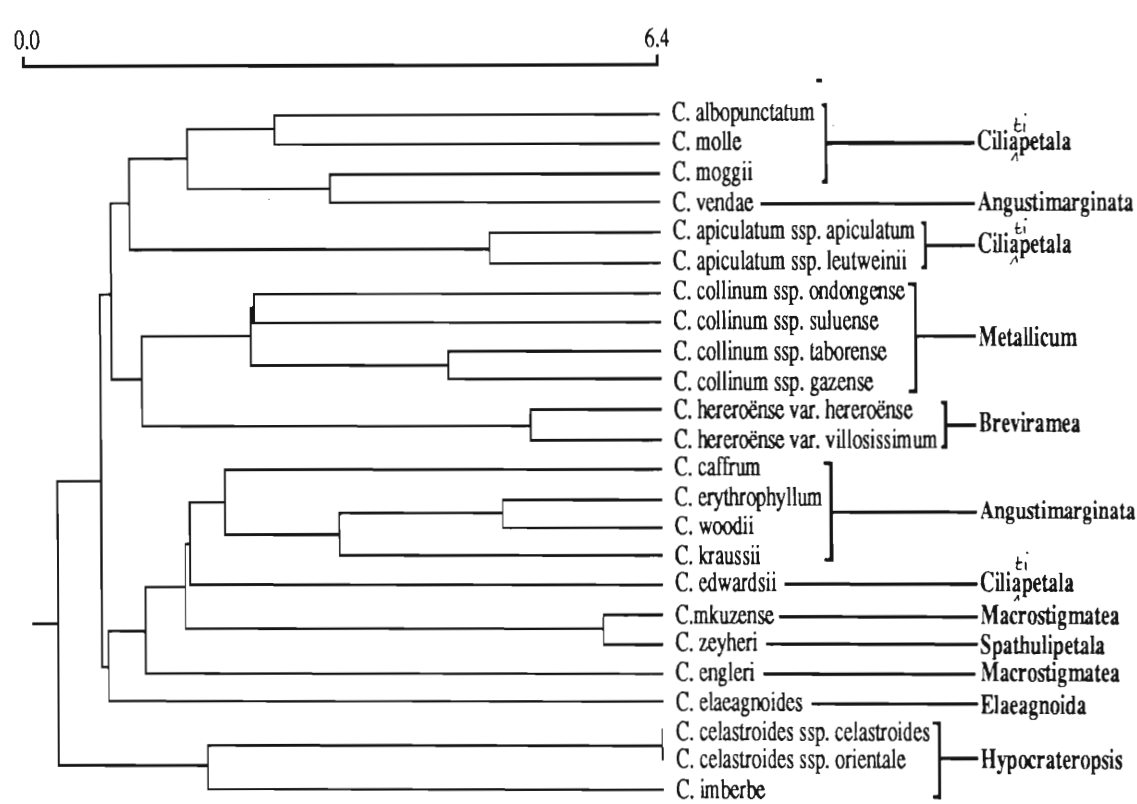
	UPGMA	WPGMA	WPGMS	SINGLE	COMPL	FLEXI
Simple matching coeff: $m/n$	0.77	0.76	0.60	0.72	0.74	0.76
$2m/(n+m)$	0.75	0.73	0.63	0.70	0.71	0.73
Rodgers & Tanimoto's distance: $m/(n+u)$	0.81	0.79	0.64	0.76	0.77	0.79
$m/u$	<b>0.91</b>	0.90	0.83	0.87	0.89	0.90
Hamann's coefficient: $(m-u)/n$	0.77	0.76	0.65	0.72	0.74	0.76



**Fig. 3.4.1** Phenogram (UPGMA) of currently recognised taxa in subgenus *Combretum* using 64 relatively consistent characters (averaged for taxa with completed sets of character lists)

**Table 3.4.2** Cophenetic correlation for various similarity coefficients vs. clustering methods for currently recognised taxa in subgenus *Combretum* using all 171 characters from the final character list (averaged for taxa with completed sets of character lists)

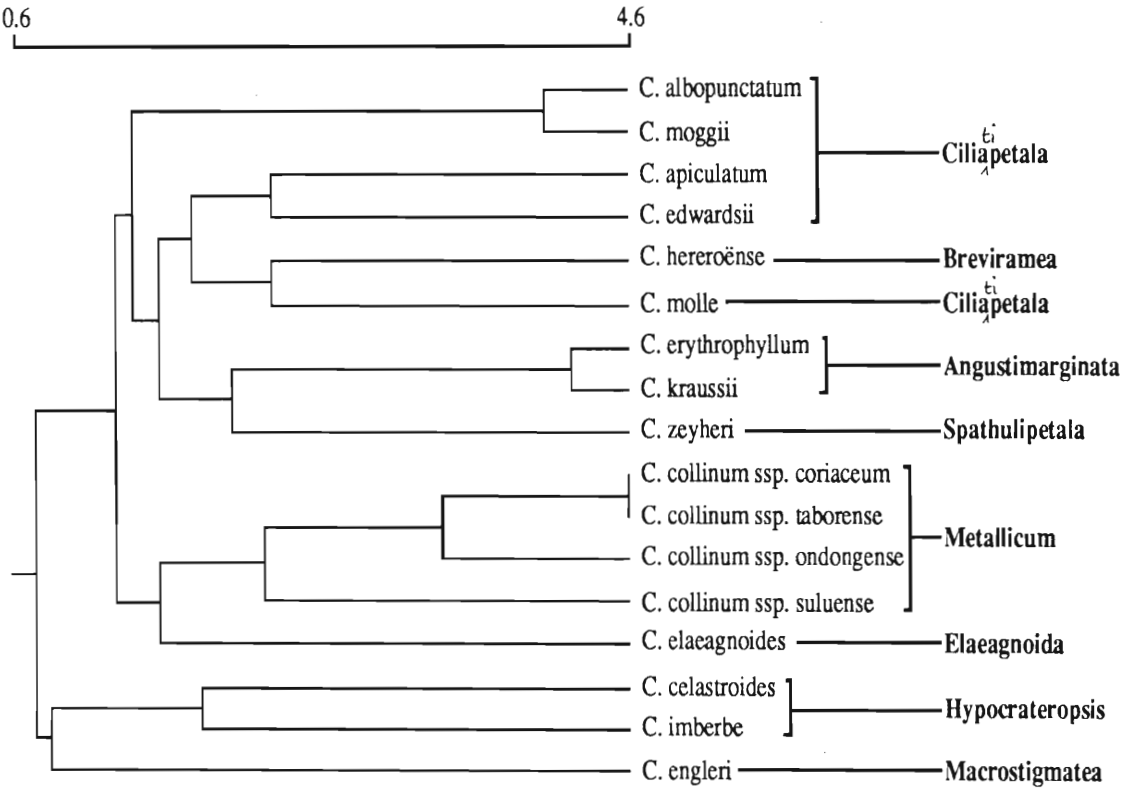
	UPGMA	WPGMA	WPGMS	SINGLE	COMPL	FLEXI
Simple matching coeff: $m/n$	0.79	0.78	0.65	0.75	0.64	0.78
$2m/(n+m)$	0.77	0.75	0.62	0.74	0.59	0.75
Rodgers & Tanimoto's distance: $m/(n+u)$	0.82	0.81	0.65	0.78	0.69	0.81
$m/u$	<b>0.89</b>	0.89	0.81	0.85	0.83	0.89
Hamann's coefficient: $(m-u)/n$	0.79	0.78	0.68	0.75	0.64	0.78



**Fig. 3.4.2** Phenogram (UPGMA) of currently recognised taxa in subgenus *Combretum* using all 171 characters from the final character list (averaged for taxa with completed sets of character lists)

**Table 3.4.3** Cophenetic correlation for various similarity coefficients vs. clustering methods for species recognised by the writer in the subgenus *Combretum* using 64 relatively consistent characters (averaged for taxa with completed sets of character lists)

	UPGMA	WPGMA	WPGMS	SINGLE	COMPL	FLEXI
Simple matching coeff: $m/n$	0.76	0.76	0.64	0.72	0.60	0.76
$2m/(n+m)$	0.75	0.75	0.63	0.71	0.56	0.74
Rodgers & Tanimoto's distance: $m/(n+u)$	0.80	0.81	0.65	0.72	0.63	0.78
$m/u$	<b>0.84</b>	0.84	0.67	0.77	0.73	0.83
Hamann's coefficient: $(m-u)/n$	0.77	0.77	0.70	0.72	0.60	0.77

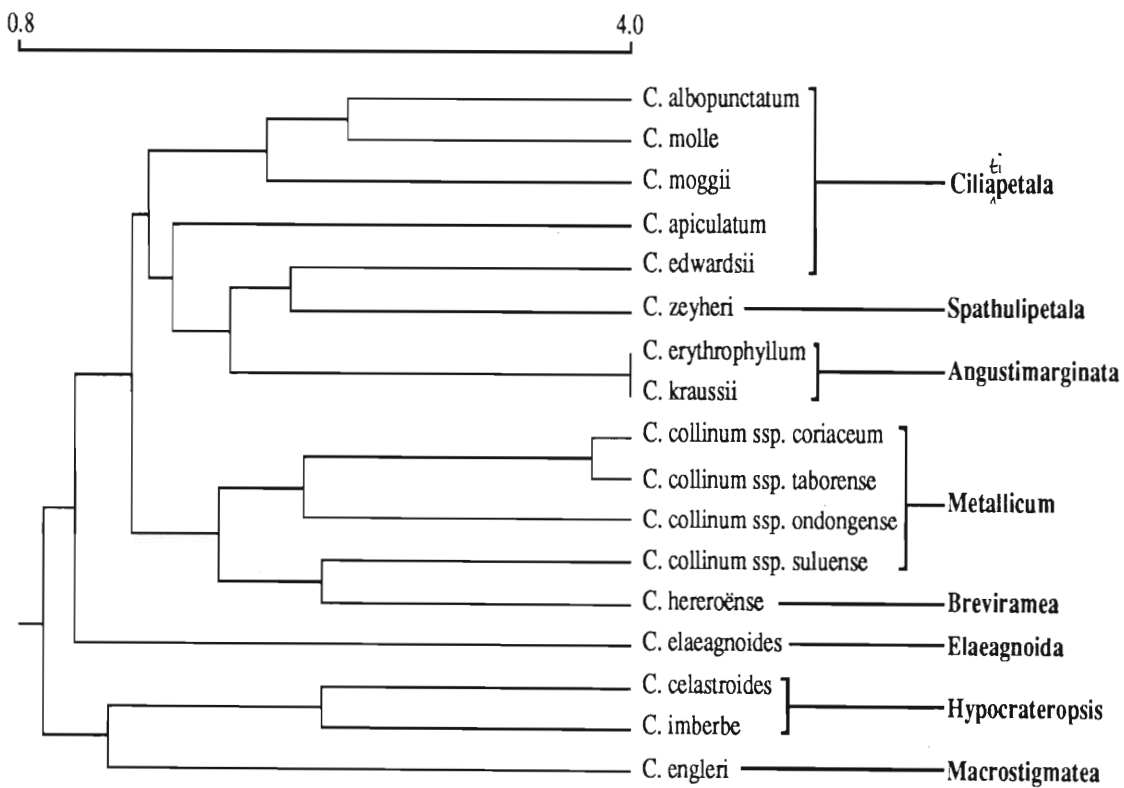


**Fig. 3.4.3** Phenogram (UPGMA) of species recognised by the writer in subgenus *Combretum* using 64 relatively consistent characters (averaged for taxa with completed sets of character lists)



**Table 3.4.4** Cophenetic correlation for various similarity coefficients vs. clustering methods for species recognised by the writer in subgenus *Combretum* using all 171 characters from the final character list (averaged for taxa with completed sets of character lists)

	UPGMA	WPGMA	WPGMS	SINGLE	COMPL	FLEXI
Simple matching coeff: $m/n$	0.78	0.78	0.66	0.74	0.61	0.78
$2m/(n+m)$	0.77	0.76	0.65	0.73	0.58	0.76
Rodgers & Tanimoto's distance: $m/(n+u)$	0.80	0.80	0.67	0.75	0.65	0.80
$m/u$	<b>0.85</b>	0.85	0.69	0.79	0.74	0.85
Hamann's coefficient: $(m-u)/n$	0.78	0.78	0.70	0.74	0.61	0.78



**Fig. 3.4.4** Phenogram (UPGMA) of species recognised by the writer in subgenus *Combretum* using all 171 characters from the final character list (averaged for taxa with completed sets of character lists)

# 4

## Discussion & Recommendations

In this study, specimens and characters were selected and recorded; the resemblances between specimens were calculated and determined; taxa were based upon those resemblances; and generalizations concerning those taxa have been made.

This is in agreement with Sneath & Sokal (1973, p. 5), who stated that generalizations cannot be made about taxa before such taxa have been recognised; taxa cannot be recognized before resemblances between specimens ~~are~~ known; and these resemblances cannot be estimated before specimens and their characters have been examined.

According to Abbott et al., characters that make the best contribution to establishing a clear pattern are those that show sharp discontinuities (1985, p. 45). This study illustrates that the most taxonomically consistent characters, including those that show the clearest discontinuities, are usually found in scale structure (Table A.7.1), a few fruit characters (Table A.7.2), and inflorescences (Table A.7.3). Branch and branchlet characteristics do not seem to have much taxonomic significance except for twining tendencies (e.g. *C. edwardsii*) and the presence of pointed lateral branches (e.g. *C. imberbe*). Many leaf characters were too varied between members of the same taxon to warrant taxonomic importance between taxa. Selected leaf characters accorded possible taxonomic merit are, however, shown in Table A.7.4. Some of these, e.g. average lamina length, average petiole length, ciliate margins, and hairs in midrib axils, have been given taxonomic significance.

Particular caution should be given to not placing great emphasis on the taxonomic importance of lamina hair distribution and concentration because these are not always consistent within one specimen or between specimens of the same taxonomic rank (e.g. specimens from *C. molle* and *C. erythrophyllum* ssp. *erythrophyllum* and ssp. *vendae*).

The biological importance of characters is seldom known, and according to Sokal & Sneath (1963), there are no *a priori* grounds for accepting one character over another. For these reasons, it is difficult to state with absolute certainty which characters should have taxonomic importance over others. However, taxonomists must attempt to make sense of the taxa with which they work, and they of necessity have to select characters which they feel are consistent and representative of each particular taxon. For example, Exell (1970) doubts whether the size of the fruit is a useful character to delimit either species or infraspecific taxa of the subgenus *Combretum*; yet Carr (1988) bases his key to the species or infraspecific taxa on lengths of fruits. Characters observed to be of probable taxonomic importance and consistency have been carefully selected in this dissertation. It is, however, felt by the writer that phenograms produced from all 171 final characters (Figs 3.4.2 and 3.4.4) are likely to be taxonomically superior to those produced from 64 characters selected for their consistency within a specimen or taxon (Figs 3.4.1 and 3.4.3), because certain combinations of seemingly consistent characters with varied characters could be of taxonomic importance, but difficult to determine.

#### **4.1 Species and infraspecific taxa**

From the results of numerical taxonomy and light and electron microscopic investigations, most currently recognised species were found to be distinct. Exceptions were found among some currently recognised species in section *Angustimarginata* and in the section *Macrostigmatea*.

Most infraspecific taxa need to be investigated further to determine their validity as separate taxa. The writer considers their separation often to be based on characters which are too variable to be valid, but further examination is necessary to provide less controvertible evidence for grouping them.

#### 4.1.1 Non valid or questionable species in *Angustimarginata*

##### *C. caffrum* and *C. woodii*

*C. caffrum* (Eckl. & Zeyh.) Kuntze and *C. woodii* Dümmer are considered to be synonyms of *C. erythrophyllum* (Burch.) Sond. and not separate species because all taxonomically important characters used in species separation in the subgenus *Combretum* are similar for all these three taxa (Table A.7.5; also Tables A.7.1–A.7.4): inflorescences in the form of spikes; upper hypanthium shapes campanulate or cupuliform; sepals ciliate; petals non-ciliate; petals spathulate (not broadly), not emarginate; disc outer hairs dense; scale diameters 45–80 µm, number of cells per scale 9–16, number of radial walls in surface view 9–16, number of tangential walls in surface view 9–16, scale outlines smooth or lightly scalloped; fruits 10–20 mm long, wing and body hair distribution sparse.

*C. caffrum* has previously been regarded as so similar to *C. erythrophyllum* that it would be reasonable to “conclude that it is merely a southern form of *C. erythrophyllum*” (Carr, 1988, p. 41). The main character distinguishing *C. caffrum* from *C. erythrophyllum* is the more narrowly elliptic shape of the leaves in *C. caffrum*. This study has shown that lamina shape is too variable to be regarded as a reliable taxonomic character in the subgenus *Combretum*, and it would appear that *C. caffrum* can certainly be grouped with *C. erythrophyllum*.

Based on scale structure, specimens labelled *C. woodii* were found to be either *C. erythrophyllum*, *C. kraussii* or *C. edwardsii*. Carr’s concept of *C. woodii* (J.D. Carr, pers comm.), specimen *Rodman 114*, was found to be *C. erythrophyllum* after scale examination (flowers and fruits are absent). Four sheets of isosyntype material of *C. woodii*, *Galpin 1176*, were examined, one from Natal Herbarium and three from Pretoria’s National Herbarium, to determine whether a mixed gathering was represented. All scales examined showed structures typical of *C. erythrophyllum*, in particular, the character of scales being delimited by 9–16 radial walls (Plates 5.1 and 5.3; Tables A.7.1 and A.7.5). Flowering material on specimens labelled *C. woodii* was also checked, particularly petal shape. Again, all such specimens were found to be either *C. erythrophyllum*, *C. kraussii* or *C. edwardsii*, corroborating results of scale analysis. Because of the confusion associated with *C. woodii*, the character list for this taxon was compiled using only the isosyntype material available. From this material, *C. woodii* can confidently be regarded as a synonym of *C. erythrophyllum*.

(Table A.7.5; also Tables A.7.1–A.7.4). It is interesting to note that the syntype of *C. woodii*, Wood 522, in the British Museum Herbarium, is labelled *C. erythrophyllum* by Wood (E.F. Hennessy, pers comm.).

### ***C. vendae***

*C. vendae* Van Wyk is not regarded here as a separate from *C. erythrophyllum* because it only differs significantly from *C. erythrophyllum* in lamina hair distribution. In characters of taxonomic importance at a species level, *C. vendae* is similar to *C. erythrophyllum* (Table A.7.5; and Tables A.7.1–A.7.4). Species such as *C. celastroides* (section *Hypocrateropsis*), *C. collinum* (section *Metallicum*, and *C. apiculatum* (section *Ciliatipetala*) are partly or wholly divided into subspecies on the basis of hair concentration. Following this trend of separating hairier specimens of species into subspecies, the status of *C. vendae* has been changed in this work from species to subspecies, i.e. to *C. erythrophyllum* ssp. *vendae*. However, it is recommended that this division be further investigated as it is possible that *C. vendae* is a synonym of *C. erythrophyllum*. Evidence for this thinking comes from the recording of specimens with glabrous, nearly glabrous or sparingly pubescent laminae (van Wyk, 1984, p. 127).

### ***C. nelsonii***

Exell (1970, 1978) regarded *C. nelsonii* Dümmer as conspecific with *C. kraussii*. Van Wyk (1984) accepts *C. nelsonii* as a distinct species. Carr (1988) includes it with *C. kraussii*, as a “shrub form”, but feels it should be reinstated as a separate species, especially as the chemical constituents of *C. nelsonii* leaves are markedly different from those of *C. kraussii* (Carr & Rogers, 1987, p. 174).

It is felt by the writer that caution should be observed when accepting the results of chemical analysis by Carr & Rogers (1987) because they worked with fresh material from which no scales were examined at any magnification greater than  $\times 10$ . The study reported here has shown that a minimum magnification of  $\times 40$  is usually required to view scales in sufficient detail to be certain of species identification. Some of the specimens examined by Carr & Rogers could therefore be unauthentic for the species they represent, e.g. based on scale structure, Carr’s concept of *C. woodii*, Rodman 114, was found by the writer to be *C. erythrophyllum*.

With reference to scale and leaf structure from authentic *C. nelsonii* material (Nelson 91, isotype) viewed by the writer, it is recommended that *C. nelsonii* be considered

conspecific with *C. erythrophyllum* (Plates 5.1 and 5.5; Tables A.7.1, A.7.4 and A.7.5). However, authentic inflorescences and fruits must be observed and recorded before this can be confirmed and it is for these reasons that *C. nelsonii* is retained here as a separate species. In addition, Carr & Rogers (1987) have not yet looked at the chemical composition of *C. erythrophyllum* leaves to determine whether their composition is matched by the leaves of *C. nelsonii*.

During this study, on the basis of scale structure, other examined material labelled *C. nelsonii* and containing inflorescences and fruits, was found to be *C. moggii*. Some of the herbarium material on loan and labelled *C. nelsonii* had up to five different identification labels, many of which were by taxonomists of repute.

### ***C. kraussii***

Many characters of *C. kraussii* are similar to those of *C. erythrophyllum* (Tables A.7.1–A.7.5). The similarity of *C. kraussii* with *C. erythrophyllum* is further illustrated by the substantial number of incorrectly labelled specimens examined resulting from the confusion between these two species, especially when leaves are young. (It was also found that these species were also sometimes confused with *C. edwardsii* (section *Ciliatipetala*)). The similarity between *C. kraussii* and *C. erythrophyllum* is further illustrated in Figs. 3.4.1 and 3.4.2 (phenograms of currently recognised taxa) where *C. kraussii* is grouped with *C. caffrum*, *C. woodii* and *C. erythrophyllum*. This similarity is also shown in Figs 3.4.3 and 3.4.4 (phenograms of species recognised by the writer) where no significant difference between *C. kraussii* and *C. erythrophyllum* (now including *C. caffrum* and *C. woodii*) is evident. It is interesting to note that no difference between *C. kraussii* and *C. erythrophyllum* emerged in Fig. 3.4.4. However, the writer is content to keep the two species separate because: *C. kraussii* consistently has an average of eight cells per scale and *C. erythrophyllum* consistently an average of 9–16 (usually nearer 16 than 9) cells per scale; petals of *C. kraussii* are often emarginate, whereas petals of *C. erythrophyllum* are non-emarginate; fruits of *C. kraussii* are usually hairier than those of *C. erythrophyllum*; mature leaves of *C. erythrophyllum* usually have more lamina exudate than do those of *C. kraussii*; and *C. erythrophyllum* has scales which are usually lighter in colour than those of *C. kraussii*.

#### 4.1.2 Non valid or questionable species in *Macrostigma*

##### *C. mkuzense*

The reasons behind the current placing of *C. mkuzense* in section *Macrostigma* instead of in section *Spathulipetala*, represented by *C. zeyheri* are unclear. The only reason given for placing *C. mkuzense* in the section *Macrostigma* is that the scales of *C. mkuzense* “agree well with those of other representatives of the section *Macrostigma*” (Carr & Retief, 1989, p. 39). It is not stated in this publication that the scales of *C. mkuzense* are also similar to those of *C. zeyheri* (Tables A.7.1 and A.7.6, Plate 7). The authors of *C. mkuzense* acknowledge that *C. zeyheri* occurs in the same area as *C. mkuzense*; that these two taxa have similar fruits; and that *C. zeyheri* is a small to medium-size tree [with a height of not more than 4–5 m (Carr, 1988)], whereas *C. mkuzense* is a scrambling or large shrub up to 5 m high (Carr & Retief, 1989). Carr maintains that the branches of the holotype of *C. mkuzense*, Carr 187, are so substantial that meat is cut on them (J.D. Carr, pers comm.), which could mean that it is a fairly large plant.

To compare *C. mkuzense* and *C. kirkii* (section *Macrostigma*), the authors of *C. mkuzense* refer to characteristic chromatographic profiles of compounds in leaf material of *Combretum* species as published by Carr and Rogers (1987). However, although Carr and Retief (1989, p. 39) state that an “examination of the profiles of *C. mkuzense* and *C. kirkii* shows similarities but also a significant difference”, no reference to *C. kirkii* can be found by the writer in the referred article. The article does, however, record that leaves of *C. mkuzense* and *C. zeyheri* contain exactly the same chemicals analysed, and in the same relative concentrations (Carr & Rogers, 1987, p. 174).

The writer also found it difficult to understand the reasons behind *C. mkuzense* being compared with species *C. kirkii* and *C. gillettianum*, not found in southern Africa, rather than with *C. zeyheri*, with which it has a great many similarities, including geographical location and scales, especially as the authors acknowledged certain similarities between *C. mkuzense* and *C. zeyheri* (Carr & Retief, 1989).

Discussion with one of the authors of *C. mkuzense*, Retief (pers comm.), revealed that she was unaware of any means of distinguishing between herbarium specimens of

*C. mkuzense* and *C. zeyheri*. The other author, Carr (pers comm.), maintains that these taxa must be viewed in the field to tell them apart.

A reasonable assumption would seem to be that specimens from different species should be able to be distinguished from each other out of the field as well as in it. Ecological factors affecting plant growth are often difficult to determine and taxonomists have great difficulty in assessing these factors, especially when working mainly from dried, herbarium specimens.

Based on personal observations, *C. mkuzense* is not considered by the writer to be a distinct species or a member of the section *Macrostigmatea*, but rather a synonym of *C. zeyheri*, section *Spathulipetala*. From the specimens examined in this work, most taxonomically important characters used in species separation in the subgenus *Combretum* were found to be similar for both *C. mkuzense* and *C. zeyheri* (Tables A.7.6 and A.7.1–A.7.4; Plates 7.1 and 7.2). The slight differences in scale size and cell number in the particular specimens examined (*C. mkuzense* scales are slightly larger and contain slightly more cells than those of *C. zeyheri*) are not considered sufficient to maintain *C. mkuzense* as a separate species. Phenograms (Figs 3.4.1 and 3.4.2) show these two species grouping close together, providing further evidence to support the change of status of *C. mkuzense* to a synonym of *C. zeyheri*. (There is not clear evidence in these phenograms to support the grouping of *C. mkuzense* with *C. engleri*, the only member of the section *Macrostigmatea* studied here). The fact that Retief, an author of *C. mkuzense* claims to be unable to distinguish apart herbarium specimens of this taxon from those of *C. zeyheri* (Retief, pers comm.) provides further evidence to “lump” these taxa.

### ***C. engleri***

Wickens (1973) suggested that *C. engleri* Schinz is conspecific with *C. schumannii* Engl., probably differing only at a subspecific or varietal level. Exell (1970) keeps these two species separate, but groups them together in *Flora Zambesiaca* (1978). Carr (1988) maintains they should be regarded as separate species as they are different in habit (e.g. *C. engleri* is a shrub whereas *C. schumannii* is a tree; *C. engleri* has leaf sizes up to 40 x 18 mm whereas leaves of *C. schumannii* average 70 x 30 mm); and in geographical distribution (*C. engleri* is found on Kalahari sands, *C. schumannii* in coastal forest or tree savannah). *C. schumannii* was not examined in this study because its distribution is usually north of southern Africa (type is from Tanzania).



The type description of *C. engleri* does not include flowering specimens. Wickens (1973) and Exell (1970, 1978) both describe the flower disc of this species (or *C. schumannii* when it is regarded as conspecific) as glabrous; petals as suborbicular/subcircular (1.3–2 mm long, 1.5–1.8 mm wide). Exell (1970) lists specimen *Miller B/1199* as a voucher of *C. engleri*. However, when specimen *Miller B/1199* was examined by the writer, the flower disc was found to be densely hairy and the petals spatulate (1.6 mm long, 0.8 mm wide, certainly not as broad as could be described as suborbicular), characters that do not match with descriptions by Wickens and Exell. Carr, however, describes the disc as having longish hairs, but gives the petal shape as broadly spatulate (1.2 mm long, 0.8 mm wide). Disc and petal characters are generally regarded as taxonomically consistent between members of a *Combretum* taxon. There is thus a large amount of confusion associated with the identification of *C. engleri* inflorescences. Authentic flowering material is difficult to find for *C. engleri*: this together with the fact that not enough material has been examined in this work from *C. engleri* or *C. schumannii* has resulted in *C. engleri* being retained here as a separate species; with the recommendation that these two taxa be investigated further.

### 4.1.3 Further recommendations for existing species and infraspecific taxa

#### 4.1.3.1 Infraspecific taxa in general

As lamina hairiness has been observed to be extremely variable within a taxon, and as this phenomenon is a character used wholly or partly to distinguish between infraspecific taxa, it is recommended that these infraspecific taxa be further investigated to determine whether their separation into subspecies or varieties is valid. In Figs 3.4.1 and 3.4.2, phenograms illustrate that each set of currently recognised subspecies or varieties examined in this dissertation group together. They are:

*C. celastroides* ssp. *celastroides* and ssp. *orientale* (section *Hypocrateropsis*)

*C. collinum* ssp. *coriaceum*, ssp. *ondongense*, ssp. *suluense* and ssp. *taborense* (section *Metallicum*)

*C. apiculatum* ssp. *apiculatum* and ssp. *leutweinii* (section *Ciliatipetala*)

*C. hereroëense* ssp. *hereroëense* var. *hereroëense* and var. *villosissimum* (section *Breviramea*)

It is also recommended that *C. psidioides* ssp. *psidioides* and ssp. *dinteri* (only given a brief, cursory examination in this work) be investigated to determine the validity of their separation into subspecies.

#### 4.1.3.2 Validity of infraspecific taxa

##### *C. collinum* (section *Metallicum*)

Okafor (1967) recognised 11 subspecies of *C. collinum*, four of which are located in the FSA area. Exell (1978) and Carr (1988) both maintain that the subspecies of *C. collinum* as given by Okafor are difficult to distinguish apart. They both suggest that *C. collinum* is an aggregate species with great variation in leaf shape, indumentum and size of fruit. Exell (1978) was reluctant to accept Okafor's divisions until germination studies had been carried out on the taxa involved. Carr (1988) experimented with germination techniques, but did not find any conclusive differences to distinguish between Okafor's subspecies. In fact, some of Carr's descriptions of the four subspecies in our area show that there is not always agreement with Okafor's key to separating these subspecies.

Further evidence of confusion concerning Okafor's subspecies of *C. collinum* in our area is that none of the four subspecies is geographically distinct. Carr (1988) examined material determined by Okafor to avoid misidentification and found that ssp. *coriaceum* and ssp. *suluense* are distributed almost identically, with ssp. *ondongense* being similarly distributed but not extending as far east as the other two. Subspecies *taborense* appears mainly within the zones of ssp. *coriaceum* and ssp. *suluense*. According to Carr (1988, p. 51), one would expect that each subspecies would be centred around a specific area, but that no such pattern exists. He thus regards the separation into subspecies as unjustified.

This work accepted the subspecies described by Okafor as distinct; with most specimens examined having been determined by him. These specimens (in limited numbers) thus usually fitted the key as given by Okafor (1967). Not enough specimens were examined in this study to provide conclusive evidence to support the proposition that the subspecies should all become synonyms of *C. collinum* Fresen.

The writer sometimes experienced difficulty in determining the reasons behind Okafor (1967) having applied certain names to subspecies of *C. collinum*.

Subspecies *gazense* (Swynn. & Bak. f.) Okafor (1967) has two synonyms described earlier than that of *C. gazense* (described in 1911). These are *C. coriaceum* (described in 1888) and *C. bajonense* (described in 1909). As Okafor examined type material from all three of these aforementioned species, it remains unexplained as to why he did not select the earliest described name in accordance with the rules of botanical nomenclature. After confirming the existence of suitable type material (E.F. Hennessy, pers comm.), the writer has changed the name of ssp. *gazense* to that of the earliest described synonym, i.e., in full, *C. collinum* ssp. *coriaceum* (Schinz) Rodman (ined.) (refer to Chapter 6 on Formal Taxonomy) in an attempt to maintain consistency of botanical nomenclature.

There are four synonyms of ssp. *suluense* described earlier than 1899, and it is not clear why Okafor chose to use the name *suluense* over the other four (*fischeri*, *brosigianum*, *fulvotomentosum* and *schinzii*). Type material for *C. fischeri*, *C. brosigianum* and *C. fulvotomentosum* had either been destroyed or not seen by Okafor, which could explain his not using them, but he had seen an isotype of *C. schinzii*, described in 1898. The writer has not changed ssp. *suluense* to an earlier name because she is uncertain of suitable type material available.

A further investigation into the *C. collinum* complex in an attempt to make better sense of this varied and confusing species is strongly recommended.

#### ***C. hereroëns* (section *Breviramea*)**

Wickens (1971, p. 413) in his review of the *C. hereroëns* complex, recognised that this is a variable species which can be divided into a number of infraspecific taxa, even although the possibility exists that further gatherings will yield intermediates to break down the current divisions, which he states is “a not uncommon problem in this genus”. He divided *C. hereroëns* into three subspecies, of which only ssp. *hereroëns* is of relevance in this study. In the same revision (1971), Wickens further divided ssp. *hereroëns* into var. *hereroëns* and var. *villosissimum*. Exell did not recognise any subspecies or infraspecific taxa for *C. hereroëns* in his Summary of the Combretaceae of Flora Zambesiaca (1970), but he used the divisions as described by Wickens (1971) in the revision of the Combretaceae in Flora Zambesiaca (1978), even though he did not find the classification into varieties satisfactory and would have preferred to regard *C. hereroëns* as an aggregate species. Exell (1978) and Carr (1988) both comment that Wickens’s divisions into varieties are based on lamina hairiness, a character which can be very variable. Carr (1988, p. 78) has observed

members of the two varieties growing contiguously: leading him to regard the two varieties as “no more than ‘glabrous’ and ‘hairy’ forms” of *C. hereroëns* ssp. *hereroëns*. The writer is inclined to agree with the comments by Exell and Carr, and recommends that *C. hereroëns* be further investigated to establish the validity of infraspecific taxa for this species with certainty. In the meantime, the divisions as proposed by Wickens (1971) have been retained.

## 4.2 Sections

The validity of currently recognised sections were determined after first establishing that the species they represent are distinct and valid. Currently recognised sections and their currently recognised species and infraspecific taxa are listed in the Introduction. These same sections, together with their recommended representative species and infraspecific taxa as presented in the synonymy of this dissertation are:

1. section *Hypocrateropsis* Engl. & Diels

*C. celastroides* Welw. ex Laws.

*C. celastroides* ssp. *celastroides*

*C. celastroides* ssp. *orientale* Exell

*C. imberbe* Wawra

*C. padoides* Engl. & Diels

2. section *Angustimarginata* Engl. & Diels

*C. erythrophyllum* (Burch.) Sond.

*C. erythrophyllum* ssp. *erythrophyllum*

*C. erythrophyllum* ssp. *vendae* (Van Wyk) Rodman comb. & stat. nov.  
(ined.)

*C. kraussii* Hochst.

*C. nelsonii* Dümmer

3. section *Macrostigma* Engl. & Diels

*C. engleri* Schinz

4. section ***Metallicum*** Fresen.

*C. collinum* Fresen.

*C. collinum* ssp. *coriaceum* (Schinz) Rodman (ined.)

*C. collinum* ssp. *ondongense* (Engl. & Diels) Okafor

*C. collinum* ssp. *suluense* (Engl. & Diels) Okafor

*C. collinum* ssp. *taborense* (Engl.) Okafor

5. section ***Spathulipetala*** Engl. & Diels

*C. zeyheri* Sond.

6. section ***Ciliatipetala*** Engl. & Diels

*C. albopunctatum* Suesseng.

*C. apiculatum* Sond.

*C. apiculatum* ssp. *apiculatum*

*C. apiculatum* ssp. *leutweinii* (Schinz) Exell

*C. edwardsii* Exell

*C. moggii* Exell

*C. molle* R.Br. ex G. Don

*C. petrophilum* Retief

*C. psidioides* Welw.

*C. psidioides* ssp. *psidioides*

*C. psidioides* ssp. *dinteri* (Schinz) Exell

7. section ***Breviramea*** Engl. & Diels

*C. hereroëense* Schinz

*C. hereroëense* ssp. *hereroëense* var. *hereroëense*

*C. hereroëense* ssp. *hereroëense* var. *villosissimum* Engl. & Diels

8. section ***Elaeagnoida*** Engl. & Diels

*C. elaeagnoides* Klotzsch

1. Section *Hypocrateropsis* is clearly distinct and valid. This is illustrated by the fact that all the phenograms produced in this study (Figs 3.4.1–3.4.4) show *C. celastroides* grouping with *C. imberbe*. *C. padoides* is not in the phenograms because time did not permit a full averaged set of characters for this species. However, the few *C. padoides* specimens observed in this study keyed out unambiguously to section *Hypocrateropsis*. Characters that make this section

different from all the others include those of flattened upper hypanthia, elliptic petals and the largest scales in the subgenus.

2. Section *Angustimarginata*, restricted to southern Africa and regarded as being comprised of species which are difficult to delimit because they are closely related and variable (van Wyk, 1984), appears to be distinct, especially when scale characters are considered. Scales from this section are always delimited only by radial walls (8–16), an exclusive phenomenon in the subgenus *Combretum*. Phenograms constructed from currently recognised species belonging to this section (Figs 3.4.1 and 3.4.2), together with those from species recognised by the writer (Figs 3.4.3 and 3.4.4), show that the species comprising section *Angustimarginata* group closely together. An exception from grouping in this section is shown in Figs 3.4.1 and 3.4.2 by *C. vendae*. In all probability, *C. vendae* does not group with *C. erythrophyllum*, *C. caffrum*, *C. woodii* or *C. kraussii* in these phenograms because specimens of *C. vendae* examined were extremely hairy compared with specimens of the other species under discussion here.

It is hoped that the recommendations which arose from the work regarding this section will assist in making species delimitation in the section less difficult.

It is recommended that *C. nelsonii* be included in phenograms after a complete, authentic character list has been compiled for this species.

3. Problems were experienced with section *Macrostigma*. Authentic inflorescence characters could not be established by the writer because of the confusion surrounding flower structure of *C. engleri*, the only species of this section represented in the FSA region. Interpretation from phenograms (Figs 3.4.1–3.4.4) does not appear to assist in unravelling this confusion. Exell (1970, 1978) acknowledges that this section is somewhat heterogeneous and that it could be divided into two subsections using disc characters (pilose or glabrous). Another complication related to this section is that it takes its name from the phenomenon of an expanded stigma, a character which is not always likely to be visible as stigmas and styles in this subgenus are often extruded earlier than the stamens, and the stigmas have subsequently often withered by the time

flowers are fully opened and examined. A further, fuller investigation into this section is strongly recommended.

4. Section *Metallicum* seems to be distinct. Scales of this section are matched most closely by those of section *Elaeagnoida*, but besides other organs, flowers of these two sections have many differences, particularly regarding petal shape, disc margin hairiness and stamen insertion (Table A.7.3); more than enough differing characters to keep these two sections separate. Section *Metallicum* is described by Exell (1970, 1978) and Wickens (1973) as having fruit wings usually somewhat “metallic” in appearance. This phenomenon was not observed in this study, perhaps because only dried specimens were examined for this species. It is felt by the writer that the naming of this section after a “metallic” wing appearance is unfortunate as this feature is not always clearly discernible.
5. Scales of the only species in section *Spathulipetala*, *C. zeyheri*, are very similar to those of *C. engleri*, section *Macrostigmatea* (Plates 6.1 & 7 ; Table A.7.1). In addition, these species representing their sections, share the character state of a slightly expanded stigma (until it shrivels) (Table A.7.3a). There are, however, significant differences between these sections, sufficient to maintain them as distinct. For example, *C. zeyheri* has larger fruits than *C. engleri* (Table A.7.2)[It would be incomplete not to mention here that *C. kirkii*, section *Macrostigmatea*, and not occurring in the FSA region, can have fruits as large as those of *C. zeyheri* (Exell, 1970, 1978)], and *C. zeyheri* typically has much larger leaves than *C. engleri* (Table A.7.4). The significance of differences between leaf sizes is shown by the fact that leaves of *C. zeyheri* tend towards being the largest in the subgenus, whereas those of *C. engleri* tend towards the smallest. Flower characters could also differ significantly between *C. engleri* and *C. zeyheri*, but inflorescence characters of *C. engleri* should be clearly established before these are determined with certainty. Further evidence supporting the retention of sections *Spathulipetala* and *Macrostigmatea*. is supplied by phenograms (Figs 3.4.1–3.4.4). These phenograms do not show any clear grouping patterns between species of these two sections.
6. Section *Ciliatipetala* is without doubt the most varied section studied in this work (Tables A.7.1–A.7.4). It would seem that the only unique characters which distinguish this section from others in the subgenus are those associated

with petals. This is the only section where petals, sometimes only the tips, are ciliate, and one of three sections with well-defined, broadly spatulate petals (the other two are *Metallicum* and *Breviramea*) (Table A.7.3). Petals of species in this section are also usually slightly shorter relative to those of species in other sections. There is a potential problem with *C. petrophilum* as this species is described as having non-ciliate petals, yet it has been placed in section *Ciliatipetala* (Retief, 1986). Unfortunately it was not within the scope of this work to investigate fully the validity of *C. petrophilum* as a separate species, but such an investigation is highly recommended. *C. petrophilum* is thus retained here as a species of the section *Ciliatipetala*, but this status is regarded as questionable until further study.

Scales of different species in this section are more heterogeneous than those from any other section (Plates 8 & 9.1, Table A.7.1), an unusual phenomenon when compared with other sections in the subgenus. However, the scales within a species remain relatively constant. For example, *C. molle* is extremely variable in terms of geographical distribution (throughout tropical and southern Africa and in Arabia), shape of leaves, indumentum and size of leaves; so much so that the range of variation is almost exactly matched in the equally variable *C. collinum* (Exell, 1970); yet the scales of *C. molle* remain relatively constant. Exell (1970, 1978) strongly advises against dividing *C. molle* into infraspecific taxa because of the polymorphic tendencies of this species. This species is so varied that some glabrous forms of *C. molle* can only be distinguished from those of *C. apiculatum* by a microscopical examination of the scales (Exell, 1970; Wickens, 1973). Wickens (1973, p. 32) comments that this occurrence is an “extremely unsatisfactory state of affairs”.

Suggestions have been made that hybridization occurs between *C. molle* and *C. apiculatum*, but when scales of possible hybrids are examined microscopically, either one or the other species is identified. However, it is possible that hybrids might have the scales of one or the other parent without intermediate scale-structures occurring (Exell, 1970, 1978).

Exell (1970, 1978) maintains that the small petals of section *Ciliatipetala* seem to have lost their role in insect attraction and that this function has been taken over by massing of the flowers, conspicuous stamens and scent. This could well be true as members of this section have been observed by the writer to flower



prolifically on most branches of the plants, *C. molle* and *C. apiculatum* in particular, together with the production of a strong-smelling, sweet scent.

Species of this section do not always group together clearly in phenograms (Figs 3.4.1–3.4.4). This is most likely to be the result of the extremely variable nature of certain species representing section *Ciliatipetala*. The writer, however, does not recommend that this section be considered for splitting until all its species have been properly investigated and determined as valid. Species not examined fully enough in this study are *C. moggii*, *C. petrophilum* and *C. psidioides*.

It is of interest to note that Stace (1969, p. 155) mentions that although connections between individual species can be traced without difficulty, the section *Ciliatipetala* could be separated into “six sections quite easily”, distinguishable by macroscopic as well as microscopic characters. He continues by stating that decisions of subdivision into further sections should await the discovery of further taxonomic characters in the genus.

7. Section *Breviramea* is represented by only one species and subspecies in the FSA area, *C. hereroënsis* ssp. *hereroënsis*.

Taking all species studied into account, scales of *C. hereroënsis* ssp. *hereroënsis* are most similar to those of *C. molle*, section *Ciliatipetala*, (Plates 8.6 & 9.3, Table A.7.1) except that the scales of *C. hereroënsis* are thinner walled and more flimsy than those of *C. molle*. However, there are so many other differences between these two taxa (Tables A.7.2–A.7.4) that they are highly unlikely ever to be confused with each other.

Flowers examined from var. *hereroënsis* and var. *villosissimum* showed that the character state of stamens being 2-seriate in insertion is not always clearly visible, especially to the inexperienced eye. This is unfortunate because stamen insertion is a character bestowed with taxonomic importance at a sectional level. The writer is, however, content to accept stamen insertion as a valid taxonomic character, and that stamens are 2-seriate in the section *Breviramea*. There appears to be little evidence from the characters observed in *C. hereroënsis* ssp. *hereroënsis* to support the rejection of the validity and distinctness of the section *Breviramea*.

8. Section *Elaeagnoida*, represented by *C. elaeagnoides*, is geographically distinct, found in the Zambesi valley and in dense *Terminalia/Colophospermum mopane* woodland (Exell, 1978; Carr, 1988) In addition, it is the only section of the subgenus with an obviously 2-seriate stamen insertion. Mention has already been made under the section *Metallicum* that the scales of *C. elaeagnoides* are similar to those of *C. collinum*, but that confusion between these two sections is unlikely to occur because so many other characters are different.

The combination of clearly 2-seriate stamens, glabrous and not broadly spatulate petals, and a glabrous disc (Table A.7.3) ensures that flowers of this section will not be mistaken for those of other sections in the subgenus. In addition, phenograms (Figs 3.4.1–3.4.4) show that *C. elaeagnoides* does not usually group closely with other species. Evidence thus supports the conclusion that the section *Elaeagnoida* is, without doubt, distinct.

# 5

## Conclusions

From investigations conducted for this study, it would appear that most limits between currently recognised sections of the subgenus *Combretum* are valid. Some confusion is, however, present in the sections *Macrostigma* and *Ciliatipetala*, but the species they represent and which have not been examined within the scope of this dissertation should be investigated further in order to determine with certainty whether these two sections are valid or how, in particular, *Ciliatipetala* should be separated.

Recommendations have been made regarding status changes for many of the species and infraspecific taxa belonging to the sections of the subgenus. It is hoped that changes of status not requiring further research will be published in an international journal in the near future.

Investigation conducted in this work has shown that microscopic examination (at least  $\times 40$ ) of scales is often required before confirmation of identification at a species and sometimes subspecies level. This requirement serves to emphasise the importance of scale structure in the taxonomy of the subgenus *Combretum*. and it may be concluded that the systematic value of scales is at least as great as that of any other organ in the subgenus (Stace, 1969). However, it should be borne in mind that too much taxonomic emphasis should not be placed on one set of characters. Using the words of Stace (1969, p. 165), “too strict an adherence to the belief that every section must be exactly delimited by scale characters would lead to the same mistakes that have been caused by similar dogmas concerning”, “glabrous versus ciliate petals and a shrubby versus arboreal habit”.

In further investigations, researchers would be advised to take more account of habit than was investigated in this work. New or additional data from sources such as pollen structure, seedling morphology, wood anatomy, phytochemistry, floral vascularization and karyotypes would probably result in a more complete picture of the subgenus and its components, as would attempts to unravel phylogenetic pathways.

This investigation has engendered a deep respect in the writer for early taxonomists who worked without such tools as electron microscopes and sophisticated computers, yet produced classification systems which are largely upheld today.

# 6

## Formal Taxonomy

As far as possible, the format of the formal taxonomy is according to the instructions to authors of taxonomic papers for submission to the South African Journal of Botany.

Genus: *Combretum* Loeffling, Iter Hispanicum. (1758) [conserved name]. Type: *C. fruticosum* (Loefl.) Stuntz (tropical American).

Trees, shrubs, shrublets or woody climbers, very rarely subherbaceous. *Leaves* opposite, subopposite, verticillate or rarely alternate, usually petiolate (rarely subsessile), almost always entire; petiole sometimes persisting (especially in climbers) forming a hooked spine. *Flowers* always ♀ (in southern Africa), actinomorphic or slightly zygomorphic (not in southern Africa), 4–5-merous, in elongated or subcapitate axillary or extra-axillary spikes or racemes or in terminal or terminal and axillary often leafy panicles. *Hypanthium* usually clearly divided into a lower part (lower hypanthium) surrounding and adnate to the ovary and an upper part (upper hypanthium) varying from flattened to infundibular and itself sometimes visibly differentiated into a lower part containing the disc (when present) and an often more expanded upper part. *Sepals* 4–5 (rarely more), deltate to ± subulate or filiform, sometimes scarcely developed. *Petals* usually 4–5 (rarely absent, in aberrant specimens and up to 7 in occasional flowers), small and inconspicuous to showy and exceeding the sepals, of various colours. *Stamens* twice as many as the petals inserted in 1 or usually 2 series inside the upper receptacle and usually exserted. *Disc* glabrous or hairy, with or without a free margin, sometimes inconspicuous or absent. Style free (in southern African species); stigma sometimes slightly expanded. *Ovary* completely

inferior. *Fruit* 4–5-winged, ridged or angled, sessile or stipitate, indehiscent or rarely tardily dehiscent; pericarp usually thin and papyraceous, sometimes coriaceous, more rarely fleshy. Cotyledons various. Plants lepidote or with microscopic (and sometimes macroscopic) stalked glands.

Information on this genus and subgenus is based on that given by Exell, 1970 (pp. 162–163), Wickens, 1973 (pp. 2–3) and Exell, 1978 (pp. 101–102).

### Subgenus *Combretum*

Scales present, although sometimes inconspicuous or hidden by the indumentum; microscopic stalked glands absent (in southern African species); flowers usually 4-merous, petals usually 4 in number, usually not red, stamens usually 8 in number; fruit usually 4-winged.

Only Sections and species represented in the Flora of southern Africa (FSA) region are listed in this work. Descriptions of species and infraspecific taxa are entirely from characters personally observed in herbarium specimens examined. For each taxon, only a character state, from the specimens examined, which represented a clear average for each observed character was used.

Species within sections are listed in alphabetical order of the species.

### Synoptical key to sections of subgenus *Combretum*

(Personally observed characters from herbarium specimens were generally used in key construction. Inflorescence characters for *Macrostigma* were taken from Wickens 1973, Exell 1978 and Carr 1988, because specimens examined personally were suspected of being labelled incorrectly. The same literature was occasionally also consulted to give upper and lower limits for measurements).

- Upper hypanthium little developed, flattened; disc conspicuously visible; petals glabrous, linear-elliptic, occasionally spatulate; sepals non-ciliate; stamens apparently 1-seriate; scales (Plate 4) conspicuous, large, usually at least (100–) 150µm in diameter, not markedly scalloped, made up of more than 50 cells, more than 50 radial walls and more than 50 tangential walls; fruits more than 20 mm long, body and wing hairs sparse..... **1. Hypocrateropsis** (p. 49)
- Upper hypanthium cupuliform, infundibular or campanulate; disc usually concealed within the upper hypanthium and usually not visible in dried specimens without

opening the flower; petals narrowly to very broadly spathulate, glabrous or ciliate, sometimes sparsely lepidote; stamens 1- or 2-seriate; scales various, sometimes inconspicuous, scalloped in outline if more than 150  $\mu\text{m}$  in diameter: Petals ciliate at the apex, broadly spathulate, sometimes lobed or emarginate, (0.5–) 1.1 (1.5) mm long; stamens apparently 1-seriate; disc with pilose margin; sepals ciliate; scales (Plates 8 and 9.1) somewhat variable, 40–120 (–130)  $\mu\text{m}$  in diameter, 8–16 cells, 8–16 radial walls, 9–16 tangential walls; fruit 15–30 mm long, stipes less than 8 mm long; leaves usually 35–69 mm long, petioles less than 8 mm long, margins usually ciliate.....

..... **6. Ciliatipetala** (p. 78)

Petals non-ciliate, narrowly spathulate to broadly spathulate, sometimes pointed, toothed, rounded or truncated if narrowly spathulate, longer than 1 mm; stamens 1- or 2-seriate:

Stamens apparently 1-seriate in insertion at or near the margin of the disc:

Fruit less than 30 mm long; scales 45–80  $\mu\text{m}$  in diameter, not conspicuously scalloped:

Petals narrowly spathulate, sometimes toothed or emarginate, nearly always as long as broad or longer; inflorescence an elongated or subcapitate spike; disc margin pilose; sepals ciliate, inner surfaces considerably hairy; scales (Plate 5) 50–80  $\mu\text{m}$  in diameter, divided only by radial walls, 8–16 cells, delimited by 8–16 radial walls, 8–16 marginal tangential walls, often obscured by glutinous secretion and/or indumentum; fruit wings and body sparsely to moderately hairy, stipe 4–8 mm long; leaves (30–) 35–70 (–90) mm long, petioles less than 8 mm long, 5–10 pairs of primary lateral veins, well defined pockets of hairs in abaxial axils of midrib and primary lateral veins, margins non-ciliate (except in *C. erythrophyllum* ssp. *vendae*)..... **2. Angustimarginata** (p. 56)

Petals broadly spathulate, usually broader than long (more narrowly spathulate in *C. cf. engleri*, Miller B/1199); inflorescence a subcapitate spike; stigma expanded before withering, disc glabrous (pilose in Carr 1988 and *C. cf. engleri*, Miller B/1199), obviously notched for insertion of stamens (*C. cf. engleri*, Miller B/1199); sepals non-ciliate (*C. cf. engleri*, Miller B/1199), inner sepal surface glabrous (*C. cf. engleri*, Miller B/1199); scales (Plate 6.1) 45–75  $\mu\text{m}$  in diameter, usually of a simple 8-celled type with the addition of a number of radial and tangential walls, 8–16 cells, 8–16 radial walls,

8–16 tangential walls; fruit wings and body sparsely hairy, stipe  $\pm$  8 mm; leaves less than 34 mm long, petioles 2–7 mm long, 3–5 pairs of primary lateral veins, well defined pockets of hairs in abaxial axils of midrib and primary lateral veins (*C. cf. engleri*, Miller B/1199), margins ciliate (*C. cf. engleri*, Miller B/1199).....

.....**3. Macrostigmatea** (p. 64)

Fruit more than 30 mm long; leaves 40–110 mm long, petioles 7–20 mm long; sepals ciliate; disc margin pilose; scales varied; pockets of hairs in abaxial axils of midrib and primary lateral veins usually present (except in *C. collinum* ssp. *ondongense*):

Petals narrowly spathulate, sometimes pointed, toothed, rounded or truncated, always longer than broad; inflorescence an elongated spike; upper hypanthium usually campanulate; stigma often expanded before withering; disc clearly notched for stamen insertion, inner surface considerably hairy; sepal inner surfaces considerably to densely hairy; scales (Plate 7) 60–90  $\mu$ m in diameter, 9–20 cells, 9–12 radial walls, 9–20 tangential walls, not conspicuously scalloped; fruit 30–80 mm long, stipe 5–10 (–25) mm long, wings and body sparsely hairy; leaf margin often ciliate, base often obtuse or rounded ..... **5. Spathulipetala** (p. 75)

Petals broadly spathulate, often broader than long; inflorescence a spike or panicle; stigma not expanded; sepal inner surfaces moderately hairy; scales (Plates 6.2–6.5) (80–) 100–180  $\mu$ m in diameter, 30–49 (–60) cells, 30–49 radial walls, 30–49 (–60) tangential walls, outlines conspicuously scalloped; fruit 30–55 mm long, stipe up to 20 m long; wings and body sparsely to considerably hairy; leaf margins sometimes ciliate ..... **4. Metallicum** (p. 66)

Stamens 2-seriate in insertion; inflorescence a spike or panicle; sepals ciliate; scales conspicuous, considerable to densely distributed on adaxial and abaxial lamina surfaces, scales (Plate 9.3) 90–140 (–175)  $\mu$ m in diameter; leaf margins ciliate; pockets of hairs in axils of abaxial midrib and primary lateral veins; fruit body and wings sparsely or moderately hairy:

Stamens not always clearly 2-seriate in insertion; petals broadly spathulate, often longer than broad; disc margin pilose; leaves 20–35 mm long, 3–5 (–6) pairs of primary lateral veins; scales (50–) 75–99 (–160)  $\mu$ m in diameter,  $\pm$  16 cells, 8–9 radial walls,  $\pm$  16 tangential walls,



conspicuously scalloped, usually with some rust-brown colouring; fruit  
 stipe usually less than 8 mm long ..... **7. Breviramea** (p. 90)  
 Stamens clearly 2-seriate in insertion; petals not broadly spatulate, always  
 longer than broad; disc margin glabrous; leaves 35–130 mm long, (8–)  
 10 (–13) pairs of primary lateral veins; scales (Plate 9.4) 115–175 µm  
 in diameter, 30–49 cells, 30–49 radial walls, 30–49 tangential walls,  
 scalloped; fruit stipe ± 12 (–15) mm long..... **8. Elaeagnoida** (p. 94)

**1. Section Hypocrateropsis** *Engl. & Diels* in Engler, H.G.A.,  
 Monographien afrikanischer Pflanzenfamilien und Gattungen 3: 11 (1899); Stace:  
 135 (1969); Exell: 167 (1970); Wickens: 11 (1973); Exell: 105 (1978).

Disc glabrous, obviously notched for stamen insertion; scales on abaxial and adaxial  
 lamina surfaces apart, scales often dome-shaped; well defined pockets of hairs  
 in abaxial axils of midrib and primary lateral veins; leaf margin usually ciliate...

..... 1. *C. celastroides*

Disc pilose at least on the margin; scales disc- or bowl-shaped; no pockets of hairs in  
 abaxial axils of midrib and primary lateral veins:

Scales on abaxial and adaxial lamina surfaces apart; leaf margin usually  
 ciliate..... 3. *C. padoides*

Scales on abaxial and adaxial lamina surfaces contiguous or overlapping; leaf  
 margin not ciliate; flower bracts absent; distinctive stalked scales on style.....

..... 2. *C. imberbe*

**1. Combretum celastroides** *Welw. ex Laws.* in Oliver, Flora of Tropical Africa  
 2: 422 (1871); Engl. & Diels: 12 (1899); Codd: 129 (1951); Stace: 12 (1961); White:  
 284 (1962); Exell: 8 (1966); Stace: 135 (1969); Exell: 167 (1970); Palmer & Pitman:  
 1637 (1973); Wickens: 11 (1973); Van Wyk: 419 (1974); Coates Palgrave: 664  
 (1977); Exell: 105 (1978); Carr: 44 (1988). Type: Angola, Huila, *Welwitsch 4370*  
 (LISU, lecto.; BM, COI, K, P, PRE!).

(a) **subsp. celastroides**; Exell in Boletim da Sociedade Broteriana Sér. 2, 42:  
 16 (1968); Stace: 137 (1969); Exell: 168 (1970); Wickens: 17 (1973); Exell: 107  
 (1978); Carr: 45 (1988).

*Combretum patelliforme* Engl. & Diels: 12 (1899), pro parte, quoad specim.  
*Antunes A 155* (B†).

*Branches* bark strips. *Leaves* opposite to alternate; **petiole** (5 - ) 5.8 ( - 7) mm long, hairs considerably to densely distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** elliptic, slightly obovate; (68 - ) 69.8 ( - 73.3) mm long, (29 - ) 32.8 ( - 39.7) mm wide; texture subcoriaceous; margin ciliate or sometimes ciliate; apex bluntly-acuminate; base obtuse or rounded; number of pairs of lateral veins 6; **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; bullae in axils along midrib and/or in axils of lateral veins, commonly occurring; hair distribution throughout surface; lamina island hairs moderately distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs moderately distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; hair concentration in axils of primary lateral veins and secondary lateral veins sparse; scales distributed throughout surface; lamina island scales mainly apart, silvery or golden; midrib scales apart to contiguous or overlapping, silvery or golden; primary lateral vein scales sparsely distributed; lamina scales sometimes impressed, scales not clearly visible, lamina exudate present; **abaxial** reticulation raised; intersecondary veins more or less plane; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales sparsely distributed; scales dome-shaped, (179 - ) 213.2 ( - 257)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale >50, number of radial walls in surface view >50, number of tangential walls in surface view >50. *Inflorescence* spike, elongated, terminal or axillary; rhachis hairs considerably to densely distributed, scales considerable, mainly apart, rust-brown; ratio of peduncle length to rhachis length 0.3. *Bracts* linear or lorate, 1.2 mm long. *Lower hypanthium* markedly prolonged beyond ovary; 4.5 mm long, 0.8 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Upper hypanthium* flattened; 0.8 mm long, 2.9 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Base of receptacle, gynoeceium and accessory tissue* ovary 1.7 mm long, 0.8 mm wide; distance from base of style to placenta 1.9 mm; style 1.7 mm long; stigma not expanded. *Sepals* 1.2 mm long, 1.9 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres;

inner hairs sparsely distributed. *Petals* elliptic, 1.9 mm long, 0.6 mm wide. *Disc* margin free; conspicuously notched for insertion of filaments. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 1.1 mm long, anthers 0.5 mm long, 0.4 mm wide. *Fruit* 18 mm long, (16.3 - ) 17 ( - 17.7) mm wide; wing texture papyraceous; stipe (1.6 - ) 1.7 ( - 1.8) mm long; peg 1 mm long; wings golden to light-brown or golden-brown; body golden to light-brown or golden-brown; glutinous only on body; rhachis hairs considerably to densely distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; wing hairs sparsely distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; body hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; fruit outline elliptic or subcircular.

**Specimens examined**

- **1628**: Sihamwenda Research Station, Lake Kariba ( - DD), *Davidson 1025* (J); Mwenda, Lake Kariba, *MacDonald 5* (J).
- **1723** (Singalamwe): Singalamwe, about 20 km east of the Kwando River ( - CD), *Hines 533* (PRE).
- **1724** (Katima Mulilo): Wanella pad, Katima Mulilo ( - AD), *Vahrmeijer & du Preez 2510* (PRE).
- **ANGOLA**: no precise locality, Huila, *Welwitsch 4370*. Grid ref. unknown (PRE, isoelectotype).

Lamina adaxial and abaxial surfaces usually moderately hairy (adaxial and abaxial midribs and lateral veins moderately or considerably hairy),  $\pm 50\text{--}100 \times 10\text{--}45$  mm; tufts of hairs in adaxial and abaxial axils of midribs and primary lateral veins .....subsp. *celastroides*

Lamina adaxial and abaxial surfaces usually sparsely hairy (adaxial and abaxial midribs and lateral veins moderately or considerably hairy), up to  $\pm 50 \times 22$  mm; tufts of hairs in abaxial, not adaxial, axils of midrib and primary lateral veins ..... subsp. *orientale*

**(b) subsp. orientale** *Exell* in Boletim da Sociedade Broteriana Sér. 2, 42: 16 (1968); Stace: 137 (1969); Exell: 169 (1970); Wickens: 17 (1973); Exell: 107 (1978); Carr: 45 (1988). Type: Mozambique, Delagoa Bay, *Schlechter 11957* (B†; BM, lecto.; BOL!, COI, K, PRE!, SAM).

*Combretum patelliforme* Engl. & Diels: 12 (1899), pro parte, excl. specim. *Antunes A 155* (B†). Type: Mozambique, Delagoa Bay, *Schlechter 11957* (B†, lecto.; BM, BOL!, COI, K, PRE!, SAM).

**Specimens examined**

— **2532** (Lourenco Marques): Delagoa Bay ( - DC), *Schlechter 11957* (BOL, PRE, isoelectotypes).

— **2632** (Bela Vista): 6 km west Muzi ( - CD), *Moll & Muller 5688* (NU); Tembe Elephant Park, *Ward 2286* (NH); 8 km west Muzi Border Post ( - DC), *Moll 5655* (NH).

**2. *Combretum imberbe* Wawra** in Sitzungsberichte der mathem.-naturw. Classe der kaiserlichen Akademie der Wissenschaften in Wien 38: 556 (1860); Engl. & Diels: 14 (1899); Henkel: 123 (1934); Codd: 130 (1951); Stace: 11 (1961); Exell: 9 (1966); De Winter et al.: 171 (1966); Exell: 7 (1968); Stace: 137 (1969); Exell: 171 (1970); Palmer & Pitman: 1645 (1973); Wickens: 18 (1973); Van Wyk: 429 (1974); Coates Palgrave: 669 (1977); Exell: 109 (1978); Carr: 81 (1988). Type: Angola, Benguela, *Wawra 247* (W, holo.; BM).

*Argyrodendron petersii* Klotzsch: 101 (1861). Type: Mozambique, Sena, *Peters s.n.* (B, holo.†).

*Combretum petersii* (Klotzsch) Engl. & Diels: 14 (1899).

*C. truncatum* Welw. ex Laws.: 427 (1871); Sim: 62 (1909); Dümmer: 231 (1913). Syntypes: Angola, Mossamedes, *Welwitsch 4283* (K); *Welwitsch 4372* (LISU, K, BM); Mozambique, near Lupata, *Kirk s.n.* (K).

*C. imberbe* var. *truncatum* (Welw. ex Laws.) Burt Davy: 246 (1926).

*C. primigenum* Marloth ex Engl.: 49 (1888); Engl. & Diels: 14 (1899). Type: “Südwest Afrika, Omumborombonga, Hereroland, Usakos”, *Marloth 1264* (B, holo.†; K, PRE!, SAM).

Icon: Carr: t.6 (1988).

*Branches* often with pairs of pointed lateral branches; bark strips. *Leaves* **petiole** (3 - ) 5.7 ( - 11) mm long, hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** oblong-elliptic, slightly obovate; (2.8 - ) 31.8 ( - 62) mm long, (1.2 - ) 13.8 ( - 26) mm wide; texture papyraceous; margin entire; apex apiculate, retuse, rounded or obtuse; number of pairs of lateral veins (5 - ) 6 ( - 7); adaxial and abaxial surfaces not easily distinguishable with the naked eye; **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; hair distribution in lamina islands only; lamina island hairs sparsely distributed; scales distributed throughout surface; lamina island scales contiguous or overlapping, silvery or golden; primary lateral vein scales considerably to densely distributed; scales disc- or bowl-shaped, (176 - ) 202 ( - 225)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale >50, number of radial walls in surface view >50, number of tangential walls in surface view >50; **abaxial** midrib raised, primary lateral veins more or less plane; intersecondary veins more or less plane; hair distribution in lamina islands only; lamina island hairs sparsely distributed; scale distribution throughout surface; lamina island scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (182 - ) 213.5 ( - 247)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale >50, number of radial walls in surface view >50, number of tangential walls in surface view >50. *Inflorescence* spike or panicle, elongated, terminal or axillary; rhachis hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; ratio of peduncle length to rhachis length 0.3. *Lower hypanthium* 2.2 mm long, 0.9 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Upper hypanthium* flattened; 1.2 mm long, 2.9 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Base of receptacle, gynoecium and accessory tissue* ovary 1.2 mm long, 0.8 mm wide; distance from base of style to placenta 0.5 mm; style 2.4 mm long; stigma not expanded; stalked scales on style present. *Sepals* 0.7 mm long, 1.7 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Petals* elliptic, spatulate (not broadly); 1.2 mm long, 0.5 mm wide. *Disc* margin free; outer hairs considerably to

densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 1.9 mm long, anthers 0.5 mm long, 0.4 mm wide. *Fruit* (16 - ) 17.3 ( - 18.5) mm long, (15 - ) 16.9 ( - 18.8) mm wide; wing texture papyraceous; stipe (1 - ) 1.3 ( - 1.5) mm long; peg (0.6 - ) 0.7 ( - 0.8) mm long; wings golden to light-brown or golden-brown; body golden to light-brown or golden-brown; rhachis hairs moderately distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; wing hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; body hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; fruit outline elliptic or subcircular.

#### **Specimens examined**

- **1714** ( Ruacana Falls): island in Cunene River below Ruacana Falls ( - AC), *Rycroft 2415* (NBG).
- **1914** (Kamanjab): Usakos, Omumborombonga ( - CA), *Marloth 1264* (PRE, isotype of *C. primigenum* Marloth ex Engl.).
- **2126** (Tlada Mabeli): Orapa ( - AD), *Allen 231* (J).
- **2527** (Rustenberg): Pilansberg ( - AA), *Peeters, Gericke & Burelli 601* (J).
- **2632** (Bela Vista): Ndumu Game Reserve ( - CD), *Bodenstein 12* (NH); Ndumu Game Reserve, edge Nymathi Pan woodland, *Moll 5333* (NH); Ndumu Game Reserve, edge of Banzi Lake, *Ward 2011* (NH); woodland at edge of floodplain, Ndumu Game Reserve, *Ward 2316* (NH).

**3. *Combretum padoides* Engl. & Diels** in Engl., *Monographien afrikanischer Pflanzenfamilien und Gattungen* 3: 13 (1899); White: 284 (1962); Exell: 7 (1968); Exell: 170 (1970); Wickens: 17 (1973); Coates Palgrave: 673 (1977); Exell: 107 (1978); Carr: 17 (1988). Type: Mozambique, "Sambesi, Boroma", *Menyharth s.n.* (Z, lecto.; K).

*Combretum tenuipes* Engl. & Diels: 13 (1899); Dümmer: 182 (1913); Burt Davy: 246 (1926); Type: Transvaal, Louw's Creek near Barberton, *Galpin 885* (Z, holo.; BOL!, SAM).

*Branches* bark strips. *Leaves* opposite or subopposite; **petiole** 10 mm long, hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery

or golden, sometimes rust-brown or with rust-brown centres; **lamina** ovate-elliptic; 41.3 mm long, 22 mm wide; texture papyraceous; margin ciliate or sometimes ciliate; apex pointed-acuminate; base obtuse, rounded or cuneate; number of pairs of lateral veins 7; **adaxial** surface reticulation more or less plane; intersecondary veins recessed; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs moderately distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales sparsely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, 64  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, lamina exudate present; **abaxial** reticulation raised; intersecondary veins raised; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, 153  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale >50, number of radial walls in surface view >50, number of tangential walls in surface view >50. *Petals* linear-elliptic. *Disc* outer hairs considerably to densely distributed. *Fruit* 14.7 mm long, 11.5 mm wide; wing texture subcoriaceous; stipe 1 mm long; peg 0.4 mm long; wings golden to light-brown or golden-brown; body dark-brown or rust-brown; rhachis hairs considerably to densely distributed, scales obscured by hairs; wing hairs sparsely distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs moderately distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; body hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; fruit outline broadly elliptic.

#### **Specimens examined**

— **2531** (Komatipoort): Louw's Creek, Barberton ( - CC), *Galpin* 885 (BOL, isotype of *C. tenuipes* Eng. & Diels); Louw's Creek, *Thorncroft* 22210 (PRE).

## 2. Section *Angustimarginata* Engl. & Diels in Engler, H.G.A.

Monographieen afrikanischer Pflanzenfamilien und Gattungen 3: 25 (1899), [excl. *C. prunifolium* & *C. kirkii*]; Stace: 155 (1969); Exell: 173 (1970); Exell: 111 (1978).

*C. nelsonii* is omitted from the key because correctly identified inflorescences for this taxon have not been personally observed. According to scale structure (Tables A.7.1 and A.7.5; Plates 5.1 and 5.5), *C. nelsonii* is a synonym of *C. erythrophyllum*, but inflorescences are required for examination before confirmation.

Scales usually with 8 cells, delimited by 8 radial walls; fruit wings and body often moderately hairy; petals often emarginate; disc sometimes very narrow.....

.....5. *C. kraussii*

Scales with 9–16 cells, delimited by 9–16 radial walls; fruit wings and body usually sparsely hairy (except in *C. erythrophyllum* ssp. *vendae* where wings and body are moderately to considerably hairy); lamina exudate usually present.....

.....4. *C. erythrophyllum*

**4. *Combretum erythrophyllum* (Burch.) Sond.** in Linnaea 23: 43 (1850); Sond.: 509 (1862); Engl. & Diels: 26 (1899); Dümmer: 140 (1913); De Winter et al.: 120 (1966); Exell: 8 (1966); Exell: 7 (1968); Stace: 157 (1969); Exell: 173 (1970); Palmer & Pitman: 1631 (1973); Van Wyk: 422 (1974); Compton: 393 (1976); Coates Palgrave: 667 (1977); Exell: 112 (1978); Carr: 69 (1988). Type: Cape, “On the banks of the Ky-gariep”, (Griqualand West, Kalahari region, Herbert Division, right bank of the Vaal River at Blaauwbosch Drift), *Burchell 1749* (K, holo.; PRE!).

### (a) subsp. *erythrophyllum*

*Terminalia? erythrophylla* Burch.: 400 (1822).

*Combretum caffrum* (Eckl. & Zeyh.) Kuntze: Revisio generum plantarum vascularium 3(2): 87 (1898); Palmer & Pitman: 1636 (1973); Coates Palgrave: 664 (1977); Carr: 40 (1988). Syntypes: “Ad ripas fluminum Kat et Vischrivier (Albany), Sondagsrivier (Uitenhage), Keyskamma et Keyrivier (Caffraria)”, *Ecklon & Zeyher 421* (K, SAM!); “Ad ripam fluminum Zondagsrivier (Uitenhage)”, *Ecklon & Zeyher 776* (BM, K); “Zondagsrivier, Kommando Kraal”, *Zeyher 537* (SAM!).



[*C. caffrum* is considered here to be a synonym of *C. erythrophyllum* and not a distinct species because all taxonomically important characters used in species separation in the subgenus *Combretum* are similar for both these taxa (Table A.7.5; Plates 5.1 and 5.2)].

*Dodonaea caffra* Eckl. & Zeyh.: 55 (1834 -35). Type: *Ecklon & Zeyher 421* (K, SAM!).

*Dodonaea conglomerata* Eckl. & Zeyh.: 55 (1834 - 35). Type: “Inter frutices fluvii Katrivier prope Fort Beaufort Caffraria terminis” *Ecklon & Zeyher 422* (K, holo.; SAM!).

*Dodonaea dubia* Eckl. & Zeyh.: 55 (1834 - 35). Type: “In saltibus fluminis ostio Boeschmansrivier (Albany)”, *Ecklon & Zeyher 423* (holo. not traced; SAM!).

*Combretum salicifolium* E. Mey. ex Hook.: t.592 (1843); Sond.: 511 (1862); Sim: 222 (1907); Sim: 64 (1909); Dümmer: 182 (1913); Stace: 157 (1969). Type: “Sundays River”, *Burke 592* (K, holo.; BM).

*C. drègeanum* Presl: 73 (1844). Syntypes: “Klein Winterhoek between Zoutpansnek and Enon”, *Drège 6849* (BM, K, SAM); “Cap b. Spei”, *Drège s.n.* (BM, K).

*C. glomeruliferum* Sond.: 47 (1850); Sond.: 509 (1862); Engl. & Diels: 26 (1899); Burtt Davy: 247 (1926); Henkel: 32, 124 (1934); Codd: 130 (1951). Type: “Port Natal”, *Gueinzus s.n.* (K).

*C. riparium* Sond.: 47 (1850); Sond.: 511 (1862). Syntypes: “Macalisberg, Crocodile River”, *Burke 352* (BM, K, SAM); “On the Magalisriver”, *Zeyher 549* (BM, K, SAM).

*C. sonderi* Gerr. ex Sond.: 511 (1862). Type: “On the Nototi (sic) R., near Natal”, *Gerrard 138* (BM, holo.).

*C. erythrophyllum* (Burch.) Sond. var. *obscurum* Heurck & Mull. Arg.: 237 (1871). *C. glomeruliferum* Sond. var. *obscurum* (Heurck & Mull. Arg.) Burtt Davy: 37, 247 (1926). Type: “Africa australis , woods on Crocodileriver”, *Zeyher 550* (K, holo.).

*C. lydenburgianum* Engl. & Diels: 26 (1899). Type: Transvaal, “near the waterfall in the town of Lydenburg”, *Wilms* 212 (BM, K)

*C. woodii* Dümmer: 181 (1913); Burt Davy: 245 (1926); Palmer & Pitman: 1635 (1973); Van Wyk: 436 (1974); Compton: 395 (1976); Carr: 147 (1988). Syntypes: Natal, “in bush, Berea near Durban”, *Wood* 522 (BM); Transvaal, “Barberton, Kaap River valley, 2300 m”, *Galpin* 1176 (K, NH!, PRE!, SAM). [The syntype *Wood* 522 (BM), 1885, is labelled *C. erythrophyllum* by Wood].

[*C. woodii* is considered here to be a synonym of *C. erythrophyllum* and not a distinct species because all taxonomically important characters used in species separation in the subgenus *Combretum* are similar for both these taxa (Table A.7.5; Plates 5.1 and 5.3)].

Icon: Carr: t.4 (1988)

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (3.4 - ) 5.3 ( - 8.3) mm long, hairs moderately distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** narrowly-elliptic, sometimes obovate; (42.9 - ) 78.3 ( - 102.5) mm long, (9.8 - ) 21.8 ( - 38.6) mm wide; texture papyraceous; margin often down-rolled, entire; apex pointed-acuminate; base cuneate; number of pairs of lateral veins (6 - ) 7 ( - 10); **adaxial** surface reticulation recessed; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs moderately distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales considerable, mainly apart, silvery or golden; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (59 - ) 67.2 ( - 78)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (12 - ) 15 ( - 16), number of radial walls in surface view (12 - ) 14 ( - 16), number of tangential walls in surface view (12 - ) 15 ( - 16); lamina exudate present; **abaxial** reticulation raised; intersecondary veins more or less plane; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales considerable, mainly apart, silvery or golden; primary lateral vein scales considerably distributed to densely

distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (55 - ) 66 ( - 76)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (13 - ) 15 ( - 16), number of radial walls in surface view (13 - ) 15 ( - 16), number of tangential walls in surface view (13 - ) 15 ( - 16); lamina exudate present. *Inflorescence* spike, axillary, glutinous; rhachis hairs considerably to densely distributed; ratio of peduncle length to rhachis length (1.1 - ) 1.6 ( - 2.1). *Bracts* linear or lorate, (0.5 - ) 1.1 ( - 2) mm long. *Lower hypanthium* (1.6 - ) 2.1 ( - 2.5) mm long, (0.5 - ) 0.6 mm wide; outer hairs considerably to densely distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* cupuliform; (1.3 - ) 1.7 ( - 2) mm long, (2.4 - ) 3.3 ( - 4.1) mm wide; outer hairs sparsely distributed. *Base of receptacle, gynoecium and accessory tissue* ovary (0.7 - ) 0.9 ( - 1.1) mm long, (0.5 - ) 0.6 mm wide; distance from base of style to placenta (0.5 - ) 0.6 mm; style (3.8 - ) 3.9 mm long; stigma not expanded. *Sepals* (0.5 - ) 0.7 ( - 0.9) mm long, (0.8 - ) 1.4 ( - 1.9) mm wide; outer hairs sparsely distributed, outer scales considerable, mainly apart, silvery or golden; ciliate at apex, ciliate at margin; inner hairs considerably to densely distributed. *Petals* spatulate (not broadly); (1.1 - ) 1.2 ( - 1.3) mm long, (0.3 - ) 0.5 ( - 0.6) mm wide. *Disc* margin free; outer hairs considerably to densely distributed; inner hairs sparsely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments (3.8 - ) 4.9 ( - 6) mm long, anthers (0.8 - ) 0.9 ( - 1) mm long, 0.5 mm wide. *Fruit* (14 - ) 15.9 ( - 18.4) mm long, (9.2 - ) 14.1 ( - 18.8) mm wide; wing texture papyraceous; stipe (4.5 - ) 6.1 ( - 9.2) mm long; peg (0.4 - ) 0.9 ( - 1.4) mm long; wings golden to light-brown or golden-brown; body golden-brown to dark-brown or rust-brown; glutinous only on body; rhachis hairs considerably to densely distributed; wing hairs sparsely distributed, scales considerable, mainly apart, silvery or golden; stipe hairs moderately distributed, scales contiguous or overlapping, silvery or golden; body hairs sparsely distributed; fruit outline elliptic or subcircular.

#### **Specimens examined**

- **2529** (Witbank): Loskop Dam Nature Reserve, Middelburg ( - AD), *Mogg 17500* (J).
- **2531** (Komatipoort): Kaap River Valley, Barberton ( - CC), *Galpin 1176* (NH, PRE, isosyntypes of *C. woodii* Dümmer).
- **2628** (Johannesburg): on road island outside J.D. Carr's residence, "Aalwynkop", Sandton, Johannesburg ( - AA), *Rodman 114* (UDW).

- **2731** (Louwsburg): Ngotshe, Magut, Pongola Dam ( - CB), *Gerstner* 3173 (NH).
- **2732** (Ubombo): between Ingwavuma and Josini, Gwaliweni Forest ( - AC), *Balkwill* 690 (NU); Gwaliweni Forest, *Moll* 4465 (NH).
- **2821** (Upington): Albany ( - BC), *Ecklon & Zeyher* 423 (SAM, isotype of *Dodonaea dubia* Eckl. & Zeyh.).
- **2923** (Douglas): Cape, “On the banks of the Ky-gariep”, (Griqualand West, Kalahari region, Herbert Division, right bank of the Vaal River at Blaauwbosch Drift) ( - BA), *Burchell* 1749 (PRE, isotype).
- **2930** (Pietermaritzburg): farm Whitson ( - CC), *Strey* 8431 (NH); New Hanover Distr. Nagle Dam area ( - DA), *Ward* 4697 (NH).
- **3128** (Umtata): ± 4 km from the Umtata/Kokstad road, on road to Shawbury. Broken country near river bank of Tsitsa River ( - BB), *Van Wyk* 7129 (NH).
- **3226** (Fort Beaufort): Adelaide Distr., Koonah River ( - CB), *Meyer* 106 (NU); Fort Beaufort ( - DC), *Ecklon & Zeyher* 422 (SAM, isotype of *Dodonaea conglomerata* Eckl. & Zeyh.).
- **3228** (Butterworth): Willowvale, Qora River crossing 10 miles from sea ( - AD), *Wells* 3587 (PRE).
- **3325** (Port Elizabeth): Sundays River, Kommandokraal ( - AA), *Zeyher* 537 (SAM, syntype of *C. caffrum* (Eckl. & Zeyh.) Kuntze).
- **3327** (Peddie): East London, Horseshoe Valley ( - BB), *Smith* 3874 (PRE).
- **Eastern Cape**: no precise locality, *Ecklon & Zeyher* 421. Grid ref. unknown (SAM, isosyntype of *C. caffrum* (Eckl. & Zeyh.) Kuntze).

[*C. vendae* and *C. erythrophyllum* are regarded in this dissertation as subspecies rather than separate species because they are similar in many taxonomically important characters. Among these are (Table A.7.5): their inflorescences are in the form of spikes; upper hypanthium shapes are campanulate; sepals are ciliate; petals are non-ciliate, spatulate (not broadly); disc outer hairs are dense; scales (Plates 5.1 and 5.4) have diameters of 45–80 µm, 9–16 cells, 9–16 radial walls, 9–16 tangential walls, smooth or slightly scalloped outlines, and fruit lengths of 10–20 mm.

The differences between *C. vendae* and *C. erythrophyllum*, mainly in terms of hairiness of leaves and fruits, are thus not considered here to be sufficient to retain these taxa as separate species].

Leaf adaxial and abaxial lamina surfaces sparsely hairy, midribs sparsely to moderately hairy, primary lateral veins sparsely hairy; fruit wings and body sparsely hairy ..... subsp. *erythrophyllum*

Leaf adaxial lamina surface moderately hairy, abaxial lamina surface densely hairy, adaxial and abaxial midribs and primary lateral veins densely hairy; fruit wings and body moderately to considerably hairy ..... subsp. *vendae*

(b) subsp. *vendae* (Van Wyk) Rodman comb. & stat. nov. (ined.). Type: Transvaal, 2230 (Messina): Vuvuha north east of Thengwe, near the village Muledzhi ( - DA), Van Wyk 3913 (PRU, holo.; K, P, PRE!).

*Combretum vendae* Van Wyk in South African Journal of Botany 3,2: 125 (1984); Carr: 140 (1988). Type: Transvaal, 2230 (Messina): Vuvuha north east of Thengwe, near the village Muledzhi ( - DA), Van Wyk 3913 (PRU, holo.; K, P, PRE!).

#### Specimens examined

— 2230 (Messina): Ha-mabila ( - CB), Van Wyk 5676 (PRE); Thengwe ( - DA), Carr 200 (PRE); Thengwe, Vuvha, Van Wyk 3913 (PRE, isotype); along road to Nuanedi, Van Wyk 5635 (NH); Thengwe, Tsharokho, Van Wyk 5644 (NH); Vuvha, naby die dorpie Muledzhi, Van Wyk 5575 (PRE).

5. *Combretum kraussii* Hochst. in Flora 27: 424 (1844); Sond.: 510 (1862); Engl. & Diels: 28 (1899); Sim: 222 (1907); Sim: 63 (1909); Burt Davy: 246 (1926); Henkel: 123 (1934); Palmer & Pitman: 248 (1961); Exell: 7 (1968); Stace: 157 (1969); Exell: 175 (1970); Palmer & Pitman: 1633 (1973); Compton: 394 (1976); Coates Palgrave: 670 (1977); Exell: 114 (1978); Carr: 89 (1988). Type: "Port Natal, in sylvis primitivis circa Umlaas River", Krauss 353 (K, holo.; BM, OXF).

Icon: Carr: t.7 (1988).

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (5.3 - ) 5.6 ( - 5.8) mm long, hairs moderately distributed, scales considerable, mainly apart, silvery or golden; **lamina** elliptic, sometimes obovate; (50.5 - ) 70.2 ( - 101.8) mm long, (20.9 - ) 28.8 ( - 39.3) mm wide; texture papyraceous or subcoriaceous; margin often down-rolled, entire; apex bluntly-acuminate; base cuneate; number of pairs of lateral veins 7 ( - 8); **adaxial** surface reticulation recessed; lamina island hairs sparsely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden to dark-grey or black; midrib scales

considerable, mainly apart, silvery or golden to dark-grey or black; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, number of cells per scale 8, number of radial walls in surface view 8, number of tangential walls in surface view 8; **abaxial** reticulation raised; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs moderately distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (63 - ) 71 ( - 79)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale 8, number of radial walls in surface view 8, number of tangential walls in surface view 8. *Inflorescence* spike, elongated, axillary, glutinous; scales apart to contiguous or overlapping, silvery or golden; ratio of peduncle length to rhachis length 0.7. *Bracts* linear or lorate, (0.7 - ) 0.9 ( - 1) mm long. *Lower hypanthium* 2.1 mm long, 0.6 mm wide; outer hairs considerably to densely distributed, outer scales apart to contiguous or overlapping, silvery or golden. *Upper hypanthium* cupuliform; 1.6 mm long, 3.5 mm wide; outer hairs sparsely distributed, outer scales considerable, mainly apart, silvery or golden. *Base of receptacle, gynoecium and accessory tissue* ovary 1 mm long, 0.6 mm wide; distance from base of style to placenta 0.5 mm; style 3.8 mm long; stigma not expanded. *Sepals* 0.7 mm long, 1.6 mm wide; outer hairs sparsely distributed, outer scales considerable, mainly apart, silvery or golden; ciliate at apex, ciliate at margin; inner hairs considerably to densely distributed. *Petals* spatulate (not broadly), often emarginate; 1.2 mm long, 0.4 mm wide. *Disc* margin free; outer hairs considerably to densely distributed, inner hairs sparsely distributed. *Stamens* inserted above disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 4.7 mm long, anthers 0.9 mm long, 0.4 mm wide. *Fruit* (14.3 - ) 15.0 ( - 15.6) mm long, (14.3 - ) 14.8 ( - 15.3) mm wide; wing texture papyraceous; stipe (3.5 - ) 4.0 ( - 4.5) mm long; peg (0.4 - ) 0.7 ( - 0.9) mm long; glutinous only on body; rhachis hairs considerably to densely distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; wing hairs moderately distributed; stipe hairs moderately distributed, scales apart to contiguous or overlapping, silvery or golden; body hairs moderately distributed; fruit outline elliptic or subcircular.

### Specimens examined

- **2632** (Bela Vista): 12 miles from Ingwavuma/Maputa road on way to Manyanseni ( - CC), *Moll 4566* (NH).
- **2732** (Louwsburg): Ngome, at forester's garage ( - CD), *Strey 9436* (NH).
- **2930** (Pietermaritzburg): Umgeni River Valley, north slopes, Inanda Distr. ( - DB), *Strey 4832* (NH).
- **2931** (Stanger): Burman Bush, Durban Distr. ( - CC), *Bourquin 59* (UDW); Stainbank Nature Reserve, Durban, *Campbell 234* (NH).
- **3030** (Port Shepstone): Nongwane Falls, 3,2 km south of Umbumbulu ( - BB), *Moll 4945* (NH).
- **3228** (Butterworth): Harefield area, c. 45 km north east of East London (on Transkei Road) ( - CA), *Ward 9371* (UDW).

**6. *Combretum nelsonii* Dümmer** in The Gardeners' Chronicle Ser. 3: 164 (1913); Burt Davy: 246 (1926); Stace: 157 (1969). Type: Transvaal, "in mountain gorge near Groote Vley, Pinnaars River", *Nelson 91* ( K, holo.; PRE!).

Icon: Carr: t.12 (1988).

Only characters from the isotype, *Nelson 91*, have been examined owing to incorrectly labelled specimens and time restraints.

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** 2.7 mm long, hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** elliptic or obovate-elliptic; 56.3 mm long, 30 mm wide; texture subcoriaceous; margin entire; apex bluntly-acuminate, acute or retuse; base obtuse, rounded or cuneate; number of pairs of lateral veins 6; **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed; scales disc- or bowl-shaped, 76 µm diameter, smooth to slightly scalloped in outline, number of cells per scale 16, number of radial walls in surface view 16, number of tangential walls in surface view 16; lamina exudate present; **abaxial** reticulation raised;

intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales, apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; lamina scales sometimes impressed; scales disc- or bowl-shaped, 73 µm diameter, smooth to slightly scalloped in outline, number of cells per scale 16, number of radial walls in surface view 16, number of tangential walls in surface view 16; lamina exudate present.

#### Specimens examined

— 2528 (Pretoria): “in mountain gorge near Groote Vley, Pinnaars River” ( - AD/CD), *Nelson 91* (PRE, isotype).

### 3. Section *Macrostigmatea* Engl. & Diels in Engler, H.G.A.,

Monographien afrikanischer Pflanzenfamilien und Gattungen 3: 24 (1899); Stace: 159 (1969); Exell: 176 (1970); Wickens: 21 (1973); Exell: 115 (1978).

[Wickens (1973) suggested that *C. engleri* Schinz is conspecific with *C. schumannii* Engl. Exell (1970) keeps these two species separate, but groups them together in *Flora Zambesiaca* (1978). In this study, not enough material from a full range of taxa were seen and *C. engleri* Schinz has therefore been retained as a separate species].

**7. *Combretum engleri* Schinz** apud De Wild. & Dur. in Bulletin de l’Herbier Boissier, Sér. 2,1: 878 (1901); Stace: 14 (1961); Exell: 8 (1966); Exell: 7 (1968); Exell: 176 (1970); Stace: 159 (1969); Palmer & Pitman: 1645 (1973); Van Wyk: 419 (1974); Coates Palgrave: 666 (1977); Carr: 66 (1988). Type: Namibia, Ombalambuenge, *Rautanen 206* (type not traced).

*Combretum myrtillifolium* Engl.: 695 (1921). Syntypes: Namibia, Neitsas, *Dinter 668* (type not traced); “Südwest Afrika, Neitsas, Dunen”, *Dinter 7278* (BOL, K).

[*C. parvifolium* Dinter: 170 (1919) non Engl. (1895)].



*Branches* often with nodal pairs of lateral branches; bark flakes and strips. *Leaves* usually opposite, sometimes 3-verticillate; **petiole** (2.3 - ) 2.4 ( - 2.5) mm long, hairs considerably to densely distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** elliptic, slightly obovate; (22 - ) 24.5 ( - 27) mm long, (9.7 - ) 12.6 ( - 15.5) mm wide; texture papyraceous; margin ciliate or sometimes ciliate; apex bluntly-acuminate; base obtuse or rounded; number of pairs of lateral veins 4 ( - 5); **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; bullae in axils along midrib and/or in axils of lateral veins, sparsely distributed; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs moderately distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales apart to contiguous or overlapping, silvery or golden; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (59 - ) 63.7 ( - 71)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, lamina exudate present; **abaxial** reticulation raised; intersecondary veins more or less plane; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs moderately distributed; primary lateral vein hairs sparsely distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (60 - ) 64.3 ( - 71)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (11 - ) 12, number of radial walls in surface view 9, number of tangential walls in surface view (11 - ) 12; lamina exudate present. *Inflorescence* spike, subcapitate, axillary; rhachis hairs moderately distributed, scales contiguous or overlapping, silvery or golden; ratio of peduncle length to rhachis length 0.1. *Bracts* obovate/club-shaped, 0.8 mm long. *Lower hypanthium* 0.6 mm long, 0.4 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* campanulate or cupuliform; 0.8 mm long, 2.2 mm wide; outer scales contiguous or overlapping, silvery or golden. *Base of receptacle, gynoecium and accessory tissue* ovary 0.4 mm long, 0.4 mm wide; distance from base of style to placenta 0.3 mm; style 3 mm long;

stigma slightly expanded. *Sepals* 0.4 mm long, 0.9 mm wide; outer scales contiguous or overlapping, silvery or golden. *Petals* spatulate (not broadly); 1.6 mm long, 0.8 mm wide. *Disc* margin free; outer hairs considerably to densely distributed; conspicuously notched for insertion of filaments. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 3 mm long, anthers 0.5 mm long, 0.4 mm wide. *Fruit* (18.8 - ) 20.2 ( - 21.7) mm long, (19 - ) 22.6 ( - 25.2) mm wide; wing texture papyraceous; stipe (6.7 - ) 7.5 ( - 8.2) mm long; wings golden to light-brown or golden-brown; body golden to light-brown or golden-brown; glutinous only on body; rhachis hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden; wing hairs sparsely distributed, scales considerable, mainly apart, silvery or golden; stipe hairs sparsely distributed, silvery or golden; body hairs sparsely distributed, scales obscured by glutinous secretion; fruit outline elliptic or subcircular.

#### **Specimens examined**

- **1714** (Ruacana Falls): 8 meilen südlich Otjehua, Kaokoveld ( - CA), *Giess & Leippert 7581a* (NBG).
- **1716** (Enana): south of airstrip at Eenhana ( - AD), *Roux 151* (NBG).
- **1719** (Runtu): Runtu, near Okavango River, Okavango N. Reserve ( - DD), *Maguire 1597* (NBG).
- **1821** (Andara): slopes of Mt. Female, Tsodilo Hills, Ngamiland ( - DB), *Banks 31* (PRE).
- **1822** (Kangara): near Netsameumo Cliffs ( - AC), *Smith 2872* (PRE, photo.).
- **1824** (Kachikau): Serondela, Chobe Distr. ( - BC), *Miller B/1199* (PRE).

**4. Section *Metallicum*** *Exell & Stace* in *Boletim da Sociedade Broteriana Sér. 2, 42: 22* (1968); *Stace: 145* (1969); *Exell: 179* (1970); *Wickens: 23* (1973); *Exell: 117* (1978).

[Syn.: sect. *Glabripetala* Engl. & Diels: 43 (1899), pro parte].

**8. *Combretum collinum*** *Fresen.* in *Museum Senckenbergianum 2: 153* (1837); Engl.: 56 (1895); Engl. & Diels: 56 (1899); Okafor: 137 (1967); Exell: 8, 10 (1968); Stace: 145 (1969); Exell: 179 (1970); Palmer & Pitman: 1641 (1973); Wickens: 24 (1973); Van Wyk: 431 (1974); Coates Palgrave: 665 (1977); Exell: 117 (1978); Carr: 49 (1988). Type: Ethiopia, Begemedder, near Gondar, Kulla, *Rueppell s.n.* (FR, holo.)

Hairs considerably to densely distributed on abaxial lamina surface; fruit wings and body sparsely hairy ..... a. subsp. *coriaceum*

Hairs sparsely to moderately distributed on abaxial lamina surface:

Fruit wings and body considerably hairy ..... c. subsp. *suluense*

Fruit wings and body sparsely hairy:

Hairy pockets in abaxial axils of midrib and primary lateral veins absent; leaves often less than 80 mm long in average ..... b. subsp. *ondongense*

Hairy pockets in abaxial axils of midrib and primary lateral veins; leaves usually more than 80 mm long in average.....d. subsp. *taborense*

[key based on that by Okafor (1967)]

(a) subsp. *coriaceum* (Schinz) Rodman (ined.). Syntypes: Namibia, Kalahari, *Fleck 421a* (K); Namibia, Ngamigebiet, 1888, *Fleck 422a* (K, Z).

*Combretum coriaceum* Schinz in Verhandlungen Botanischen Vereins der Provinz Brandenburg 30: 247 (1888). Syntypes: Namibia, Kalahari, *Fleck 421a* (K); Namibia, Ngamigebiet, 1888, *Fleck 422a* (K, Z).

*C. bajonense* Sim: 63, t.63 (1909). Type: Mozambique, Magenja da Costa, 1908, *Sim 5715* (renumbered as *20901*) (PRE, holo.!, NU).

*C. gazense* Swynn. & Bak.f.: 68 (1911); Codd: 129 (1951). Type: Mozambique, Gazaland, Mount Umtereni, *Swynnerton 587* (BM, holo.; K).

*C. mechowianum* O. Hoffm. subsp. *gazense* (Swynn. & Bak.f.) Duvign.: 81, t.8, c–d (1956). Type: Mozambique, Gazaland, Mount Umtereni, *Swynnerton 587* (BM, holo.; K).

*C. collinum* Fresen. subsp. *gazense* (Swynn. & Bak.f.) Okafor: 145 (1967); Exell: 182 (1970); Palmer & Pitman: 1642 (1973); Wickens: 27 (1973); Van Wyk: 431 (1974); Coates Palgrave: 665 (1977); Exell: 120 (1978); Carr: 51 (1988).

*C. mechowianum* auctt. non O. Hoffm.: 131 (1880—1882), pro parte.

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (7.2 - ) 9 ( - 10.8) mm long, hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; **lamina** broadly-elliptic, slightly obovate; (75 - ) 96.5 ( - 118) mm long, (37 - ) 47 ( - 57) mm wide; texture

subcoriaceous; margin ciliate or sometimes ciliate; number of pairs of lateral veins 9; **adaxial** surface reticulation with midrib raised, primary lateral veins more or less plane; intersecondary veins more or less plane; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; primary lateral vein hairs moderately distributed; hair concentration in axils of midrib and primary lateral veins sparse; scales distributed throughout surface; lamina island scales apart to contiguous or overlapping, midrib scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; lamina scales sometimes impressed, lamina exudate present; **abaxial** reticulation raised; intersecondary veins raised; hair distribution throughout surface; lamina island hairs considerably to densely distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs considerably to densely distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales obscured by hairs, primary lateral vein scales obscured by hairs; scales disc- or bowl-shaped, (97 - ) 105.5 ( - 114)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale  $\pm 30$ , number of radial walls in surface view  $\pm 30$ , number of tangential walls in surface view  $\pm 30$ . *Inflorescence* panicle or spike, axillary; rhachis hairs considerably to densely distributed, scales obscured by hairs, ratio of peduncle length to rhachis length 0.2. *Bracts* oblong or rectangular, 1 mm long. *Lower hypanthium* 2.9 mm long, 1 mm wide; outer hairs considerably to densely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Upper hypanthium* campanulate; 3 mm long, 4.5 mm wide; outer hairs considerably to densely distributed, outer scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Base of receptacle, gynoecium and accessory tissue* ovary 1.3 mm long, 1 mm wide; distance from base of style to placenta 0.7 mm; style 5.1 mm long; stigma not expanded. *Sepals* 1 mm long, 2.2 mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; ciliate at apex, ciliate at margin; inner hairs moderately distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres. *Petals* broadly spatulate; 1.9 mm long, 1.7 mm wide. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 5.8 mm long, anthers 0.8 mm long, 0.6 mm wide. *Fruit* (36.3 - ) 36.7 ( - 37) mm long, (37 - ) 37.5 ( - 38) mm wide; wing texture

subcoriaceous; stipe (5 - ) 5.9 ( - 6.8) mm long; wing hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; body hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; fruit outline elliptic or subcircular.

#### Specimens examined

— **2017** (Waterberg): Waterberg, Otjuvarongo ( - AC), *Keet 15521* (PRE).

— **Namibia**: no precise locality, Okavango River, *Keet 1646*. Grid ref. unknown (PRE).

— **Mozambique**: no precise locality, Magenja da Costa, *Sim 5715* (renumbered as *20901*). Grid ref. unknown (PRE, holotype; NU, isotype).

(b) **subsp. ondongense** (*Engl. & Diels*) *Okafor* in Boletim da Sociedade Broteriana, Sér. 2, 41: 146 (1967); Palmer & Pitman: 1643 (1973); Exell: 120 (1978); Carr: 50 (1988). Type: Namibia, “Amboland zwischen Ondonga und Unkussyama”, *Rautanen 234* (HBG, holo.; BM, K).

*Combretum ondongense* Engl. & Diels : 56 (1899). Type: Namibia, “Amboland zwischen Ondonga und Unkussyama”, *Rautanen 234* (HBG, holo.; BM, K).

*C. mechowianum* auctt. non O. Hoffm.: 131 (1880—1882), pro parte.

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (9.7 - ) 10.5 ( - 11.7) mm long, hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** elliptic, slightly obovate; (59 - ) 68.1 ( - 77.2) mm long, (23 - ) 29.7 ( - 36.3) mm wide; texture subcoriaceous; margin entire; apex bluntly-acuminate; base obtuse or rounded; number of pairs of lateral veins 9; **adaxial** surface reticulation raised; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, 159 µm diameter,

conspicuously scalloped in outline, number of cells per scale  $\pm 50$ , number of radial walls in surface view  $\pm 50$ , number of tangential walls in surface view  $\pm 50$ ; lamina exudate present; **abaxial** reticulation raised; intersecondary veins more or less plane; hair distribution along midrib and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; scale distribution throughout surface; lamina island scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (122 - ) 147.3 ( - 176)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale  $\pm 50$ , number of radial walls in surface view  $\pm 50$ , number of tangential walls in surface view  $\pm 50$ . *Inflorescence* spike, elongated, axillary; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; ratio of peduncle length to rhachis length 0.6. *Bracts* oblong or rectangular, 1.2 mm long. *Lower hypanthium* 2.4 mm long, 0.9 mm wide; outer hairs moderately distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* cupuliform; 2.2 mm long, 3 mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden. *Base of receptacle, gynoecium and accessory tissue* ovary 1.3 mm long, 0.9 mm wide; distance from base of style to placenta 0.7 mm; style 3.7 mm long; stigma not expanded. *Sepals* 0.9 mm long, 1.3 mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden; ciliate at apex, ciliate at margin; inner hairs moderately distributed, inner scales apart to contiguous or overlapping, silvery or golden. *Petals* broadly spathulate; 1.7 mm long, 1.9 mm wide. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 4.6 mm long, anthers 0.8 mm long, 0.8 mm wide. *Fruit* (34.5 - ) 35.6 ( - 36.2) mm long, (29.3 - ) 33.1 ( - 38) mm wide; wing texture subcoriaceous; stipe (6.5 - ) 7.5 ( - 8) mm long; wings golden to light-brown or golden-brown; body dark-brown or rust-brown; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; wing hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; body hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; fruit outline broadly elliptic.

### Specimens examined

- **1714** (Ruacana Falls): Ruacana, flats south to south west of the airport ( - AD), *Leistner, Oliver, Steenkamp & Vorster* 39 (PRE).
- **1715** (Unuangua): 5 miles east of Oshikango near Ondipa Mission Station ( - BD), *De Winter & Giess* 7000 (PRE).
- **2027** (Plumtree) to **2127** (Francistown): Francistown to Bosoli, *Pole Evans* 3236(34). Grid ref. unknown (PRE).

(c) **subsp. *suluense*** (*Engl. & Diels*) *Okafor* in Boletim da Sociedade Broteriana, Sér. 2, 41: 143 (1967); Exell: 182 (1970); Palmer & Pitman: 1641 (1973); Wickens: 28 (1973); Van Wyk: 434 (1974); Compton: 393 (1976); Coates Palgrave: 665 (1977); Exell: 120 (1978); Carr: 51 (1988). Type: Swaziland, hillslope, Horo Mine, *Galpin* 1264 (Z, holo.; BOL, K, NH!, PRE!, SAM).

[It is unclear why Okafor, 1967, designated the name *suluense* rather than older names].

*Combretum suluense* Engl. & Diels: 54 (1899); Dümmer: 183 (1913); Burt Davy: 248 (1926); Henkel: 124 (1934); Codd: 132 (1951). Type: Swaziland, hillslope, Horo Mine, *Galpin* 1264 (Z, holo.; BOL, K, NH!, PRE!, SAM).

*C. schinzii* Engl. ex Engl. & Diels: 54, t.17B, a–d (1898). Type: Namibia, Onkumbi, *Schinz* 1051 (B, holo.†; Z).

*C. junodii* Dümmer: 183 (1913). Type: Transvaal, hills, Shilouvane, *Junod* 613 (K).

*C. griseiflorum* S. Moore: 227 (1921). Type: Transvaal, Nelspruit, *Breyer s.n.* sub *Rogers* 24018 (BM, holo.).

*C. millerianum* Burt Davy: 279 (1921). Type: Swaziland, Buckham's to Forbes' Coal Mine (plentiful on Lebombo Flats), *Burt Davy* 10681 (BOL, holo; K).

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (12.8 - ) 17.2 ( - 24.2) mm long, hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; **lamina** elliptic, slightly obovate; (74.3 - ) 107.2 ( - 158.9) mm long, (31 - ) 38.2 ( - 50.7) mm wide; texture subcoriaceous; margin ciliate or sometimes ciliate; base oblique, subcordate or rounded; number of pairs of lateral veins (7 - ) 9 ( - 11); **adaxial** intersecondary veins

more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs moderately distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs moderately distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales apart to contiguous or overlapping, silvery or golden; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (109 - ) 110.5 ( - 112)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale (26 - ) 28 ( - 30), number of radial walls in surface view (24 - ) 27 ( - 30), number of tangential walls in surface view (29 - ) 30; lamina exudate present; **abaxial** reticulation raised; intersecondary veins raised; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; midrib hairs considerably to densely distributed; primary lateral vein hairs considerably to densely distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales contiguous or overlapping, silvery or golden; midrib scales, apart to contiguous or overlapping, silvery or golden; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (125 - ) 142 ( - 159)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale  $\pm 40$ , number of radial walls in surface view  $\pm 40$ , number of tangential walls in surface view  $\pm 40$ ; lamina exudate present. *Inflorescence* spike, elongated, axillary; rhachis hairs considerably to densely distributed, scales obscured by hairs; ratio of peduncle length to rhachis length 0.5. *Bracts* linear or lorate, 1.2 mm long. *Lower hypanthium* 3.1 mm long, 0.9 mm wide; outer hairs considerably to densely distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* campanulate; 2.7 mm long, 3.4 mm wide; outer hairs moderately distributed, outer scales considerable, mainly apart, silvery or golden. *Base of receptacle, gynoecium and accessory tissue* ovary 1.3 mm long, 0.9 mm wide; distance from base of style to placenta 1.3 mm; style 4.2 mm long; stigma not expanded. *Sepals* 0.8 mm long, 1.9 mm wide; outer hairs moderately distributed, outer scales considerable, mainly apart, silvery or golden; ciliate at apex, ciliate at margin; inner hairs moderately distributed. *Petals* broadly spatulate; 1.3 mm long, 1.7 mm wide. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 3.4 mm long, anthers 0.8 mm long, 0.6 mm wide. *Fruit* (31.4 - ) 35.5 ( - 39.3) mm long, (10.2 - ) 26.6 ( - 41) mm wide; wing texture subcoriaceous; stipe (2.3 - ) 10.4 ( - 19.3) mm long; peg (0.5 - ) 0.7 ( - 1) mm long; wings dark-brown or rust-brown; body dark-brown or rust-brown; glutinous only on



body; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; wing hairs considerably to densely distributed, scales apart to contiguous or overlapping, stipe hairs moderately distributed, scales contiguous or overlapping; body hairs moderately distributed, scales contiguous or overlapping; fruit outline elliptic or subcircular.

#### Specimens examined

- 1714 (Ruacana Falls): Kaokoveld, “Felshang des Berges südlich Ruacana” ( - AC), *Giess & Leippert* 7604 (NBG).
- 2330 (Tzaneen): Duiwelskloof, Letaba ( - CA), *Scheepers* 1133 (NH).
- 2331 (Phalaborwa): De Hoop Misson Station near Sumsane (sic) Post Office ( - DD?), *Greenwood* 12 (NU).
- 2531 (Komatipoort): Horo Mine ( - CB), *Galpin* 1264 (NH, PRE, isotypes); Kaapmuiden, *Thorncroft* 852 (NH).
- 2631 (Mbabane): George Wallis Bridge, Manzini ( - AD), *Compton* 28993 (NH).

(d) **subsp. taborense** (*Engl.*) *Okafor* in Boletim da Sociedade Broteriana, Sér. 2, 41: 144 (1967); Exell: 182 (1970); Palmer & Pitman: 1642 (1973); Wickens: 26 (1973); Exell: 120 (1978); Carr: 51 (1988). Type: Tanzania, Tabora, *Stuhlmann* 506 (B, holo.†).

*Combretum taborense* Engl.: 290 (1895). Type: Tanzania, Tabora, *Stuhlmann* 506 (B, holo.†).

*C. mechowianum* O. Hoffm. subsp. *taborense* (*Engl.*) Duvign.: 80 (1956).

*C. mechowianum* auct. non. O. Hoffm.: 131 (1880—1882), pro parte.

*Branches* bark flakes and strips. *Branchlets* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (11 - ) 11.4 ( - 11.7) mm long, hairs moderately distributed, scales sparsely distributed, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** broadly-elliptic; (79.3 - ) 92.7 ( - 106) mm long, (39 - ) 41.3 ( - 43.5) mm wide; texture subcoriaceous; margin entire; apex pointed-acuminate; base obtuse or rounded; number of pairs of lateral veins 12; **adaxial** surface reticulation raised; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart,

silvery or golden to dark-grey or black; midrib scales considerable, mainly apart, silvery or golden to dark-grey or black; primary lateral vein scales sparsely distributed; lamina scales sometimes impressed, **abaxial** reticulation raised; intersecondary veins raised; lamina island hairs sparsely distributed; midrib hairs moderately distributed; tufts of hairs in axils of midrib and primary lateral veins; scale distribution throughout surface; lamina island scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales sparsely distributed, silvery or golden to dark-grey or black; scales disc- or bowl-shaped, (168 - ) 168.5 ( - 169)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale  $\pm 40$ , number of radial walls in surface view  $\pm 40$ , number of tangential walls in surface view  $\pm 40$ . *Inflorescence* panicle or spike, axillary, glutinous; rhachis hairs considerably to densely distributed, scales obscured by hairs; ratio of peduncle length to rhachis length 0.4. *Bracts* oblong or rectangular, 0.9 mm long. *Lower hypanthium* 3.3 mm long, 1.1 mm wide; outer hairs considerably to densely distributed, outer scales obscured by hairs. *Upper hypanthium* campanulate; 2.3 mm long, 4.1 mm wide; outer hairs considerably to densely distributed, outer scales obscured by hairs. *Base of receptacle, gynoecium and accessory tissue* ovary 1.3 mm long, 1.1 mm wide; distance from base of style to placenta 1.4 mm; style 4.7 mm long; stigma not expanded. *Sepals* 1.2 mm long, 2 mm wide; outer hairs moderately distributed, outer scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; ciliate at apex, ciliate at margin; inner hairs moderately distributed. *Petals* broadly spatulate; 1.5 mm long, 1.4 mm wide. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 4.6 mm long, anthers 1.1 mm long, 0.7 mm wide. *Fruit* (38 - ) 39 ( - 40) mm long, (35 - ) 35.8 ( - 36.5) mm wide; wing texture subcoriaceous; stipe (6 - ) 8.5 ( - 11) mm long; wings golden-brown to dark-brown or rust-brown; body dark-brown or rust-brown; glutinous on body and wings; rhachis hairs considerably to densely distributed, scales obscured by hairs; wing hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs moderately distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; body hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; fruit outline elliptic or subcircular.

#### Specimens examined

- **0831, ZAMBIA:** Mpulungu to Abercorn, *Greenway 6197*. Grid ref. unknown (PRE).  
— **1723** (Singalamwe): Kasungu, Kasungu Distr. ( - DD), *Brass 17443* (PRE).

**5. Section *Spathulipetala*** Engl. & Diels in Engler, H.G.A., *Monographien afrikanischer Pflanzenfamilien und Gattungen* 3: 58 (1899); Stace: 158 (1969); Exell: 185 (1970); Wickens: 31 (1973); Exell: 122 (1978).

**9. *Combretum zeyheri*** Sond. in *Linnaea* 23: 46 (1850); Sond.: 510 (1862); Engl. & Diels: 59 (1899); Sim: 63 (1909); Dümmer: 116 (1913); Burt Davy: 248 (1926); Henkel: 123 (1934); Codd: 133 (1951); Codd: t.1230 (1956); Palmer & Pitman: 249 (1961); Stace: 14 (1961); White: 285 (1962); De Winter et al.: 124 (1966); Exell: 11 (1966); Exell: 8 (1968); Stace: 158 (1969); Exell: 185 (1970); Palmer & Pitman: 1627 (1973); Wickens: 31 (1973); Van Wyk: 438 (1974); Compton: 395 (1976); Coates Palgrave: 676 (1977); Exell: 122 (1978); Carr: 151 (1988). Type: “Africa australis, in silvis mont. Macalisberg”, *Zeyher 552* (TCD, holo.; BM, K, MEL, SAM!, Z).

*Combretum odontopetalum* Engl. & Diels: 60 (1899). Type: Namibia, “Amboland, Unkuanyama”, *Wulffhorst 14* (B, holo.†; K).

*C. calocarpum* Gilg. ex Dinter: 169 (1919). Syntypes: Namibia, “Hereroland, Neitsas”, *Dinter 795* (BM); Otjit-jika, *Dinter 2877* (type not traced); Tsumeb, *Dinter s.n.* (type not traced); “Grootfontein, Ambo in Nord Hereroland”, *Engler 6297* (K).

*C. mkuzense* Carr & Retief in *Bothalia* 19: 38 (1989). Type: Natal, 2732 (Ubombo): Mkuze Game Reserve headquarters ( - CA), *Carr 187* (PRE, holo.! ; K).

[*C. mkuzense* is considered here to be a synonym of *C. zeyheri* and not a distinct species because most taxonomically important characters used in species separation in the subgenus *Combretum* are similar for both these taxa (Table A.7.6; Plates 7.1 and 7.2). The slight differences in scale size and cell number (*C. mkuzense* scales are slightly larger and contain slightly more cells than those of *C. zeyheri*) are not considered sufficient to maintain *C. mkuzense* as a separate species].

*Combretum* sp. nov. Carr: 155 (1988).

[*Combretum xanthothyrsus* auct. non Engl. & Diels: Coates Palgrave: 675 (1977)].

Icones: Codd: t.1230 (1956); Exell: t.33 (1978); Carr: t.1 (1988).

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (5 - ) 8.2 ( - 12) mm long, hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; **lamina** oblong-elliptic, slightly obovate; (45 - ) 66.7 ( - 100) mm long, (25 - ) 35.2 ( - 52.7) mm wide; texture subcoriaceous; margin ciliate or sometimes ciliate; apex bluntly-acuminate, rounded or obtuse; base obtuse or rounded; number of pairs of lateral veins (7 - ) 8 ( - 10); **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; bullae in axils along midrib and/or in axils of lateral veins, commonly occurring; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales considerable, mainly apart, silvery or golden; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (57 - ) 67.3 ( - 83)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (12 - ) 15 ( - 16), number of radial walls in surface view (9 - ) 10 ( - 11), number of tangential walls in surface view (12 - ) 15 ( - 18); lamina exudate present; **abaxial** reticulation raised; intersecondary veins more or less plane; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs moderately distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales considerable, mainly apart, silvery or golden; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (60 - ) 71.5 ( - 82)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (12 - ) 16 ( - 19), number of radial walls in surface view (8 - ) 9 ( - 10), number of tangential walls in surface view (12 - ) 17 ( - 20). *Inflorescence* spike, elongated, axillary; rhachis hairs considerably to densely distributed, scales obscured by hairs, scales contiguous or overlapping, silvery or golden; ratio of peduncle length to rhachis length (0.2 - ) 0.4 ( - 0.6). *Bracts* linear to obovate, (0.6 - ) 0.8 ( - 0.9) mm long. *Lower hypanthium* (2.5 - ) 2.8 ( - 3.3) mm long, (0.7 - ) 1.0 ( - 1.2) mm wide;

outer hairs considerably to densely distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* campanulate; (1.8 - ) 2.2 ( - 2.7) mm long, (3 - ) 3.5 ( - 3.8) mm wide; outer hairs moderately distributed, outer scales considerable, mainly apart, silvery or golden. *Base of receptacle, gynoecium and accessory tissue* ovary (1.3 - ) 1.6 ( - 1.9) mm long, (0.7 - ) 1.0 ( - 1.2) mm wide; distance from base of style to placenta (0.5 - ) 0.7 ( - 0.8) mm; style (5.2 - ) 5.7 ( - 6.1) mm long; stigma slightly expanded. *Sepals* (0.6 - ) 0.9 ( - 1.3) mm long, (1.3 - ) 1.5 ( - 1.6) mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden; ciliate at apex, ciliate at margin; inner hairs considerably to densely distributed. *Petals* spatulate (not broadly); (1.5 - ) 1.8 ( - 2.3) mm long, (0.6 - ) 0.7 ( - 0.9) mm wide; outer scales present, mainly apart. *Disc* margin free; outer hairs considerably to densely distributed, inner hairs considerably to densely distributed; conspicuously notched for insertion of filaments. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments (5.4 - ) 5.6 ( - 5.7) mm long, anthers (1 - ) 1.1 mm long, 0.7 mm wide. *Fruit* (29 - ) 40.6 ( - 61) mm long, (33 - ) 47.6 ( - 62.3) mm wide; wing texture subcoriaceous; stipe (3.5 - ) 7.9 ( - 11) mm long; peg (1 - ) 1.3 ( - 1.5) mm long; wings golden to light-brown or golden-brown; body dark-brown or rust-brown; glutinous only on body; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; wing hairs sparsely distributed, scales considerable, mainly apart, silvery or golden; stipe hairs moderately distributed, scales apart to contiguous or overlapping, silvery or golden; body hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden; fruit outline elliptic or subcircular.

#### **Specimens examined**

- 2527 (Rustenberg): “Macalisberg” ( - DA/DB), Zeyher 552 (SAM, isotype).
- 2632 (Bela Vista): Ndumu Hill, Ndumu Game Reserve ( - CD), Pooley 479 (NU); Mkonyane, Ndumu Game Reserve, Pooley 676 (NH).
- 2732 (Ubombo): Ingwavuma Hills ( - AA), Strey 8170 (NH); 4 miles south of Ingwavuma, Ward 2048; Ingwavuma Distr., Ward 3165 (NH); Ingwavuma ( - AC), Ward 5661 (NH, UDW); Mkuze Game Reserve (African staff quarters area) ( - CA), Carr 187 (PRE, holotype of *C. mkuzense* Carr & Retief); Mkuze Game Reserve, Msinga Sand Forest, White 10388 (PRE); Mkuze Game Reserve ( - CA/CB), Ward 3568 (PRE); east side of farm “Shotton 13810” ( - CD), Ward 8793 (PRE).

**6. Section Ciliatipetala** Engl. & Diels in Engler, H.G.A., Monographien afrikanischer Pflanzenfamilien und Gattungen 3: 32 (1899) [Ciliatipetalae excl. *C. fulvotomentosum*]; Stace: 149 (1969); Exell: 187 (1970); Wickens: 32 (1973); Exell: 125 (1978).

*C. moggii*, *C. petrophilum*, *C. psidioides* ssp. *psidioides* and *C. psidioides* ssp. *dinteri* are not included in the key because most characters for these taxa were not examined owing to time restraints.

The scale characters in this section are more heterogeneous than in other sections.

Scales usually glistening; leaves often obovate-elliptic, apex often retuse; fruit wings and body moderately to densely hairy ..... 10. *C. albopunctatum*

Scales usually not glistening; leaves very variable; fruit wings and body sparsely hairy (except in *C. apiculatum* ssp. *leutweinii*)

Plant a climber or scrambler; pockets of hairs in abaxial axils of midrib and primary lateral veins; lamina texture papyraceous ..... 12. *C. edwardsii*

Plant a tree or shrub:

Fruit less than 20 mm long; petals lobed; no pockets of hairs in abaxial axils of midrib and primary lateral veins; lamina texture coriaceous; scales 90–199 µm in diameter, conspicuously scalloped..... 14. *C. molle*

Fruit 20–30 mm long; well defined pockets of hairs in abaxial axils of midrib and primary lateral veins; scales 50–100 µm in diameter, not conspicuously scalloped ..... 11. *C. apiculatum*

**10. Combretum albopunctatum** Suesseng. in Mitteilungen der Botanischen Staatssammlung München 1: 336 (1953); Stace: 13 (1961) Exell: 7 (1966); Stace: 154 (1969); Exell: 188 (1970); Palmer & Pitman: 1641 (1973); Coates Palgrave: 662 (1977); Exell: 126 (1978); Carr: 29 (1988). Syntypes: Namibia, Bagani, Volk 2119 (PRE!); Popafällen, Volk 2105 (type not traced).

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (3.1 - ) 3.6 ( - 4) mm long, hairs considerably to densely distributed, scales contiguous or overlapping, silvery or golden; **lamina** broadly-elliptic or obovate-elliptic; (34 - ) 38.9 ( - 45.3) mm long, (20.3 - ) 25.1 ( - 28) mm wide; texture subcoriaceous; margin ciliate or sometimes ciliate; apiculate, acuminate, acute or retuse; base rounded or subcordate; number of pairs of lateral veins 6; **adaxial** surface reticulation more or

less plane; intersecondary veins more or less plane; hair distribution throughout surface; lamina island hairs moderately distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs moderately distributed; hair concentration in axils of midrib and primary lateral veins sparse; hair concentration in axils of primary lateral veins and secondary lateral veins sparse; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales considerable, mainly apart, silvery or golden; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, lamina exudate present; **abaxial** reticulation raised; intersecondary veins raised; hair distribution throughout surface; lamina island hairs moderately distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs considerably to densely distributed; hair concentration in axils of midrib and primary lateral veins sparse; hair concentration in axils of primary lateral veins and secondary lateral veins sparse; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales considerable, mainly apart, silvery or golden; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (74 - ) 78.5 ( - 86)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (12 - ) 15 ( - 16), number of radial walls in surface view 8, number of tangential walls in surface view (12 - ) 15 ( - 16). *Inflorescence* spike, elongated, axillary; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; ratio of peduncle length to rhachis length 1.1. *Bracts* linear or lorate, 0.4 mm long. *Lower hypanthium* 1.5 mm long, 0.5 mm wide; outer hairs considerably to densely distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* campanulate or cupuliform; 1.5 mm long, 2.1 mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden. *Base of receptacle, gynoeceium and accessory tissue* ovary 0.6 mm long, 0.5 mm wide; distance from base of style to placenta 0.5 mm; style 3.3 mm long; stigma not expanded. *Sepals* 0.4 mm long, 0.7 mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden; ciliate at apex, ciliate at margin; inner hairs sparsely distributed. *Petals* broadly spatulate; 0.5 mm long, 0.7 mm wide; ciliate at apex, ciliate at margin. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 3 mm long, anthers 0.6 mm long, 0.4 mm wide. *Fruit* (19.4 - ) 20.9 ( - 22.1) mm long, (16.4 - ) 18.7 ( - 20.7) mm wide; wing texture papyraceous; stipe (3 - ) 5.3 ( - 8) mm long; peg 0.5 mm long; wings golden to pinky-brown or reddish- or purple-brown; body golden

to light-brown or golden-brown; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; wing hairs moderately distributed, scales apart to contiguous or overlapping, silvery or golden; stipe hairs considerably to densely distributed, scales contiguous or overlapping, silvery or golden; body hairs considerably to densely distributed, scales contiguous or overlapping, silvery or golden; fruit outline elliptic or subcircular.

#### Specimens examined

- **1823** (Siambisso): between Hunters Africa N° 2 camp and Smith's camp ( - BD), *Smith 1164* (PRE).
- **1821** (Andara): 12 km from Andara near Okavango River ( - AB), *Giess 14898* (PRE); Caprivi side of river at Bagani Pontoon ( - BA), *De Winter 4337* (PRE); häufig auf Sand, Bagani, *Volk 2119* (PRE, syntype).
- **Botswana**: no precise locality, *Miller B181*. Grid ref. unknown (PRE).

**11. *Combretum apiculatum* Sond.** in *Linnaea* 23: 45 (1850); Sond.: 510 (1862); Laws.: 425 (1871); Engl. & Diels: 42 (1899); Sim: 63 (1909); Burt Davy: 425 (1926); Henkel: 122 (1934); Codd: 128 (1951); Palmer & Pitman: 244 (1961); Stace: 13 (1961) White: 286 (1962); De Winter et al.: 118 (1966); Exell: 7 (1968); Stace: 152 (1969); Exell: 192 (1970); Palmer & Pitman: 1632 (1973); Wickens: 35 (1973); Van Wyk: 419 (1974); Compton: 393 (1976); Coates Palgrave: 663 (1977); Exell: 129 (1978); Carr: 32 (1988). Syntypes: "Macalisberg", *Burke 520* (BM, SAM!); "Africa australis, in silvis ad Magalisberge" *Zeyher 553* (BM, K, S, SAM!).

*Combretum apiculatum* forma *sulphureum* Heurck & Mull. Arg.: 229 (1871).  
*C. apiculatum* var. *sulphureum* (Heurck & Mull. Arg.) Dümmer: 164 (1913).

*C. apiculatum* forma *viscosum* Heurck & Mull. Arg.: 231 (1871).  
*C. apiculatum* var. *viscosum* (Heurck & Mull. Arg.) Dümmer: 164 (1913).

(a) **subsp. *apiculatum***; Exell in *Mitteilungen aus der Botanischen Staatssammlung München* 4: 3 (1961); Stace: 13 (1961); Exell: 7 (1966); Exell: 18 (1968); Stace: 152 (1969); Exell: 194 (1970); Exell: 131 (1978).

Icon: Carr: t.2 (1988).

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (2.9 - ) 4.8 ( - 6) mm long, scales apart to contiguous or overlapping; **lamina** broadly-elliptic or obovate-elliptic; (54.7 - ) 63.3 ( - 77.5) mm long, (23.1 - ) 26.9 ( - 33.5) mm wide;



texture papyraceous; margin ciliate or sometimes ciliate; apex apiculate; base oblique, subcordate or rounded; number of pairs of lateral veins (7 - ) 8 ( - 10); **adaxial** surface reticulation with midrib more or less plane, primary lateral veins raised; intersecondary veins more or less plane; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; primary lateral vein hairs sparsely distributed; hair concentration in axils of midrib and primary lateral veins sparse; scales distributed throughout surface; lamina island scales considerable, mainly apart, primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (60 - ) 66.8 ( - 70)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (8 - ) 10 ( - 13), number of radial walls in surface view 8 ( - 9), number of tangential walls in surface view (8 - ) 10 ( - 13); lamina exudate present; **abaxial** reticulation raised; intersecondary veins raised; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; lamina island scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (53 - ) 65.9 ( - 77.7)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale 8 ( - 9), number of radial walls in surface view 8, number of tangential walls in surface view (8 - ) 9; lamina exudate present. *Inflorescence* spike, elongated, axillary, glutinous; rhachis hairs moderately distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; ratio of peduncle length to rhachis length (0.4 - ) 0.9 ( - 1.2). *Bracts* linear or lorate, (0.6 - ) 0.8 ( - 1.1) mm long. *Lower hypanthium* (1.3 - ) 2.3 ( - 3.4) mm long, (0.5 - ) 0.6 ( - 0.7) mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Upper hypanthium* campanulate; (2.1 - ) 2.2 ( - 2.4) mm long, (2.5 - ) 2.7 ( - 2.8) mm wide; outer hairs moderately distributed, outer scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres. *Base of receptacle, gynoecium and accessory tissue* ovary (0.9 - ) 1.0 ( - 1) mm long, (0.5 - ) 0.6 mm wide; distance from base of style to placenta (0.6 - ) 0.9 ( - 1.3) mm; style (3.9 - ) 4.7 ( - 5.5) mm long; stigma not expanded. *Sepals* (0.5 - ) 0.6 ( - 0.7) mm long, (1.4 - ) 1.6 ( - 1.8) mm wide; outer hairs sparsely distributed, outer scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; ciliate at apex, inner

hairs moderately distributed. *Petals* broadly spatulate; (1.1 - ) 1.5 ( - 2.1) mm long, (0.7 - ) 1.5 ( - 2) mm wide; outer hairs sparsely distributed; ciliate at apex, ciliate at margin. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted above disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments (4.7 - ) 5.6 ( - 6.6) mm long, anthers (1 - ) 1.2 ( - 1.3) mm long, (0.4 - ) 0.7 ( - 0.9) mm wide. *Fruit* (17 - ) 20.9 ( - 24.7) mm long, (20 - ) 20.7 ( - 21.3) mm wide; wing texture papyraceous; stipe (4 - ) 5.4 ( - 6.8) mm long; peg (0.5 - ) 0.8 ( - 1) mm long; wings golden to light-brown or golden-brown; body golden to light-brown or golden-brown; glutinous on body and wings; rhachis hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden; wing hairs sparsely distributed, scales apart to contiguous or overlapping, stipe hairs sparsely distributed, scales apart to contiguous or overlapping, body hairs sparsely distributed, scales apart to contiguous or overlapping.

#### Specimens examined

- **2330** (Tzaneen): 55 km van Tzaneen, Gravelotte verby, op pad na Mica ( - DC), *Pienaar* 732 (PRE).
- **2527** (Rustenberg): “Macalisberg” ( - DA/DB), *Burke* 520 (SAM, isosyntype); “Macalisberge”, *Zeyher* 553 (SAM, isosyntype).
- **2529** (Witbank): Groblersdal, next to golf course ( - AB), *Venter* 2981 (PRE).
- **2731** (Louwsburg): Itala Nature Reserve, Craigadam section ( - AD/CB), *Porter & Ward* 217 (NH); Pongola farm ( - BC), *Nel* 49 (NH).
- **2732** (Ubombo): 2 km west of Makane’s ( - AA), *Moll* 5632 (NH); Ingwavuma East Hills, *Strey* 8169 (NH); between Ingwavuma and Josini, Gwaliweni Forest ( - AC), *Balkwill* 692 (NU); 1 mile south west Jozini Dam , *Strey & Moll* 3688 (NH).

Lamina adaxial and abaxial surfaces sparsely hairy, midribs sparsely to moderately hairy, primary lateral veins sparsely hairy, lamina texture papyraceous, scales 50–70µm in diameter (Plate 8.3) .....subsp. *apiculatum*  
 Lamina adaxial and abaxial surfaces moderately hairy, midribs considerably to densely hairy, primary lateral veins considerably to densely hairy, lamina texture coriaceous, scales 70–100µm in diameter (Plate 8.4).....subsp. *leutweinii*

(b) subsp. *leutweinii* (*Schinz*) *Exell* in Mitteilungen aus der Botanischen Staatssammlung München 4 : 3 (1961); *Stace*: 13 (1961); *Exell*: 8 (1966); *Stace*: 152

(1969); Exell: 132 (1978). Syntypes: S.W.Africa: Otjiwarongo: Waterberg, *Dinter* 413 (Z); Grootfontein: Otavi, *Dinter* 5356 (Z).

*Combretum leutweinii* Schinz apud De Wild. & Dur.: 878 (1901).

*C. apiculatum* var.? *pilosiuscula* Engl. & Diels: 43 (1899). Type: Mozambique, Boroma, *Menyharth* 892 (Z, holo.).

*C. kwebense* N.E.Br.: 111 (1909). Type: Botswana, Ngamiland, Kwebe Hills, *Lugard* 48 (K, holo.).

#### Specimens examined

— 1917 (Tsumeb): farm Auros GR595 ( - DA), *Giess* 12395 (PRE).

— 1918 (Grootfontein): farm Awagobib (GR45), Grootfontein Distr. ( - CA), *Merxmüller & Giess* 30238 (PRE).

— 2017 (Waterberg): Waterberg Plateau ( - AC/AD), *Boss TM* 34970 (PRE).

**12. *Combretum edwardsii* Exell** in Boletim da Sociedade Broteriana Sér. 2, 42: 19 (1968); Palmer & Pitman: 1618 (1973); Carr: 59 (1988). Type: Natal, 2929 (Underberg): Impendle, Lundy's Hill, upper edge of Umkomaas Valley (-DB), *Edwards* 3147 (PRE, holo.!: K, NH!).

*Branches* have a tendency to twine; bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (2.8 - ) 7.0 ( - 9.1) mm long, hairs considerably to densely distributed, scales apart to contiguous or overlapping; **lamina** oblong-elliptic, slightly obovate; (49.4 - ) 63.8 ( - 89.5) mm long, (21.2 - ) 31 ( - 40) mm wide; texture papyraceous; margin often down-rolled; margin ciliate or sometimes ciliate; apiculate or acuminate; base oblique, subcordate or rounded; number of pairs of lateral veins (6 - ) 7 ( - 8); **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs considerably to densely distributed; primary lateral vein hairs moderately distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, midrib scales considerable, mainly apart, silvery or golden; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (61 - ) 69 ( - 82)  $\mu$ m diameter, smooth to slightly scalloped in outline, number of cells per scale (15 - ) 16 ( - 19), number of radial walls in surface view (8 - ) 10 ( - 13), number of tangential walls in surface view (15 - ) 17 ( - 20); lamina exudate present; **abaxial** reticulation raised; intersecondary veins more or less plane; hair

distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs moderately distributed; primary lateral vein hairs moderately distributed; scale distribution throughout surface; lamina island scales considerable, mainly apart, rust-brown; midrib scales considerable, mainly apart, rust-brown; primary lateral vein scales considerably distributed to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (58 - ) 80.3 ( - 97)  $\mu\text{m}$  diameter, smooth to slightly scalloped in outline, number of cells per scale (13 - ) 16 ( - 18), number of radial walls in surface view (8 - ) 9 ( - 11), number of tangential walls in surface view (14 - ) 16 ( - 18); lamina exudate present. *Inflorescence* spike, elongated, axillary, glutinous; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, rust-brown; ratio of peduncle length to rhachis length (0.9 - ) 1.4 ( - 2.2). *Bracts* linear or lorate, (0.4 - ) 0.7 ( - 0.8) mm long. *Lower hypanthium* (2.7 - ) 2.9 ( - 3.1) mm long, (0.6 - ) 1.3 ( - 2.6) mm wide; outer scales contiguous or overlapping, rust-brown. *Upper hypanthium* infundibular; (1.7 - ) 2.1 ( - 2.6) mm long, (0.9 - ) 2.0 ( - 2.8) mm wide; outer scales apart to contiguous or overlapping, rust-brown. *Base of receptacle, gynoeceium and accessory tissue* ovary (1.1 - ) 1.2 ( - 1.4) mm long, (0.6 - ) 0.8 ( - 0.9) mm wide; distance from base of style to placenta (0.5 - ) 1.2 ( - 1.6) mm; style (2.9 - ) 4.7 ( - 5.9) mm long; stigma not expanded. *Sepals* (0.5 - ) 0.6 ( - 0.7) mm long, (1.2 - ) 1.4 ( - 1.7) mm wide; outer scales apart to contiguous or overlapping; ciliate at apex, ciliate at margin. *Petals* broadly spatulate; (0.7 - ) 1 ( - 1.2) mm long, (1 - ) 1.4 ( - 1.8) mm wide; ciliate at apex, ciliate at margin. *Disc* adnate to upper hypanthium; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments (3.9 - ) 4.8 ( - 5.7) mm long, anthers (0.7 - ) 0.8 ( - 1) mm long, 0.5 ( - 0.6) mm wide. *Fruit* (17.5 - ) 20.2 ( - 24.5) mm long, (17.3 - ) 20.8 ( - 24) mm wide; wing texture papyraceous; stipe (3.7 - ) 4.9 ( - 7.2) mm long; peg (0.1 - ) 0.5 ( - 1) mm long; wings golden to light-brown or golden-brown; body dark-brown or rust-brown; glutinous only on body; rhachis hairs considerably to densely distributed; wing hairs sparsely distributed, scales considerable, mainly apart, rust-brown; stipe scales apart to contiguous or overlapping, rust-brown; body hairs sparsely distributed, scales apart to contiguous or overlapping, rust-brown; fruit outline elliptic or subcircular.

### Specimens examined

- 2632 (Bela Vista): Ndumu Game Reserve ( - CD), *Moll* 5362 (NH).
- 2732 (Ubombo): Mkuze Game Reserve ( - CA), *Ward* 3608 (NH); Mkuze Game Reserve, Msinga Sand Forest, *White* 10388 (NH); Mkante 13813, adjacent the Nibela Native Reserve ( - CD), *Ward* 111 (NH).
- 2830 (Dundee): farm 'Dulumbi', Kranskop ( - DD), *Law* 29 (NBG).
- 2929 (Underberg): Lundy's Hill, upper edge of Umkomaas Valley ( - DB), *Edwards* 3147 (PRE, holotype; NH, isotype).
- 2930 (Pietermaritzburg): Maritzdal Farm, Dargle ( - AC), *Edwards* 3139 (NH); Dargle, Lions River, *Moll* 3361 (NH, PRE); Kilgobbin, Dargle, *Moll* 5473 (NH); Krantzkloof Nature Reserve, Nqutu Kloof ( - DD), *Van Wyk* 8126 (NH).
- 3030 (Port Shepstone): Umtamvuna Nature Reserve ( - CC), *Abbott* 1377 (NH), *Rogers s.n.* (UDW); Umtamvuna Nature Reserve on cliff top, *Rogers s.n. sub E.F.Hennessy* 453 (UDW).

**13. *Combretum moggii* Exell** in Boletim da Sociedade Broteriana 42: 21 (1968); Stace: 153 (1969); Palmer & Pitman: 1647 (1973); Coates Palgrave: 671 (1977); Carr: 98 (1988). Type: Transvaal, "Olifants River gorge, farm Slaghoek 126, Middelburg district; 20 radial miles NW", *Mogg* 22400 ( PRE, holo.!: BM, J, K).

Icon: Carr: t.9 (1988).

The only characters examined, owing to time restraints, were of the scales from the holotype, *Mogg* 22400, and scales and inflorescences from the specimen *Mogg* 23931.

**Leaves** **adaxial** scales disc- or bowl-shaped, 125  $\mu$ m diameter, smooth to slightly scalloped in outline, number of cells per scale  $\pm$  32, number of radial walls in surface view  $\pm$  17, number of tangential walls in surface view  $\pm$  32; **abaxial** scales disc- or bowl-shaped, smooth to slightly scalloped in outline, number of cells per scale  $\pm$  31, number of radial walls in surface view  $\pm$  15, number of tangential walls in surface view  $\pm$  30. **Inflorescence** spike, subcapitate, axillary; rachis hairs considerably to densely distributed, scales obscured by hairs. **Bracts** linear to obovate, 2.2 mm long. **Lower hypanthium** 1.5 mm long, 0.7 mm wide; outer hairs considerably to densely distributed, outer scales obscured by hairs. **Upper hypanthium** 3 mm long, 3.7 mm wide; outer hairs considerably to densely distributed, outer scales apart to contiguous or overlapping, silvery or golden. **Base of receptacle, gynoeceium and accessory tissue** ovary 0.9 mm long, 0.7 mm wide; distance from base of style to placenta

0.5 mm; style 5.4 mm long; stigma not expanded. *Sepals* 0.6 mm long, 1.2 mm wide; outer hairs considerably to densely distributed, outer scales apart to contiguous or overlapping, silvery or golden; ciliate at apex, ciliate at margin; inner hairs considerably to densely distributed. *Petals* broadly spathulate; 1.3 mm long, 1.9 mm wide; ciliate at apex, ciliate at margin. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments 5.1 mm long, anthers 1 mm long, 0.6 mm wide.

#### Specimens examined

— **2529** (Witbank): Middelburg, Olifants River Gorge (farm Slaghoek 126, Middelburg Distr., 20 radial miles north west) (- CD), *Mogg 22400* (PRE, holotype); Langkloof, 12 miles north west of Middelburg, *Mogg 23931* (J).

**14. *Combretum molle* R.Br. ex G. Don** in Transactions of the Linnean Society of London 15: 431 (1827); White: 286 (1962); Exell: 7 (1968); Stace: 151 (1969); Exell: 189 (1970); Palmer & Pitman: 1647 (1973); Wickens: 33 (1973); Van Wyk: 425 (1974); Compton: 394 (1976); Coates Palgrave: 671 (1977); Exell: 127 (1978); Carr: 102 (1988). Type: Ethiopia, *Salt s.n.* (BM, holo.).

*Combretum gueinzii* Sond.: 43 (1850); Sond.: 509 (1862); Engl. & Diels: 38 (1899); Dümmer: 116 (1913); Codd: 130 (1951). Type: “ad Port Natal in silvis”, *Gueinziius 567* (S, holo.; K, SAM!).

*C. holosericeum* Sond.: 44 (1850); Sond.: 510 (1862); Lawson: 430 (1871); Sim: 63 (1909); Dümmer: 116 (1913); Burtt Davy: 247 (1926); Henkel: 124 (1934). Syntypes: “South Africa, Macalisberg”, *Burke 521* (BM, K, SAM!); “Africa Australis, Macalisberg”, *Zeyher 575* (BM, K, PRE!, SAM!).

*C. galpinii* Engl. & Diels: 41 (1899). Type: “Transvaal, hillside, Avoca near Barberton”, *Galpin 1112* (K, holo.; BOL, NH!, PRE!, SAM).

*C. welwitschii* Engl. Diels: 40 (1899). Type: “Angola, Cuanza Norte, Golungo Alto”, *Welwitsch 4316* (LISU, lecto.; BM, COI, K, P).

Icones: Exell: t.36 (1978); Carr: t.10 (1988).

*Branches* bark flakes and strips; circular projections left behind after leaf fall. *Leaves* opposite or subopposite; **petiole** (4.5 - ) 5.7 ( - 6.4) mm long, hairs considerably to densely distributed, scales contiguous or overlapping, silvery or golden; **lamina**

broadly-elliptic or obovate-elliptic; (6.8 - ) 64.9 ( - 95.1) mm long, (4.1 - ) 36.6 ( - 46.7) mm wide; texture coriaceous; margin ciliate or sometimes ciliate; apex apiculate, rounded or obtuse; base rounded or subcordate; number of pairs of lateral veins (7 - ) 8; **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs moderately distributed; midrib hairs considerably to densely distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, midrib scales apart to contiguous or overlapping, primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (76 - ) 97 ( - 130)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale 16, number of radial walls in surface view 8, number of tangential walls in surface view 16; lamina exudate present; **abaxial** reticulation raised; intersecondary veins raised; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs moderately distributed; primary lateral vein hairs moderately distributed; scale distribution throughout surface; lamina island scales contiguous or overlapping, midrib scales, apart to contiguous or overlapping, silvery or golden; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (100 - ) 114.3 ( - 137)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale 16, number of radial walls in surface view 8, number of tangential walls in surface view 16. *Inflorescence* spike, elongated, axillary; rhachis hairs considerably to densely distributed, scales apart to contiguous or overlapping, silvery or golden; ratio of peduncle length to rhachis length (0.4 - ) 0.5 ( - 0.6). *Bracts* linear or lorate, (0.6 - ) 0.7 ( - 0.8) mm long. *Lower hypanthium* (1.2 - ) 1.6 ( - 2) mm long, (0.5 - ) 0.6 ( - 0.7) mm wide; outer hairs considerably to densely distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* campanulate; (1.3 - ) 1.6 ( - 1.8) mm long, (2.9 - ) 3.4 ( - 3.8) mm wide; outer hairs moderately distributed, outer scales apart to contiguous or overlapping, silvery or golden. *Base of receptacle, gynoecium and accessory tissue* ovary 0.9 mm long, 0.7 mm wide; distance from base of style to placenta 1 mm; style (5.4 - ) 5.6 ( - 5.8) mm long; stigma not expanded. *Sepals* (0.3 - ) 0.5 ( - 0.6) mm long, (0.7 - ) 0.9 ( - 1.1) mm wide; outer hairs sparsely distributed, outer scales apart to contiguous or overlapping, silvery or golden; ciliate at apex, ciliate at margin; inner hairs sparsely distributed. *Petals* broadly spatulate and lobed; (0.7 - ) 0.8 ( - 0.9) mm long, (0.3 - ) 0.4 ( - 0.5) mm wide; ciliate at apex, ciliate at margin. *Disc* margin free; outer hairs considerably to densely distributed. *Stamens* inserted at or near disc margin; in apparently 1, but actually 2 series, not clearly distinguished; filaments (5.5 - ) 5.6

( - 5.7) mm long, anthers 0.8 mm long, (0.5 - ) 0.6 mm wide. *Fruit* (17.4 - ) 19.0 ( - 20.2) mm long, (15 - ) 16.1 ( - 18) mm wide; wing texture papyraceous; stipe (2.4 - ) 2.6 ( - 3) mm long; peg (0.6 - ) 0.7 ( - 0.8) mm long; wings golden to light-brown or golden-brown; body golden to light-brown or golden-brown; wing hairs sparsely distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; body hairs sparsely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; fruit outline broadly elliptic.

#### Specimens examined

- **2527** (Rustenburg): “Macalisberg”, Cape ( - D[A,B,C,D?]), *Zeyher* 575 (PRE, syntype of *C. holosericeum* Sond.).
- **2531** (Komatipoort ): Kaap River Valley, Hillside Avoca near Barberton ( - CC), *Galpin* 1112 (NH, PRE, isotypes of *C. galpinii* Engl. & Diels).
- **2731** (Louwsburg): Jozini Dam, summit of Lebombo Mts ( - BD), *Ross* 1657 (NH).
- **2732** (Bela Vista): Tembe Elephant Park, Sihangwane ( - AB), *Ward* 832 (NH).
- **2832** (Mtubatuba): Hlabisa, near Ezincakeni Dam, Hluhluwe Game Reserve ( - AA), *Pegel & Bourquin* NDO 91 (NH).
- **2930** (Pietermaritzburg): University of Durban-Westville, Westville ( - DD), *De Smidt* 91 (UDW); Nkutu Falls, Pinetown, *Redshaw* 16 (NH).

**15. *Combretum petrophilum* Retief** in Bothalia 16: 44 (1986); Carr: 124 (1988). Type: Transvaal, 2430 (Pilgrim’s Rest): in fissures on steeply-sloping slab rock on right hand side of south portal of Strijdom Tunnel ( - BC), *Carr* 203 (PRE, holo.!, photo.!, K).

Icon: Carr: t.13 (1988).

[Only scales from the holotype, *Carr* 203, were examined owing to time restraints].

*Leaves* **adaxial** lamina scales sometimes impressed, scales disc- or bowl-shaped, 67 µm diameter, smooth to slightly scalloped in outline; **abaxial** lamina exudate present; lamina scales sometimes impressed, scales disc- or bowl-shaped, 57 µm diameter, smooth to slightly scalloped in outline, number of cells per scale ± 12,



number of radial walls in surface view  $\pm 9$ , number of tangential walls in surface view  $\pm 12$ ; lamina exudate present.

#### Specimens examined

— **2430** (Pilgrim's Rest): in fissures on steeply-sloping slab rock on right hand side of south portal of Strijdom Tunnel ( - BC), *Carr 203* (PRE, holotype; photo.).

**16. *Combretum psidioides* Welw.** in Annaes Conselho Ultramarino, Sér. 1, 24: 249 (1856); Engl. & Diels: 51 (1899); Stace: 14 (1961); White: 286 (1962); Exell: 8 (1968); Stace: 154 (1969); Exell: 196 (1970); Wickens: 37 (1971); Palmer & Pitman: 1651 (1973); Wickens: 37 (1973); Coates Palgrave: 674 (1977); Exell: 133 (1978); Carr: 133 (1988). Type: Angola "In dumetosis interioris Provinciae Angolensis, rarior avis. Arbuscula elegans foliis maximis, habitu exacte *Psidiorum*. Quicuze." *Welwitsch 4378* (LISU, lecto.; BM, COI, K).

(a) **subsp. *psidioides***; Exell in Mitteilungen Botanischen Staatssammlung München 4: 5 (1961); Stace: 14 (1961); Exell: 197 (1970); Stace: 154 (1969); Wickens: 38 (1971); Wickens: 37 (1973); Coates Palgrave: 675 (1977); Exell: 134 (1978); Carr: 135 (1988).

*Combretum omahecae* Gilg & Dinter ex Engl.: 698 (1921). Type: Namibia, "bei Otjituo und Naitsas" (ex lit.) (type not traced).

[Scale examination was attempted from adaxial and abaxial laminas of specimen *Steyl 21*. Unfortunately, no clear scales were visible although numerous stomata (Plate 9.2) on the abaxial lamina were observed to be characteristic of the specimen. No other characters or specimens were examined owing to time restraints].

#### Specimens examined

— **1823** (Siambisso): Lizauli, Oos-Caprivi ( - AB), *Steyl 21* (PRE).

(b) **subsp. *dinteri* (Schinz) Exell** in Mitteilungen Botanischen Staatssammlung München 4: 3 (1961); Stace: 14 (1961); Exell: 10 (1966); Stace: 154 (1969); Exell: 198 (1970); Wickens: 39 (1971); Palmer & Pitman: 1651 (1973); Coates Palgrave: 675 (1977); Exell: 135 (1978); Carr: 135 (1988). Syntypes: Namibia: Otjiwarongo, Waterberg Plateau, *Dinter 580* (Z); Ombalambuenge, Ondonga, *Rautanen 235* (Z).

*Combretum dinteri* Schinz: 877 (1901).

*C. quirirense* Engl. & Diels: 318 (1903). Type: Angola, Bie, R. Cuiriri, *Baum* 722 (B, holo.†; BM).

[Scale examination was attempted from adaxial and abaxial laminae of specimen *Rodin 9310*. Unfortunately, scales were too shrivelled or obscured by hairs to be clearly visible. The adaxial lamina surface was moderately hairy and the abaxial lamina surface was densely hairy. No other characters or specimens were examined owing to time restraints].

#### **Specimens examined**

— **1715** (Ondangua): 104 km east of Oshikango ( - BD), *Rodin 9310* (PRE).

**7. Section *Breviramea*** Engl. & Diels in Engler, H.G.A., *Monographien afrikanischer Pflanzenfamilien und Gattungen* 3: 61 (1899); Stace: 148 (1969); Exell: 199 (1970); Wickens: 40 (1973); Exell: 136 (1978).

**17. *Combretum hereroëense*** Schinz in *Verhandlungen des Botanischen Vereins der Prov. Brandenburg* 30: 245 (1888); Engl. & Diels: 63 (1899); Dümmer: 201 (1913); Dinter: 170 (1919); Stace: 12 (1961); White: 285 (1962); Exell: 8 (1966); Exell: 8 (1968); Stace: 149 (1969); Exell: 199 (1970); Wickens: 413 (1971); Palmer & Pitman: 1639 (1973); Wickens: 40 (1973); Van Wyk: 427 (1974); Compton: 39 (1976); Coates Palgrave: 668 (1977); Exell: 138 (1978); Carr: 77 (1988). Type: Namibia, Otjovazandu, *Schinz 431* (Z, holo.; B†).

(a) **subsp. *hereroëense***; Wickens in *Kew Bulletin* 25: 413 (1971).

#### **variety *hereroëense***

*Combretum transvaalense* Schinz: 202 (1894); Dümmer: 201 (1913); Burt Davy: 246 (1926); Codd: 133 (1951); Palmer & Pitman: 249 (1961). Type: Transvaal, Makapansberge, *Rehmann 5470* (Z, holo.).

*C. sambesiacum* Engl. & Diels: 63 (1899). Type: Mozambique, Boroma, *Menyharth 892B* (Z, holo.; K, fragment).

*C. porphyrolepis* Engl. & Diels: 63 (1899), nom. illegit. Syntypes: Transvaal, Hillsides, Queen's River valley, Barberton, *Galpin 560* (K, Z); *Galpin 561* (BOL!, K,

Z); *Galpin* 756 ( BOL!, K, PRE!, SAM, Z); Komatipoort, *Schlechter* 11772 ( B†, BM, BOL!, K); Transvaal, *Rehmann* 5470 (Z), [holo. of *C. transvaalense* Schinz].

*C. rautanenii* Engl. & Diels: 64 (1899). Syntypes: Botswana, Chansis, *Fleck* 420 A (Z); *Fleck* 428 A (Z); Moichas, *Fleck* 430 A (Z); Namibia, Katumare, *Rautanen* 199 (Z).

*C. rhodesicum* Bak. f.: 435 (1899). Syntypes: Zimbabwe, Bulawayo, *Rand* 582, (BM); *Rand* 483 (BM).

*C. transvaalense* var. *bolusii* Dümmer: 201 (1913). Type: Transvaal, “juxta ripas flum. Kaup prope Barberton”, *Bolus* 7763 (K, holo.).

*C. transvaalense* var. *ochreo-lepidotum* Dümmer: 201 (1913). Syntypes: Transvaal, “Leeuw Spruit in ditione Barberton”, *Bolus* 7768, 7769 (K).

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (2.1 - ) 3.1 ( - 4.2) mm long, hairs considerably to densely distributed, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; **lamina** oblong-elliptic, sometimes obovate; (26.3 - ) 31.2 ( - 37.9) mm long, (14.4 - ) 17.4 ( - 19.5) mm wide; texture subcoriaceous; margin ciliate or sometimes ciliate; apex apiculate, rounded or obtuse; number of pairs of lateral veins (4 - ) 5 ( - 7); **adaxial** surface reticulation more or less plane; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; midrib hairs considerably to densely distributed; primary lateral vein hairs moderately distributed; scales distributed throughout surface; lamina island scales considerable, mainly apart, silvery or golden; midrib scales apart to contiguous or overlapping, silvery or golden; primary lateral vein scales considerably to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (64 - ) 89.8 ( - 112)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale 16 ( - 17), number of radial walls in surface view 8 ( - 9), number of tangential walls in surface view 16 ( - 17); lamina exudate present; **abaxial** reticulation raised; intersecondary veins more or less plane; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; midrib hairs moderately distributed; primary lateral vein hairs moderately distributed; hair concentration in axils of midrib and primary lateral veins sparse; scale distribution throughout surface; lamina island scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; midrib scales, apart to contiguous or overlapping, silvery or

golden, sometimes rust-brown or with rust-brown centres; primary lateral vein scales considerably distributed to densely distributed; lamina scales sometimes impressed, scales disc- or bowl-shaped, (84 - ) 99 ( - 112)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale 16, number of radial walls in surface view 8 ( - 9), number of tangential walls in surface view (15 - ) 16; lamina exudate present. *Inflorescence* spike or panicle, terminal and axillary; glutinous; rhachis hairs considerably to densely distributed, scales obscured by hairs; ratio of peduncle length to rhachis length 0.2 ( - 0.3). *Bracts* linear or lorate, (1.1 - ) 1.4 ( - 1.6) mm long. *Lower hypanthium* (2.4 - ) 2.6 ( - 2.8) mm long, (0.8 - ) 1.0 ( - 1.1) mm wide; outer scales obscured by glutinous secretion. *Upper hypanthium* campanulate; (2.4 - ) 2.5 ( - 2.6) mm long, (2.8 - ) 3 ( - 3.2) mm wide; outer hairs moderately distributed. *Base of receptacle, gynoecium and accessory tissue* ovary (1.4 - ) 1.5 mm long, (0.9 - ) 1.0 ( - 1) mm wide; distance from base of style to placenta (0.7 - ) 0.8 mm; style (4.4 - ) 4.6 ( - 4.8) mm long; stigma not expanded. *Sepals* (0.5 - ) 0.7 ( - 0.8) mm long, (1.1 - ) 1.4 ( - 1.6) mm wide; outer hairs moderately distributed; ciliate at apex, ciliate at margin; inner hairs considerably to densely distributed. *Petals* broadly spatulate; (1.5 - ) 1.8 ( - 2) mm long, (1.2 - ) 1.7 ( - 2.2) mm wide. *Disc* margin free; outer hairs considerably to densely distributed, inner hairs sparsely distributed. *Stamens* inserted at or near disc margin; in 2 series; filaments (3 - ) 3.4 ( - 3.7) mm long, anthers 0.6 mm long, (0.5 - ) 0.6 mm wide. *Fruit* (15 - ) 17.7 ( - 20.5) mm long, (12.3 - ) 17.0 ( - 22.5) mm wide; wing texture papyraceous; stipe (3.2 - ) 4.6 ( - 6) mm long; peg (0.3 - ) 0.5 ( - 0.6) mm long; wings golden-brown to dark-brown or rust-brown; body dark-brown or rust-brown; glutinous on body and wings; rhachis hairs considerably to densely distributed, scales obscured by hairs; wing hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; stipe hairs moderately distributed, scales contiguous or overlapping, rust-brown; body hairs moderately distributed, scales apart to contiguous or overlapping; fruit outline elliptic or subcircular.

#### **Specimens examined**

— **2531** (Komatipoort): Komatipoort ( - BD), *Schlechter 11772* (BOL, isosyntype of *C. porphyrolepis* Engl. & Diels); Queens River Valley, Barberton ( - CC), *Galpin 561* (BOL, isosyntype of *C. porphyrolepis* Engl. & Diels); *Galpin 756* (BOL, PRE, isosyntypes of *C. porphyrolepis* Engl. & Diels, nom. illegit.).

— **2631** (Mbabane): Mafutseni ( - BC), *Bolus 11883* (BOL).

- **2632** (Bela Vista): Nkonjane/Aberkorn drift ( - CC), *Moll & Pooley* 4173 (NH); Ndumo Game Reserve ( - CD), *Ward* 2368 (NH).
- **2732** (Ubombo): junction of road from Lebombo Mountains to Ndumu and Pongola ( - AA), *Bodenstein* 107 (NH); 1 km west Makane's Pont, *Moll & Muller* 5683 (NH); Ingwavuma, *Strey* 9815 (NH).
- **no precise locality**, *Leendertz* 1149. Grid ref. unknown (BOL).

[Wickens (1971, pp.413–416 and 1973, pp. 40–42) divided *C. hereroëense* into three subspecies. Only the type subspecies occurs in the FSA area. Wickens further divided subspecies *hereroëense* into var. *hereroëense* and var. *villosissimum* Engl. & Diels, mainly on the density of hair distribution and reticulation prominence. These two varieties have been retained here although it is felt that their separation is based on characters which can be variable. Relatively constant characters such as scale structure and distribution are similar in both varieties].

Lamina adaxial and abaxial surfaces sparsely to moderately hairy, midribs and primary lateral veins moderately to considerably hairy, pockets of hairs absent in axils of adaxial midrib and primary lateral veins .....var. *hereroëense*  
 Lamina adaxial surface moderately hairy, abaxial surface considerably to densely hairy, midribs and primary lateral veins considerably to densely hairy, well defined pockets of hairs in axils of midribs and primary lateral veins .....  
 .....var. *villosissimum*

(b) **variety villosissimum** Engl. & Diels in Monographien afrikanischer Pflanzenfamilien und Gattungen 3: 63 (1899); Dümmer: 201 (1913); Wickens: 414 (1971); Wickens: 41 (1973). Type: Transvaal, Makapansberge, Streydpoort, *Rehmann* 5471 ( Z, holo.).

*C. eilkeranum* Schinz: 246 (1888). Type: Namibia, Kunene, *Schinz* 420 (Z, holo.)

*C. villosissimum* (Engl. & Diels ) Engl.: 705 (1921).

*C. transvaalense* var. *villosissimum* (Engl. & Diels) Burt Davy: 246 (1926).

#### Specimens examined

- 1712 (Posto Velho): south of the river at Etanga ( - DD), *De Winter & Leistner 5457* (PRE).
- 1724 (Katima Mulilo): south van Katima Mulilo, Katima Mulilo Distr. ( - AD), *Geldenhuis 193* (PRE).
- 1817 (Tsintsabis): Grootfontein ( - DD), Giess 9464 (PRE).
- 1819 (Karakuwisa): Cigarette, N.E. of Karakuwisa ( - DC), *Maguire 2312* (NBG).

**8. Section Elaeagnoida** *Engl. & Diels* in Engler, H.G.A., *Monographieen afrikanischer Pflanzenfamilien und Gattungen* 3: 23 (1899); Stace: 139 (1969); Exell: 202 (1970); Exell: 140 (1978).

**18. Combretum elaeagnoides** *Klotzsch* in Peters, *Naturwissenschaftliche Reise nach Mossambique - Botanik* 1: 73 (1861); Laws.: 426 (1871), excl. specim. Angola; Engl. & Diels: 23 (1899); Sim: 62 (1909); White: 284 (1962); Exell: 7 (1968); Stace: 139 (1969); Exell: 202 (1970); Palmer & Pitman: 1643 (1973); Coates Palgrave: 666 (1977); Exell: (1978); Carr: 63 (1988). Type: Mozambique, Sambesi Jitsch: Tete, *Peters s.n.* (B, holo.†; BM, K, fragments).

*Branches* bark flakes and strips. *Leaves* opposite or subopposite; **petiole** (4.4 - ) 5.5 ( - 8.3) mm long, hairs moderately distributed, scales contiguous or overlapping, silvery or golden; **lamina** elliptic, slightly obovate; (49 - ) 75.8 ( - 96.3) mm long, (20 - ) 29.8 ( - 36.7) mm wide; texture subcoriaceous; margin ciliate or sometimes ciliate; apex pointed-acuminate; base oblique, subcordate or rounded; number of pairs of lateral veins (9 - ) 10 ( - 12); **adaxial** surface reticulation with midrib recessed, primary lateral veins more or less plane; intersecondary veins more or less plane; hair distribution along midrib, lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; scales distributed throughout surface; lamina island scales apart to contiguous or overlapping, silvery or golden; midrib scales apart to contiguous or overlapping, silvery or golden; primary lateral vein scales considerably to densely distributed; scales disc- or bowl-shaped, (101 - ) 119.3 ( - 134)  $\mu$ m diameter, conspicuously scalloped in outline, number of cells per scale 30 ( - 31), number of radial walls in surface view (12 - ) 27 ( - 35), number of tangential walls in surface view (30 - ) 32 ( - 40); **abaxial** reticulation raised; intersecondary veins more or less

plane; hair distribution along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands; lamina island hairs sparsely distributed; midrib hairs sparsely distributed; primary lateral vein hairs sparsely distributed; hair concentration in axils of midrib and primary lateral veins considerable to dense; scale distribution throughout surface; primary lateral vein scales considerably distributed to densely distributed; scales disc- or bowl-shaped, (121 - ) 128.5 ( - 138)  $\mu\text{m}$  diameter, conspicuously scalloped in outline, number of cells per scale (27 - ) 32 ( - 40), number of radial walls in surface view (12 - ) 28 ( - 40), number of tangential walls in surface view (28 - ) 32 ( - 40). *Inflorescence* spike or panicle, subcapitate if spike, axillary; rhachis hairs obscured by scales, scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; ratio of peduncle length to rhachis length 0.6. *Bracts* oblong or rectangular, 0.6 mm long. *Lower hypanthium* 2.2 mm long, 0.5 mm wide; outer hairs moderately distributed, outer scales contiguous or overlapping, silvery or golden. *Upper hypanthium* infundibular; 2.2 mm long, 2.9 mm wide; outer hairs moderately distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres. *Base of receptacle, gynoeceium and accessory tissue* ovary 1 mm long, 0.5 mm wide; distance from base of style to placenta 1 mm; style 2.9 mm long; stigma not expanded. *Sepals* 0.6 mm long, 1.2 mm wide; outer hairs sparsely distributed, outer scales contiguous or overlapping, silvery or golden, sometimes rust-brown or with rust-brown centres; ciliate at apex, ciliate at margin; inner hairs moderately distributed, scales considerable, mainly apart, silvery or golden, sometimes rust-brown or with rust-brown centres. *Petals* spatulate (not broadly); 1.7 mm long, 0.5 mm wide. *Disc* adnate to upper hypanthium. *Stamens* inserted above disc margin; in 2 series; filaments 3.3 mm long, anthers 0.4 mm long, 0.4 mm wide. *Fruit* (16.5 - ) 18.9 ( - 22.7) mm long, (18.2 - ) 21.7 ( - 24.3) mm wide; wing texture subcoriaceous; stipe (11.4 - ) 12.1 ( - 12.5) mm long; peg 0.4 mm long; wings golden to light-brown or golden-brown; body golden to light-brown or golden-brown; rhachis hairs sparsely distributed, scales contiguous or overlapping, silvery or golden; wing hairs sparsely distributed, scales apart to contiguous or overlapping, silvery or golden; stipe hairs sparsely distributed, scales contiguous or overlapping, silvery or golden; body hairs sparsely distributed, scales contiguous or overlapping, silvery or golden; fruit outline elliptic or subcircular.

### **Specimens examined**

- **1723** (Singalamwe): Kwando flood plain, Western Caprivi Strip ( - DC), *Tinley 1425* (PRE).
- **1724** (Katima Mulilo): Silumbi area, 1,5 km east of Silumbi School ( - DC), *Cawood & Ward 21* (NU).
- **1824** (Kachikau): southernmost Goha Hill, Botswana ( - AC), *Smith 2063* (PRE).
- **2033** (Chibavava): Mutarara, Manica & Sofala Distr. ( - DC), *Andrada 1628* (NU).



# Appendices

# A.1 Terminology

The following diagrams were hand-drawn by the writer and then scanned into the computer. They were then suitably annotated for inclusion in this work.

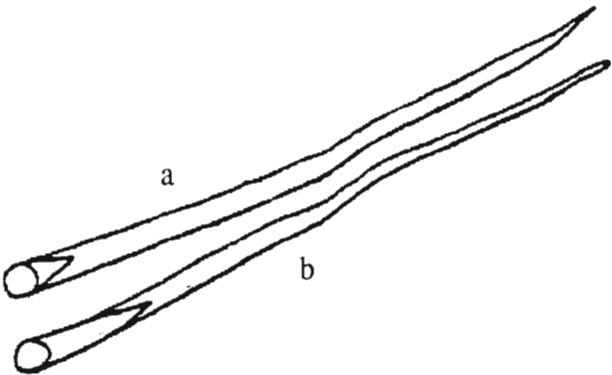


Fig. A.1.1 Combretaceous hairs  
a. *C. apiculatum*  
b. *C. erythrophyllum*

(reference: Stace, 1961)

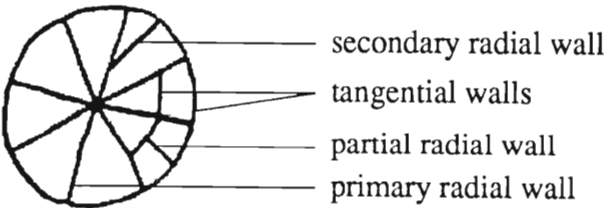


Fig. A.1.2 Generalised *Combretum* scale

(reference: Stace, 1969)

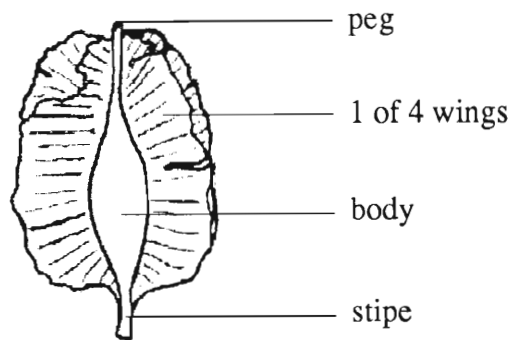


Fig. A.1.3 Generalised *Combretum* fruit

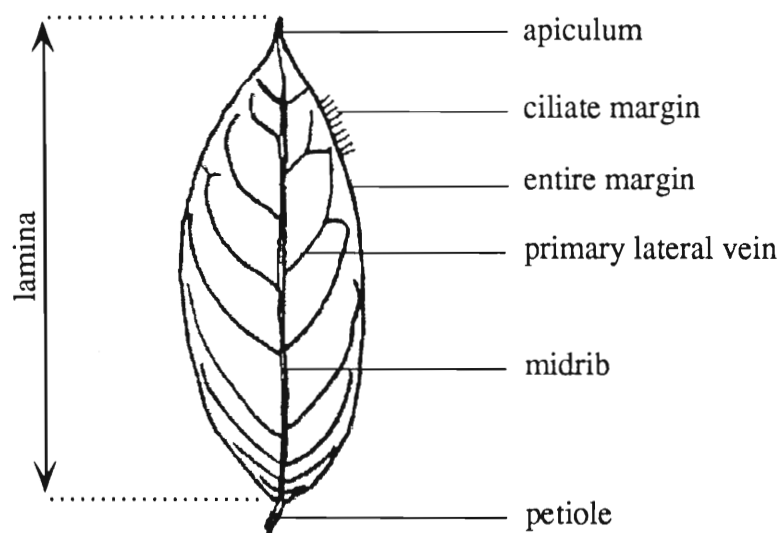
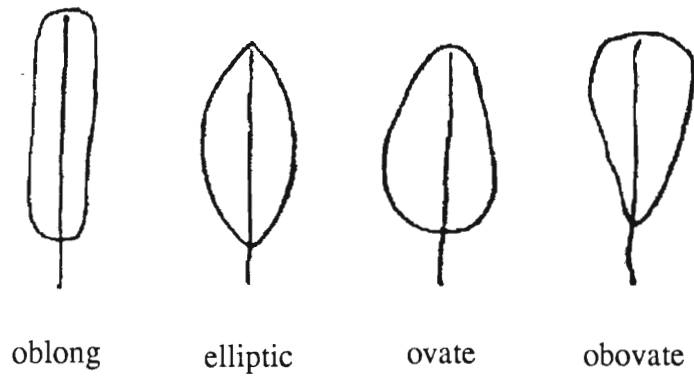
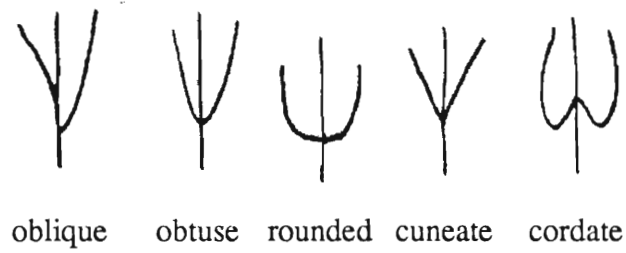


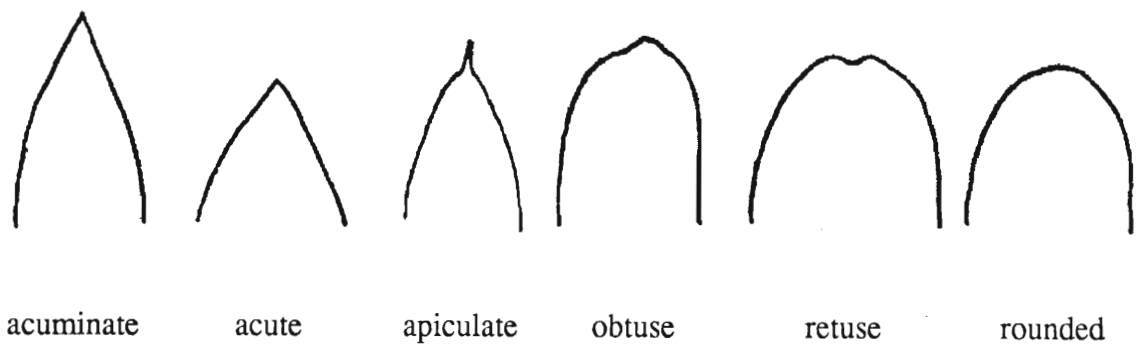
Fig. A.1.4 Generalised *Combretum* leaf



**Fig. A.1.5** Leaf shapes

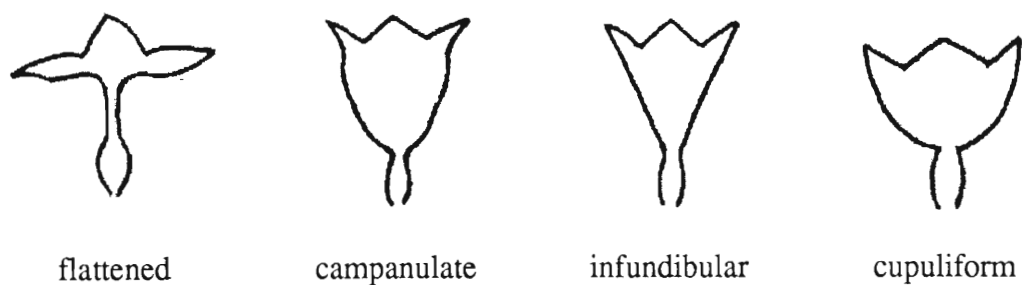


**Fig. A.1.6** Leaf bases

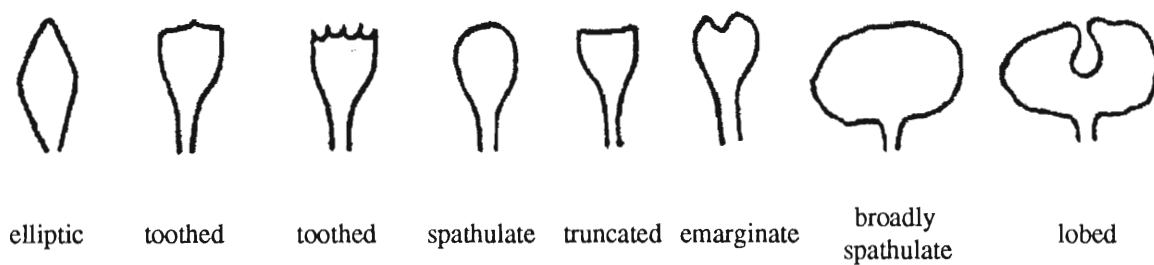


**Fig. A.1.7** Leaf apices

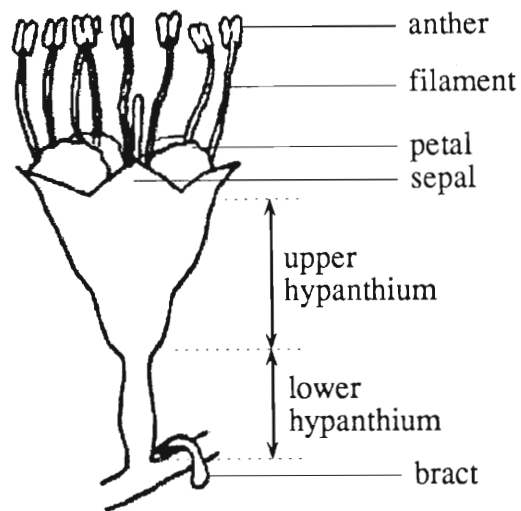
(Reference: Radford, 1986)



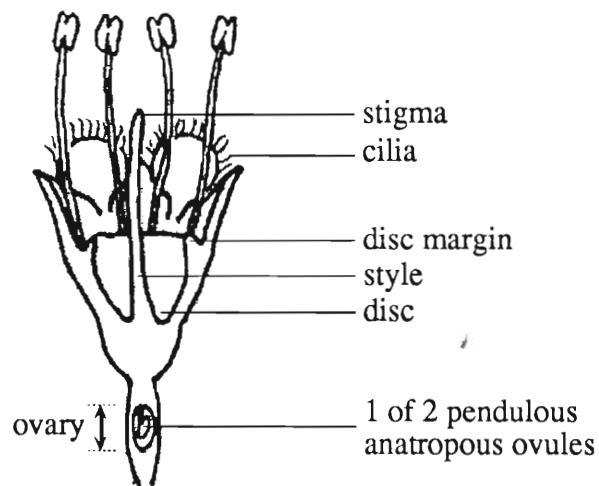
**Fig. A.1.8** Upper hypanthium shapes



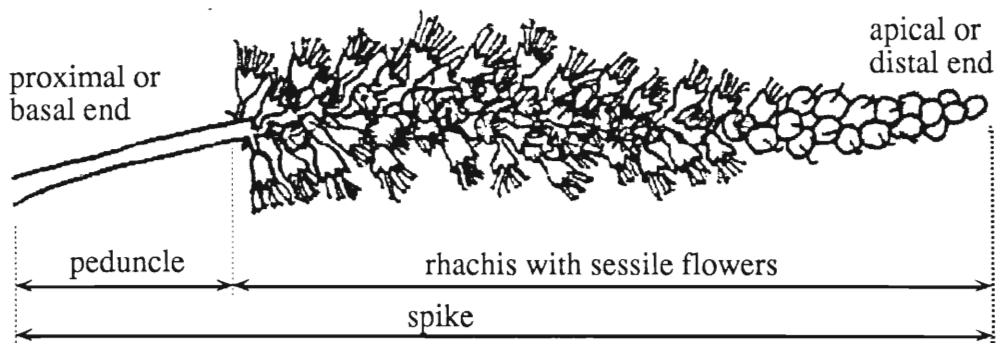
**Fig. A.1.9** Petal shapes



**Fig. A.1.10** Generalised flower - external view  
(reference: Cronquist, 1981)

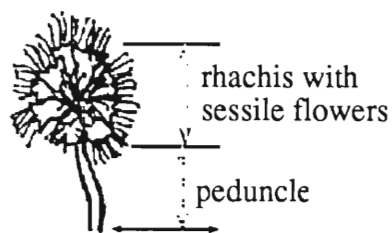


**Fig. A.1.11** Generalised flower - longitudinal section  
(reference: Cronquist, 1981)



**Fig. A.1.12** Elongated spicate inflorescence

(reference: Carr, 1988)



**Fig. A.1.13** Subcapitate spicate inflorescence

(reference: Carr, 1988)

## A.2 Original character list

The order of character states is not important in this work as each has equal rank. These states have thus been reordered here (slightly differently than for the list used in data collection) for greater clarity and readability. Numbering of characters has also been neatened.

### ***COMBRETUM* CHARACTERISTICS**

#### **1 BRANCH**

- 1.1 Age
  - young
  - mature
- 1.2 Twining
  - not observed or recorded by collector
  - observed
  - recorded by collector, but not observed on specimen
- 1.3 Pairs of sharply pointed lateral branchlets
  - absent
  - present
- 1.4 Texture
  - smooth
  - ridged
  - conspicuously ridged
  - shallowly fissured
  - deeply fissured
  - smooth to flaking
- 1.5 Bark
  - flakes
  - strips
  - flakes and strips
  - does not flake or strip
- 1.6 Bark outer colour
  - light-grey
  - dark-grey
  - grey-brown
  - golden-brown
  - golden-brown to reddish-brown
  - grey to rust-brown
  - rust-brown
  - reddish-brown
  - golden-brown to rust-brown
  - dark-brown to black
  - golden-brown to black-brown
  - grey to black



- 1.7 Tissue underlying flaked or stripped bark - colour
  - light-grey
  - dark-grey
  - grey-brown
  - golden-brown
  - golden-brown to reddish-brown
  - grey to rust-brown
  - rust-brown
  - reddish-brown
  - not visible
- 1.8 Hairs on outer bark (except at bases of petioles)
  - absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 1.9 Hair colour
  - silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 1.10 Scales on outer bark
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
  - considerably lepidote at nodes, otherwise scales absent
- 1.11 Scales on branch, if densely lepidote
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion

- 1.12 Scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 1.13 Axillary bud colour
- light-brown
  - dark-brown
  - dark-brown to black
  - rust-brown
  - reddish-brown
  - grey to brown
  - grey to black
- 1.14 Axillary buds glutinous
- no
  - yes
- 1.15 Axillary bud hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 1.16 Axillary bud hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown

- 1.17 Axillary bud scales
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
- 1.18 Axillary bud scales if densely lepidote
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 1.19 Axillary bud scale colour
  - silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 1.20 Circular projections left behind after leaf fall
  - not observed
  - prominent
  - present, but not prominent
- 1.21 Dense tufts of hairs at bases of some petioles
  - not observed
  - observed
- 1.22 Glutinous secretion on branch
  - not observed
  - observed
- 1.23 Shape in cross-section
  - roughly circular
  - roughly square
  - roughly pentangular
  - roughly hexagonal
  - roughly oval
  - flattened
  - circular to flattened

## 2 BRANCHLET

- 2.1 Age
  - young
  - mature
- 2.2 Twining
  - not observed or recorded by collector
  - observed
  - recorded by collector, but not observed on specimen
- 2.3 Texture
  - smooth
  - ridged
  - conspicuously ridged
  - shallowly fissured
  - deeply fissured
  - smooth to flaking
- 2.4 Bark
  - flakes
  - strips
  - flakes and strips
  - does not flake or strip
- 2.5 Bark outer colour
  - light-grey
  - dark-grey
  - grey-brown
  - golden-brown
  - golden-brown to reddish-brown
  - grey to rust-brown
  - rust-brown
  - reddish-brown
  - golden-brown to rust-brown
  - dark-brown to black
  - golden-brown to black-brown
  - grey to black
- 2.6 Tissue underlying flaked or stripped bark - colour
  - light-grey
  - dark-grey
  - grey-brown
  - golden-brown
  - golden-brown to reddish-brown
  - grey to rust-brown
  - rust-brown
  - reddish-brown
  - not visible

- 2.7 Hairs on outer bark (except at bases of petioles)
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 2.8 Hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 2.9 Scales on outer bark
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
  - considerably lepidote at nodes, otherwise scales absent
- 2.10 Branchlet scales, if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 2.11 Scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 2.12 Axillary bud colour
  - light-brown
  - dark-brown
  - dark-brown to black
  - rust-brown
  - reddish-brown
  - grey to brown
  - grey to black
- 2.13 Axillary buds glutinous
  - no
  - yes
- 2.14 Axillary bud hairs
  - absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 2.15 Axillary bud hair colour
  - silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 2.16 Axillary bud scales
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 2.17 Axillary bud scales,
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion

- 2.18 Axillary bud scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 2.19 Circular projections left behind after leaf fall
- not observed
  - prominent
  - present, but not prominent
- 2.20 Dense tufts of hairs at bases of some petioles
- not observed
  - observed
- 2.21 Glutinous secretion on branchlet
- not observed
  - observed
- 2.22 Shape in cross-section
- roughly circular
  - roughly square
  - roughly pentagonal
  - roughly hexagonal
  - roughly oval
  - flattened
  - circular to flattened

### 3 LEAF

- 3.1 Age
- young
  - mature
- 3.2 Arrangement
- opposite
  - sub-opposite
  - opposite to sub-opposite
  - 3-4-verticillate
  - alternate
  - opposite to alternate
  - opposite to 3-4-verticillate
- 3.3 Petiole length
- ..... mm

- 3.4 Petiole hairs
  - absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 3.5 Petiole hair colour
  - silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 3.6 Petiole scales
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 3.7 Petiole scales, if densely lepidote
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 3.8 Petiole scale colour
  - silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres



- 3.9 Lamina shape
  - elliptic
  - narrowly-elliptic
  - broadly-elliptic
  - ovate-elliptic
  - oblong-elliptic
  - elliptic to oblong
- 3.10 Lamina shape
  - obovate
  - slightly obovate
  - obovate-elliptic
- 3.11a Lamina length
  - ..... mm
- 3.11b Lamina width
  - ..... mm
- 3.12 Lamina texture
  - coriaceous
  - subcoriaceous
  - papyraceous
- 3.13 Margin down-rolled
  - absent
  - present
  - conspicuously present
- 3.14 Margin
  - entire
  - ciliate
- 3.15 Margin wavy
  - absent
  - slightly
  - conspicuously
- 3.16 Leaf apex
  - bluntly-acuminate
  - pointed-acuminate
  - mucronate
  - mucronulate
  - apiculate
  - twisted
  - mucronate or mucronulate
  - mucronate and twisted
  - apiculate to acuminate
- 3.17 Leaf apex
  - acute
  - retuse
  - rounded
  - obtuse
  - retuse or rounded
  - acute or rounded
  - acuminate
  - obtuse or rounded
  - acute to obtuse
  - acute to retuse

- 3.18 Leaf base
- cuneate
  - narrowly cuneate
  - cordate to subcordate
  - rounded to subcordate
  - oblique
  - obtuse
  - rounded
  - oblique to subcordate
  - oblique to rounded
  - oblique to cuneate
  - obtuse to cuneate
- 3.19 Number of pairs of lateral veins  
.....
- 3.20 Adaxial and abaxial surfaces
- not easily distinguishable with a dissecting microscope
  - relatively easily distinguishable with a dissecting microscope

### ***LEAF ADAXIAL SURFACE***

- 3.21 Colour
- shiny
  - dull
- 3.22 Colour
- light-green
  - dark-green
  - silvery-green
  - grey-green
  - yellow-green
  - brown
  - reddish-brown
  - olive-green
  - rust-green
- 3.23 Reticulation
- raised
  - conspicuously raised
  - sunken
  - plane
  - more or less plane
  - midrib more or less plane, primary lateral veins raised
  - midrib sunken, primary lateral veins more or less plane
  - midrib sunken, primary lateral veins raised
  - midrib raised, primary lateral veins more or less plane
- 3.24 Intersecondary veins
- raised
  - conspicuously raised
  - sunken
  - plane
  - more or less plane
  - obscured by scales



- 3.25 Domatia on midrib
  - absent
  - present
- 3.26 Domatia on branch veins
  - absent
  - present
- 3.27 Glands in axils of veins
  - absent
  - sparse
  - dense
  - only present in axils along midrib
- 3.28 Hair distribution
  - in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and branch veins
  - along midrib and in axils of midrib and primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by scales
- 3.29 Lamina island hairs
  - absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
  - tomentulose along secondary and intersecondary veins, otherwise sparse
- 3.30 Lamina island hair colour
  - silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown

- 3.31 Midrib hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 3.32 Midrib hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 3.33 Primary lateral vein hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely pubescent
- 3.34 Hair concentration in axils of midrib and primary lateral veins
- absent
  - sparse
  - considerable
  - dense
- 3.35 Hair concentration in axils of primary lateral veins and secondary lateral veins
- absent
  - sparse
  - considerable
  - dense
- 3.36 Scale concentration in axils of midrib and primary lateral veins
- absent
  - sparse
  - considerable
  - dense
  - obscured by hairs

- 3.37 Scale concentration in axils of primary lateral veins and secondary lateral veins
- absent
  - sparse
  - considerable
  - dense
  - obscured by hairs
- 3.38 Scale distribution
- in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib and in axils of midrib and main primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by hairs
- 3.39 Lamina island scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
  - densely lepidote on veins, considerably lepidote in between veins
- 3.40 Lamina island scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 3.41 Lamina island scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 3.42 Midrib scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 3.43 Midrib scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 3.44 Midrib scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 3.45 Primary lateral vein scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 3.46 Scales impressed
- not observed
  - observed
- 3.47 Scale shape
- disc
  - bowl
  - disc- to bowl
- 3.48 Scale diameter  
.....  $\mu\text{m}$
- 3.49 Scale outline
- wavy
  - smooth
  - scalloped
- 3.50 Number of cells per scale  
.....

- 3.51 Number of radial walls in surface view  
.....
- 3.52 Number of tangential cells in surface view  
.....
- 3.53 Papillae-  
  - absent
  - sparse
  - considerable number
- 3.54 Exudate  
  - absent
  - present

### ***LEAF ABAXIAL SURFACE***

- 3.55 Colour  
  - shiny
  - dull
- 3.56 Colour  
  - light-green
  - dark-green
  - silvery-green
  - grey-green
  - yellow-green
  - brown
  - reddish-brown
  - olive-green
  - rust-green
- 3.57 Reticulation  
  - raised
  - conspicuously raised
  - sunken
  - plane
  - more or less plane
  - midrib more or less plane, primary lateral veins raised
  - midrib sunken, primary lateral veins more or less plane
  - midrib sunken, primary lateral veins raised
  - midrib raised, primary lateral veins more or less plane
- 3.58 Intersecondary veins  
  - raised
  - conspicuously raised
  - sunken
  - plane
  - more or less plane
  - obscured by scales
- 3.59 Domatia on midrib  
  - absent
  - present
- 3.60 Domatia on lateral veins  
  - absent
  - present

- 3.61 Glands in axils of veins
- absent
  - sparse
  - dense
  - only present in axils along midrib
- 3.62 Hair distribution
- in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib and in axils of midrib and primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by scales
- 3.63 Lamina island hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
  - tomentulose along secondary and intersecondary veins, otherwise sparse
- 3.64 Lamina island hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown



- 3.65 Midrib hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 3.66 Midrib hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 3.67 Primary lateral vein hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 3.68 Hair concentration in axils of midrib and primary lateral veins
- absent
  - sparse
  - considerable
  - dense
- 3.69 Hair concentration in axils of primary lateral veins and secondary lateral veins
- absent
  - sparse
  - considerable
  - dense
- 3.70 Scale concentration in axils of midrib and primary lateral veins
- absent
  - sparse
  - considerable
  - dense
  - obscured by hairs

- 3.71 Scale concentration in axils of primary lateral veins and secondary lateral veins
- absent
  - sparse
  - considerable
  - dense
  - obscured by hairs
- 3.72 Scale distribution
- in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib and in axils of midrib and primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by hairs
- 3.73 Lamina island scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
  - densely lepidote on veins, considerably in between veins
- 3.74 Lamina island scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 3.75 Lamina island scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 3.76 Midrib scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 3.77 Midrib scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 3.78 Midrib scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 3.79 Primary lateral vein scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 3.80 Scales impressed
- not observed
  - observed
- 3.81 Scale shape
- disc
  - bowl
  - disc- to bowl
- 3.82 Scale diameter  
.....  $\mu\text{m}$
- 3.83 Scale outline
- wavy
  - smooth
  - scalloped
- 3.84 Number of cells per scale  
.....

- 3.85 Number of radial walls in surface view  
.....
- 3.86 Number of tangential cells in surface view  
.....
- 3.87 Papillae.  
  - absent
  - sparse
  - considerable number
- 3.88 Exudate  
  - absent
  - present

## 4 INFLORESCENCE

- 4.1 Inflorescence type  
  - spike
  - raceme
  - panicle
- 4.2 Inflorescence if spike  
  - elongated
  - subcapitate
  - glomeruliform
- 4.3 Inflorescence arrangement  
  - axillary
  - extra-axillary
  - terminal
  - terminal and axillary
- 4.4 Inflorescence glutinous  
  - not observed
  - observed
- 4.5 Rhachis hairs  
  - absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent

- 4.6 Rhachis hair colour
  - silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 4.7 Rhachis scales
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 4.8 Rhachis scales if densely lepidote
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 4.9 Rhachis scale colour
  - silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 4.10 Ratio of peduncle length to rhachis length
  - .....
- 4.11 Flower attachment
  - sessile
  - pedicellate
- 4.12 Pedicel length
  - ..... mm
- 4.13 Bracts
  - not observed
  - observed
- 4.14 Bract shape
  - filiform
- 4.15 Bract length
  - ..... mm

### ***HYPANTHIUM***

- 4.16 Lower hypanthium markedly prolonged beyond ovary
  - not observed
  - observed
- 4.17 Lower hypanthium colour
  - dark-brown to black
- 4.18a Lower hypanthium length  
..... mm
- 4.18b Lower hypanthium width  
..... mm
- 4.19 Lower hypanthium outer hairs
  - absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.20 Lower hypanthium outer hair colour
  - silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silver to brown
- 4.21 Lower hypanthium outer scales
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 4.22 Lower hypanthium if outer scales densely lepidote
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping

- 4.23 Lower hypanthium outer scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 4.24 Lower hypanthium glands
- not observed
  - observed
- 4.25 Lower hypanthium gland shape
- 4.26 Upper hypanthium shape
- cupuliform
  - infundibular
  - patelliform
- 4.27 Upper hypanthium colour
- dark-brown to black
  - golden to brown
- 4.28a Upper hypanthium length  
..... mm
- 4.28b Upper hypanthium width  
..... mm
- 4.29 Upper hypanthium outer hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.30 Upper hypanthium outer hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown

- 4.31 Upper hypanthium outer scales
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 4.32 Upper hypanthium outer scales if densely lepidote
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 4.33 Upper hypanthium outer scale colour
  - silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 4.34 Upper hypanthium glands
  - not observed
  - observed
- 4.35 Upper hypanthium gland shape

***BASE OF RECEPTACLE, GYNOECIUM AND ACCESSORY TISSUE***

- 4.36 Ovary texture
  - ridged
  - smooth
- 4.37a Ovary length
  - ..... mm
- 4.37b Ovary width
  - ..... mm
- 4.38 Distance from base of style to placenta
  - ..... mm
- 4.39 Number of ovules
  - two
  - .....
- 4.40 Ovule position
  - pendulous
  - .....



- 4.41 Ovule inclination
  - anatropous
  - .....
- 4.42 Style attachment
  - free
  - adnate
- 4.43 Style length
  - ..... mm
- 4.44 Sigma slightly expanded
  - not observed
  - observed

### ***CALYX***

- 4.45 Sepal number
  - 4
  - 5
- 4.46 Sepal colour
  - inconspicuous
  - showy
- 4.47 Sepal colour
  - green
  - yellow-green
  - golden to golden-brown
  - rust-brown
  - reddish-brown
  - light-brown
  - dark-brown to black
- 4.48 Sepal shape
  - deltoid
  - subulate
  - filiform
- 4.49a Sepal length
  - ..... mm
- 4.49b Sepal width
  - ..... mm
- 4.50 Sepal glands
  - not observed
  - observed

- 4.51 Sepal outer hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.52 Sepal outer hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 4.53 Sepal outer scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 4.54 Sepal outer scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 4.55 Sepal outer scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 4.56    Sepals ciliate at apex
  - not observed
  - observed
- 4.57    Sepals ciliate at margin
  - not observed
  - observed
- 4.58    Sepal inner hairs
  - absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.59    Sepal hair colour
  - silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 4.60    Sepal inner scales
  - absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 4.61    Sepal inner scales if densely lepidote
  - mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion

- 4.62    Sepal inner scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

### ***COROLLA***

- 4.63    Petal number
- 4
  - 5
- 4.64    Petal colour
- inconspicuous
  - showy
- 4.65    Petal colour
- green
  - yellow-green
  - golden to golden-brown
  - rust-brown
  - reddish-brown
  - light-brown
  - dark-brown
  - yellow
  - cream
  - creamy-green
- 4.66    Petal shape
- elliptic
  - linear-elliptic
  - ovate
  - obovate
- 4.67    Petal shape
- subreniform
  - sub-circular
  - obtriangular
  - spatulate
- 4.68a   Petal length
- ..... mm
- 4.68b   Petal width
- ..... mm

- 4.69 Petal glandular
- not observed
  - observed
- 4.70 Petal outer hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.71 Petal outer hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 4.72 Petal outer scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 4.73 Petal outer scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion

- 4.74 Petal outer scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres
- 4.75 Petals ciliate at apex
- not observed
  - observed
- 4.76 Petals ciliate at margin
- not observed
  - observed
- 4.77 Petal inner hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.78 Petal inner hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 4.79 Petal inner scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion

- 4.80 Petal inner scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 4.81 Petal inner scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

*DISC (glandular tissue between base filaments and ovary)*

- 4.82 Disc margin
- free
  - adnate
- 4.83 Disc outer hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.84 Disc outer hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown

- 4.85 Disc inner hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 4.86 Disc inner hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 4.87 Disc notched for insertion of filaments
- not observed
  - observed
- 4.88 Disc colour
- green
  - yellow-green
  - golden-brown
  - rust-brown
  - reddish-brown
  - light-brown
  - dark-brown
  - yellow
  - cream
  - creamy-green

### ***ANDROECIUM***

- 4.89 Stamen insertion
- inside upper hypanthium
  - at upper hypanthium margin
  - inside upper hypanthium where disc joins hypanthium
- 4.90 Stamen number
- 8
  - 10
- 4.91 Stamen series
- 1
  - 2
  - apparently 1, but actually 2 not clearly distinguished



- 4.92 Stamens if 2-seriate, antipetalous whorl and antisepalous whorl
- absent
  - present
- 4.93a Filament length  
..... mm
- 4.93b Anther length  
..... mm
- 4.93c Anther width  
..... mm
- 4.94 Anther attachment
- basifixed
  - dorsifixed
  - versatile

## 5 FRUIT

- 5.1 Age
- young
  - mature
- 5.2 Wing number
- 4
  - 5
- 5.3a Fruit length  
..... mm
- 5.3b Fruit width  
..... mm
- 5.4 Wing texture
- ridged with radial striations
  - smooth
- 5.5 Wing texture
- coriaceous
  - subcoriaceous
  - papyraceous
- 5.6 Fruit attachment
- sessile
  - stipitate
- 5.7 Stipe length  
..... mm
- 5.8 Peg (style remains)
- absent
  - very short or absent
  - present
- 5.9 Peg length  
..... mm

- 5.10 Wing colour
- light-brown
  - golden-brown
  - dark-brown
  - reddish-brown
  - rust-brown
  - grey-brown
  - reddish-grey
  - dark-purple
  - pink to dark-red
  - dark-red
  - green
  - yellow-green
  - golden-brown to dark-brown
  - golden-brown to reddish-brown
  - golden
  - golden to pink
- 5.11 Body colour
- light-brown
  - golden-brown
  - dark-brown
  - reddish-brown
  - rust-brown
  - grey-brown
  - reddish-grey
  - dark-purple
  - pink to dark-red
  - dark-red
  - green
  - yellow-green
  - golden-brown to dark-brown
  - golden-brown to reddish-brown
  - golden
  - golden to pink
- 5.12 Fruit with metallic appearance
- not observed
  - observed
- 5.13 Fruit glutinous
- not observed
  - observed on body and wings
  - observed only on body

- 5.14 Rhachis hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 5.15 Rhachis hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 5.16 Rhachis scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 5.17 Rhachis scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 5.18 Rhachis scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 5.19 Wing hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 5.20 Wing hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 5.21 Wing scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 5.22 Wing scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 5.23 Wing scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 5.24 Stipe hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 5.25 Stipe hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 5.26 Stipe scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 5.27 Stipe scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 5.28 Stipe scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 5.29 Body hairs
- absent
  - pubescent
  - sparsely pubescent
  - sparsely pubescent to pilose
  - tomentose
  - tomentulose
  - hirsute
  - pilose
  - sparse
  - obscured by scales
  - sparse to pilose
  - sparse to hirsute
  - sparse to tomentulose
  - sparse to sparsely-pubescent
- 5.30 Body hair colour
- silvery
  - golden
  - golden to rust
  - light-grey
  - dark-grey
  - silvery to brown
- 5.31 Body scales
- absent
  - sparsely lepidote
  - considerably lepidote
  - densely lepidote
  - obscured by hairs
  - obscured by glutinous secretion
- 5.32 Body scales if densely lepidote
- mainly overlapping
  - contiguous or overlapping
  - mainly apart
  - apart to contiguous
  - apart or contiguous or overlapping
  - obscured by glutinous secretion
- 5.33 Body scale colour
- silvery
  - silver-green
  - grey-green
  - golden to dark-green
  - silvery to golden-brown
  - silvery, some with rust centres
  - golden to brown
  - golden to rust-brown
  - rust-brown
  - obscured by glutinous secretion
  - silvery to dark-grey
  - silvery to black
  - golden
  - golden, some with rust centres

- 5.34 Infructescence arrangement
- axillary
  - extra-axillary
  - terminal
  - terminal and axillary
- 5.35 Fruit outline
- elliptic
  - broadly elliptic
  - circular to sub-circular
  - sub-circular
  - elliptic to sub-circular
  - broadly elliptic to sub-circular
  - oblate

### **A.3 Final character list**

The order of character states is not important in this work as each has equal rank. These states have thus been reordered here (slightly differently than for the list used in data collection) for greater clarity and readability. Numbering of characters has also been neatened.

## ***COMBRETUM* CHARACTERISTICS**

### **1 BRANCHES**

- 1.1 Twining
  - not observed on specimen or recorded by collector
  - observed on specimen or recorded by collector
- 1.2 Pairs of pointed lateral branchlets
  - absent
  - often present
- 1.3 Bark
  - flakes
  - strips
  - flakes and strips
  - does not flake or strip
- 1.4 Circular projections left behind after leaf fall
  - absent
  - present
- 1.5 Dense tufts of hairs at bases of some petioles
  - absent
  - present

### **2 BRANCHLETS**

- 2.1 Twining
  - not observed on specimen or recorded by collector
  - observed on specimen or recorded by collector
- 2.2 Bark
  - flakes
  - strips
  - flakes and strips
  - does not flake or strip
- 2.3 Dense tufts of hairs at bases of some petioles
  - absent
  - present



### 3 LEAVES

- 3.1 Arrangement
- opposite or subopposite
  - opposite to alternate
  - usually opposite, sometimes 3-verticillate
- 3.2 Petiole length  
..... mm
- 3.3 Petiole hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 3.4 Petiole scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 3.5 Petiole scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 3.6 Petiole scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 3.7 Lamina shape
- narrowly-elliptic
  - elliptic
  - broadly-elliptic
  - ovate-elliptic
  - oblong-elliptic
- 3.8 Lamina shape
- slightly obovate
  - obovate
  - obovate-elliptic
- 3.9a Lamina length  
..... mm
- 3.9b Lamina width  
..... mm
- 3.9c Ratio of lamina length to lamina width  
.....
- 3.9d Ratio of lamina length to petiole length  
.....

- 3.10 Lamina texture
  - papyraceous
  - subcoriaceous
  - coriaceous
- 3.11 Margin down-rolled
  - absent
  - present
- 3.12 Margin
  - entire
  - ciliate or sometimes ciliate
- 3.13 Leaf apex
  - bluntly-acuminate
  - pointed-acuminate
  - acute
  - apiculate or acuminate
  - apiculate
- 3.14 Leaf apex
  - retuse
  - rounded or obtuse
  - retuse, rounded or obtuse
- 3.15 Leaf base
  - cuneate
  - cuneate, obtuse or rounded
  - obtuse or rounded
  - rounded or subcordate
  - cordate or subcordate
  - oblique
  - oblique, subcordate or rounded
  - oblique or cuneate
- 3.16 Number of pairs of lateral veins
 

.....
- 3.17 Adaxial and abaxial surfaces
  - not easily distinguishable with the naked eye
  - relatively easily distinguishable with the naked eye

### ***LEAF ADAXIAL SURFACES***

- 3.18 Reticulation
  - raised
  - recessed
  - more or less plane
  - midrib more or less plane, primary lateral veins raised
  - midrib recessed, primary lateral veins more or less plane
  - midrib recessed, primary lateral veins raised
  - midrib raised, primary lateral veins more or less plane
- 3.19 Intersecondary veins
  - raised
  - recessed
  - more or less plane
  - obscured by scales

- 3.20 Bullae in axils along midrib and/or in axils of lateral veins
- absent
  - sparse
  - commonly occurring
- 3.21 Hair distribution
- in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and branch veins
  - along midrib and in axils of midrib and primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by scales
- 3.22 Lamina island hairs
- absent
  - sparsely distributed
  - moderately distributed
  - moderately distributed along secondary and intersecondary veins, otherwise sparse
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 3.23 Midrib hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 3.24 Primary lateral vein hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 3.25 Hair concentration of tufts in axils of midrib and primary lateral veins
- usually or always absent
  - sparse
  - considerable to dense

- 3.26 Hair concentration of tufts in axils of primary lateral veins and secondary lateral veins
- usually or always absent
  - sparse
  - considerable to dense
- 3.27 Scale distribution
- in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib and in axils of midrib and main primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by hairs
  - obscured by glutinous secretion
- 3.28 Lamina island scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 3.29 Lamina island scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 3.30 Lamina island scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 3.31 Midrib scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 3.32 Midrib scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping

- 3.33 Midrib scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 3.34 Primary lateral vein scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 3.35 Scales of lamina impressed
- absent
  - sometimes present
- 3.36 Scale shape
- disc or bowl
  - dome
  - not clearly visible
- 3.37 Scale diameter  
.....  $\mu\text{m}$
- 3.38 Scale outline
- smooth or slightly scalloped
  - conspicuously scalloped
- 3.39 Number of cells per scale  
.....
- 3.40 Number of radial walls in surface view  
.....
- 3.41 Number of tangential walls in surface view  
.....
- 3.42 Lamina exudate
- absent
  - present

### ***LEAF ABAXIAL SURFACES***

- 3.43 Reticulation
- raised
  - recessed
  - more or less plane
  - midrib more or less plane, primary lateral veins raised
  - midrib recessed, primary lateral veins more or less plane
  - midrib recessed, primary lateral veins raised
  - midrib raised, primary lateral veins more or less plane
- 3.44 Intersecondary veins
- raised
  - recessed
  - more or less plane
  - obscured by scales

- 3.45 Bullae in axils along midrib and/or in axils of lateral veins
- absent
  - sparsely distributed
  - commonly occurring
- 3.46 Hair distribution
- in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib and in axils of midrib and primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by scales
- 3.47 Lamina island hairs
- absent
  - sparsely distributed
  - moderately distributed
  - moderately distributed along secondary and intersecondary veins, otherwise sparse
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 3.48 Midrib hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 3.49 Primary lateral vein hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 3.50 Hair concentration of tufts in axils of midrib and primary lateral veins
- usually or always absent
  - sparse
  - considerable to dense

- 3.51 Hair concentration of tufts in axils of primary lateral veins and secondary lateral veins
- usually or always absent
  - sparse
  - considerable to dense
- 3.52 Scale distribution
- in lamina islands only
  - along midrib only
  - along midrib and in lamina islands
  - along midrib and lateral veins only
  - along midrib, lateral veins and in lamina islands
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib and in axils of midrib and primary lateral veins
  - along midrib, lateral veins and in axils of midrib and primary lateral veins
  - along midrib, lateral veins, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib and in axils of midrib and primary lateral veins only
  - along midrib, in axils of midrib and primary lateral veins and in lamina islands
  - along midrib, lateral veins, in axils of midrib and primary lateral veins, in axils of primary lateral veins and secondary lateral veins, and in lamina islands
  - obscured by hairs
- 3.53 Lamina island scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 3.54 Lamina island scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 3.55 Lamina island scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 3.56 Midrib scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 3.57 Midrib scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping

- 3.58 Midrib scale colour
  - silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 3.59 Primary lateral vein scales
  - absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 3.60 Scales on lamina impressed
  - absent
  - sometimes present
- 3.61 Scale shape
  - disc or bowl
  - dome
  - not clearly visible
- 3.62 Scale diameter
 

.....  $\mu\text{m}$
- 3.63 Scale outline
  - smooth or slightly scalloped
  - conspicuously scalloped
- 3.64 Number of cells per scale
 

.....
- 3.65 Number of radial walls in surface view
 

.....
- 3.66 Number of tangential walls in surface view
 

.....
- 3.67 Lamina exudate
  - absent
  - present

## 4 INFLORESCENCE

- 4.1 Inflorescence type
  - spike
  - panicle
  - spike or panicle
- 4.2 Inflorescence if spike
  - elongated
  - subcapitate
- 4.3 Inflorescence arrangement
  - axillary
  - extra-axillary
  - terminal
  - terminal and/or axillary



- 4.4 Inflorescence glutinous
  - not observed
  - observed
- 4.5 Rhachis hairs
  - absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.6 Rhachis scales
  - absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 4.7 Rhachis scales if considerably to densely distributed
  - mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 4.8 Rhachis scale colour
  - silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 4.9 Ratio of peduncle length to rhachis length  
.....
- 4.10 Bracts
  - absent
  - present
- 4.11 Bract shape
  - linear or strap-shaped
  - linear to obovate
  - oblong or rectangular
  - obovate or club-shaped
- 4.12 Bract length  
..... mm

### ***HYPANTHIUM***

- 4.13 Lower hypanthium markedly prolonged beyond ovary
  - not observed
  - observed
- 4.14a Lower hypanthium length  
..... mm
- 4.14b Lower hypanthium width  
..... mm

- 4.15 Lower hypanthium outer hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.16 Lower hypanthium outer scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 4.17 Lower hypanthium if outer scales considerably to densely distributed
- contiguous or overlapping
  - mainly apart
  - apart to contiguous or overlapping
  - obscured by glutinous secretion
  - obscured by hairs
- 4.18 Lower hypanthium outer scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 4.19 Upper hypanthium shape
- flattened
  - cupuliform
  - infundibular
  - campanulate
  - campanulate or infundibular
  - campanulate or cupuliform
- 4.20a Upper hypanthium length  
..... mm
- 4.20b Upper hypanthium width  
..... mm
- 4.21 Upper hypanthium outer hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.22 Upper hypanthium outer scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion

- 4.23 Upper hypanthium outer scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 4.24 Upper hypanthium outer scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion

#### ***BASE OF RECEPTACLE, GYNOECIUM AND ACCESSORY TISSUE***

- 4.25a Ovary length  
..... mm
- 4.25b Ovary width  
..... mm
- 4.26 Distance from base of style to placenta  
..... mm
- 4.27 Style length  
..... mm
- 4.28 Stigma slightly expanded
- not observed
  - observed
- 4.29 Stalked scales on style
- absent
  - present

#### ***CALYX***

- 4.30a Sepal length  
..... mm
- 4.30b Sepal width  
..... mm
- 4.31 Sepal outer hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.32 Sepal outer scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion

- 4.33 Sepal outer scales if considerably to densely distributed
  - mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 4.34 Sepal outer scale colour
  - silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 4.35 Sepals ciliate at apex
  - not observed
  - observed
- 4.36 Sepals ciliate at margin
  - not observed
  - observed
- 4.37 Sepal inner hairs
  - absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.38 Sepal inner scales
  - absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 4.39 Sepal inner scales if considerably to densely distributed
  - mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 4.40 Sepal inner scale colour
  - silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion

### ***COROLLA***

- 4.41 Petal shape
  - elliptic
  - linear-elliptic
  - oblong
- 4.42 Petal shape
  - spatulate (not broadly)
  - spatulate (not broadly) and emarginate
  - broadly spatulate
  - broadly spatulate and lobed

- 4.43a Petal length  
..... mm
- 4.43b Petal width  
..... mm
- 4.44 Petal outer hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.45 Petal outer scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 4.46 Petal outer scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 4.47 Petal outer scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 4.48 Petals ciliate at apex
- not observed
  - observed
- 4.49 Petals ciliate at margin
- not observed
  - observed
- 4.50 Petal inner hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.51 Petal inner scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 4.52 Petal inner scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping

- 4.53 Petal inner scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion

*DISC (glandular tissue between base filaments and ovary)*

- 4.54 Disc margin
- free
  - adnate to upper hypanthium
- 4.55 Disc outer hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.56 Disc inner hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 4.57 Disc conspicuously notched for insertion of filaments
- not observed
  - observed

*ANDROECIUM*

- 4.58 Stamen insertion
- above disc margin
  - at or near disc margin
- 4.59 Stamen series
- clearly 2
  - apparently 1, but actually 2 not clearly distinguished
- 4.60a Filament length
- ..... mm
- 4.60b Anther length
- ..... mm
- 4.60c Anther width
- ..... mm

## 5 FRUIT

- 5.1a Fruit length (excluding peg)  
..... mm
- 5.1b Fruit width  
..... mm
- 5.2 Wing texture
- papyraceous
  - subcoriaceous
  - coriaceous
- 5.3 Stipe length  
..... mm
- 5.4 Peg (style remains)
- absent
  - very short or absent
  - present
- 5.5 Peg length  
..... mm
- 5.6 Wing colour
- golden to light-brown or golden-brown
  - golden-brown to dark-brown or rust-brown
  - golden to pinky-brown or reddish- or purple-brown
  - yellow-green
  - grey-brown or reddish-grey
  - dark-brown or rust-brown
  - dark-purple or dark-red
- 5.7 Body colour
- golden to light-brown or golden-brown
  - golden-brown to dark-brown or rust-brown
  - golden to pinky-brown or reddish- or purple-brown
  - yellow-green
  - grey-brown or reddish-grey
  - dark-brown or rust-brown
  - dark-purple or dark-red
- 5.8 Fruit glutinous
- not observed
  - observed only on body
  - observed on body and wings
- 5.9 Rhachis hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion

- 5.10 Rhachis scales
  - absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 5.11 Rhachis scales if considerably to densely distributed
  - mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 5.12 Rhachis scale colour
  - silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 5.13 Wing hairs
  - absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 5.14 Wing scales
  - absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 5.15 Wing scales if considerably to densely distributed
  - mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 5.16 Wing scale colour
  - silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 5.17 Stipe hairs
  - absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 5.18 Stipe scales
  - absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion



- 5.19 Stipe scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 5.20 Stipe scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 5.21 Body hairs
- absent
  - sparsely distributed
  - moderately distributed
  - considerably to densely distributed
  - obscured by scales
  - obscured by glutinous secretion
- 5.22 Body scales
- absent
  - sparsely distributed
  - considerably to densely distributed
  - obscured by hairs
  - obscured by glutinous secretion
- 5.23 Body scales if considerably to densely distributed
- mainly apart
  - apart to contiguous or overlapping
  - contiguous or overlapping
- 5.24 Body scale colour
- silvery or golden
  - silvery or golden, sometimes rust-brown or with rust-brown centres
  - silvery or golden to dark-grey or black
  - rust-brown
  - obscured by glutinous secretion
- 5.25 Fruit outline
- elliptic
  - broadly elliptic
  - elliptic or subcircular
  - circular or subcircular
  - oblate

**A.4 Data collection form**

This form corresponds with the final character list in Appendix A.3

***Combretum* data collection**

**Specimen:** *Combretum* .....

**Collector:** name: ..... number: .....

**Date of collection:** .....

**Height of specimen:**                      **Altitude:**

**Locality/District**

**Degree Reference:**

**Habitat:**

**Herbarium:**

- a NH
- b UDW
- c NBG
- d NU
- e J
- f PRE
- g SAM
- h BOL

**Notes:**



		4.35	a b	4.60c	.....mm
<b>HYPANTHIUM</b>		4.36	a b		
		4.37	a b c d e f	<b>FRUIT</b>	
4.13	a b	4.38	a b c d e		
4.14a	.....mm	4.39	a b c	5.1a	.....mm
4.14b	.....mm	4.40	a b c d e	5.1b	.....mm
4.15	a b c d e f			5.2	a b c
4.16	a b c d e	<b>COROLLA</b>		5.3	.....mm
4.17	a b c			5.4	a b c
4.18	a b c d e	4.41	a b c	5.5	.....mm
4.19	a b c d e f	4.42	a b c d	5.6	a b c d e f g
4.20a	.....mm	4.43a	.....mm	5.7	a b c d e f g
4.20b	.....mm	4.43b	.....mm	5.8	a b c
4.21	a b c d e f	4.44	a b c d e f	5.9	a b c d e f
4.22	a b c d e	4.45	a b c d e	5.10	a b c d e
4.23	a b c	4.46	a b c	5.11	a b c
4.24	a b c d e	4.47	a b c d e	5.12	a b c d e
		4.48	a b	5.13	a b c d e f
<b>BASE OF RECEPTACLE,</b>		4.49	a b	5.14	a b c d e
<b>GYNOECIUM AND</b>		4.50	a b c d e f	5.15	a b c
<b>ACCESSORY TISSUE</b>		4.51	a b c d e	5.16	a b c d e
		4.52	a b c	5.17	a b c d e f
4.25a	.....mm	4.53	a b c d e	5.18	a b c d e
4.25b	.....mm			5.19	a b c
4.26	.....mm	<b>DISC</b>		5.20	a b c d e
4.27	.....mm			5.21	a b c d e f
4.28	a b	4.54	a b	5.22	a b c d e
4.29	a b	4.55	a b c d e f	5.23	a b c
		4.56	a b c d e f	5.24	a b c d e
<b>CALYX</b>		4.57	a b	5.25	a b c d e
4.30a	.....mm	<b>ANDROECIUM</b>			
4.30b	.....mm				
4.31	a b c d e f	4.58	a b		
4.32	a b c d e	4.59	a b		
4.33	a b c	4.60a	.....mm		
4.34	a b c d e	4.60b	.....mm		

## **A.5 Computer Database program (TAXON)**

A computer database program (TAXON) was specified, designed and implemented for the following reasons:

- The amount of raw data produced by this study was too large for data processing by hand.
- Various checks were necessary to verify the integrity of the data.
- The data was required in several different formats for input into the NTSYS-pc and DELTA programs.
- Various operations on the data would be possible, such as editing, production of natural language descriptions, creating “average” specimens, and processing data subsets.
- The NTSYS-pc and DELTA programs were somewhat difficult to operate, and a user-friendly interface to them would make them more usable.

So that the program would be useful in future projects, it was designed in a totally general way to handle many different character types.

The program was written in Turbo Pascal 5.5 for the IBM-PC, and consists of approximately 14 000 lines of source code. The program was developed and used on a Mitac 386 computer with a math-coprocessor and hard disk.

The TAXON program consists of several parts:

### **A.5.1 Template creation and editing**

The template is a definition of each character and character state. A character is defined as being multi-state (including two-state) data, continuous (real-valued) data, or discrete (integer-valued) data. A facility to convert continuous and discrete character data to multi-state data is included. Bounds can be set on the data to prevent illegal values from being input.

Characters can be edited at any stage, new character states added and existing states removed without affecting the OTU data. Adding a new character will require editing of the OTU data to add in relevant data for each OTU. Deleting a character will also delete the values for that character in the OTU data.

Characters can be enabled and disabled at will for editing and processing purposes.

### **A.5.2 OTU (Operational Taxonomic Unit) Data creation and editing**

Once a template has been created, the user can enter data into the database. The user is prompted for the character data for a specimen (OTU) and the data is checked for correct values before being stored on disk.

The unit of storage is an OTU, which is identified by a unique, user-provided number and a descriptive label.

Various options are provided to display and edit the data on disk:

- Backup and restoring of data for integrity purposes.
- Merging of two databases into one.
- Saving the contents of the database in text format for manual checking and archiving purposes.
- Displaying lists of characters common to all OTUs.
- Merging specified OTUs into one representative average OTU.
- Creation of a natural language description of an OTU, based on the data and the character template.

### **A.5.3 Data export to third-party programs**

Character and OTU information can be exported (stored in another relevant format) for use by other programs, in particular DELTA and NTSYS-pc.

### **A.5.4 Use of third-party programs**

NTSYS-pc and DELTA can be executed directly from the TAXON program, and the user is prompted for all required parameters. This reduces the complexity of operation of these programs to a few menu selections, with the TAXON program handling creation and deletion of parameters, data and temporary files. In addition, the TAXON program will also interpret the output data files from these programs and display the data in a more user-friendly fashion.

In particular, there exist menu options to display phenograms and cladograms and compute cophenetic correlation coefficients via NTSYS-pc, and produce natural language descriptions via DELTA.

## **A.6 Numerical Taxonomy program (NTSYS-pc)**

There was only one freely available numerical taxonomy program available to the writer to perform phenetic taxonomic analysis, namely NTSYS-pc. The version used was 1.2.

NTSYS-pc is a suite of programs that allow various types of multivariate statistical analyses to be performed on taxonomic data on an IBM-PC or compatible. The programs available in the version used include:

### **COPH**

Compute a cophenetic value matrix to verify the applicability of a particular selection of similarity/dissimilarity indices and clustering techniques.

### **MXCOMP**

Compares two symmetrical matrices and computes their matrix correlation. Used in conjunction with COPH above. The correlation coefficient takes on absolute values between 0 and 1, with 0 being totally uncorrelated and 1 being totally correlated. A value of between 0.8 and 1 usually indicates that a statistically meaningful correlation has been achieved.

### **SAHN**

Performs the various clustering algorithms that Sneath and Sokal (1973) refer to as: Sequential, Agglomerative, Hierarchical and Nested clustering methods.

### **SIMINT**

Computes various similarity or dissimilarity indices for continuous (interval measure) quantitative data. Since the majority of the data in this study was unordered multi-state, any data of this form were converted into multi-state data by dividing the range into numbers of equal sized segments.

### **SIMQUAL**

Computes various association coefficients for qualitative and data with unordered states.



## **STAND**

Performs a linear transformation of a data matrix so as to eliminate the effects of different scales of measurements. Since the processed data was converted to unordered multi-state form, this was not necessary.

## **TREE**

Displays a tree in the form of a phenogram or cladogram.

Other programs in the NTSYS-pc suite were not used and are not discussed here.

### **A.6.1 Creation of a Phenogram**

The SIMQUAL or SIMINT programs are used to convert a rectangular data matrix (character values vs. OTUs) into a symmetrical similarity/dissimilarity matrix. If the data consists of continuous quantitative values then the STAND program should be used initially to standardise the values.

The SAHN program then performs cluster analysis on the similarity/dissimilarity matrix to create a “tree matrix”.

The TREE or TREEG (graphics) programs can then be used to print or display the tree matrix in the form of a phenogram.

In order to test the statistical veracity of the analysis, the tree matrix should be compared against a matrix of cophenetic values produced by the CPH program. The comparison is done using the MXCOMP program. This produces a cophenetic correlation coefficient.

### **A.6.2 Similarity/Dissimilarity Measures**

These measures compute a “distance” between two OTUs, based on the number of corresponding characters that match. The only measures used in this study (on multi-state data) are described below, where:

$m$  = no. of matches

$u$  = no. of mismatches

$n$  = total number of characters ( $n = m + u$ )

**Simple matching coefficient:  $m/n$** 

This is one of the oldest and simplest coefficients, introduced by Sokal and Michener (1958). Obviously it will have a value of 0 for totally mismatched OTUs and 1 for identical OTUs.

 **$2m/(n+m)$  & Hamann's coefficient:  $(m-u)/n$** 

Similar measures having 0 for totally mismatched OTUs and 1 for identical OTUs.

**Rodgers & Tanimoto's distance:  $m/(n+u)$** 

This has similar properties to the simple matching coefficient,  $m/n$ , above and is preferred by Sneath and Sokal (1973).

 **$m/u$** 

Gives a value of 0 for totally mismatched OTUs and an unlimited value ( $\infty$ ) for identical OTUs.

**A.6.3 Clustering Techniques**

The various clustering techniques used in this study were:

**Unweighted pair-group method, arithmetic averages (UPGMA)**

This is the most commonly used clustering method. The average similarity/dissimilarity of a new OTU is compared with each OTU of an existing cluster, without any weighting being applied to the cluster OTUs, to determine whether the new OTU should be a member of that cluster.

This technique does not work well if there is an imbalance between the numbers of (nearly) identical OTUs.

**Weighted pair-group method, arithmetic averages (WPGMA)**

This differs from UPGMA by weighting the member most recently admitted to a cluster equal with all previous members. This method increases the average distance between clusters over that of UPGMA.

**Weighted pair-group method, Spearman's averages (WPGMS)**

This technique utilises Spearman's sums of variables, and is similar to WPGMA, but causes a high degree of distortion of the original similarity matrix.

**Single-link method (SINGL)**

For an OTU to join an already existing cluster, it must have a similarity equal to the closest member within that cluster. Thus, connections between OTUs and clusters, and between two clusters are established by single links between pairs of OTUs.

**Complete-link method (COMPL)**

For an OTU to join an already existing cluster, it must have a similarity to that cluster equal to its similarity to the farthest member within that cluster. When two clusters join, their similarity is that existing between the farthest pair of members, one in each cluster.

**Flexible clustering (FLEXI)**

This technique allows the clustering method to adjust the method of clustering by means of a parameter,  $\beta$ .  $\beta$  varies between -1 and 1.

## **A.7 Tables of character comparison**

Tables comparing averaged characters selected for their apparent taxonomic potential were constructed for each taxon examined using scales, fruits, inflorescences and leaves; mainly for the purpose of key construction.

In all tables listed here, examined taxa are in alphabetical order.

**Table A.7.1a** A comparison of averaged scale characters selected for their taxonomic potential in the taxa examined

	No. of Cells					No. of Radial Walls					No. of Tangential Walls				
	≤8	9-16	17-29	30-49	≥50	≤8	9-16	17-29	30-49	≥50	≤8	9-16	17-29	30-49	≥50
<i>C. albopunctatum</i>		✓				✓						✓			
<i>C. apiculatum</i> ssp. <i>apiculatum</i>	✓	✓				✓						✓			
<i>C. apiculatum</i> ssp. <i>leutweinii</i>		✓				✓						✓			
<i>C. caffrum</i>		✓					✓					✓			
<i>C. celastroides</i> ssp. <i>celastroides</i>					✓					✓					✓
<i>C. celastroides</i> ssp. <i>orientale</i>					✓					✓					✓
<i>C. collinum</i> ssp. <i>coriaceum</i>				✓					✓					✓	
<i>C. collinum</i> ssp. <i>ondongense</i>				✓					✓					✓	
<i>C. collinum</i> ssp. <i>suluense</i>				✓					✓					✓	
<i>C. collinum</i> ssp. <i>taborense</i>				✓					✓					✓	
<i>C. edwardsii</i>		✓					✓					✓			
<i>C. elaeagnoides</i>				✓				✓						✓	
<i>C. engleri</i>		✓					✓					✓			
<i>C. erythrophyllum</i>		✓					✓					✓			
<i>C. hereroëns</i> var. <i>hereroëns</i>		✓				✓						✓			
<i>C. hereroëns</i> var. <i>villosissimum</i>		✓				✓						✓			
<i>C. imberbe</i>					✓					✓					✓
<i>C. kraussii</i>	✓					✓					✓				
<i>C. mkuzense</i>			✓				✓						✓		
<i>C. moggii</i>				✓				✓						✓	
<i>C. molle</i>		✓				✓						✓			
<i>C. nelsonii</i>		✓					✓					✓			
<i>C. padoides</i>					✓					✓					✓
<i>C. vendae</i>		✓					✓					✓			
<i>C. woodii</i>		✓					✓					✓			
<i>C. zeyheri</i>		✓					✓					✓			

✓ character observed by the writer

**Table A.7.1b** A comparison of averaged scale characters selected for their taxonomic potential in the taxa examined

	Diameter ( $\mu\text{m}$ )			Outline		Shape	
	$\leq 89$	90-199	$\geq 200$	smooth	scalloped (markedly)	disc or bowl	dome
<i>C. albopunctatum</i>	✓			✓		✓	
<i>C. apiculatum</i> ssp. <i>apiculatum</i>	✓			✓		✓	
<i>C. apiculatum</i> ssp. <i>leutweinii</i>	✓			✓		✓	
<i>C. caffrum</i>	✓			✓		✓	
<i>C. celastroides</i> ssp. <i>celastroides</i>			✓	✓			✓
<i>C. celastroides</i> ssp. <i>orientale</i>			✓	✓			✓
<i>C. collinum</i> ssp. <i>coriaceum</i>		✓			✓	✓	
<i>C. collinum</i> ssp. <i>ondongense</i>		✓			✓	✓	
<i>C. collinum</i> ssp. <i>suluense</i>		✓			✓	✓	
<i>C. collinum</i> ssp. <i>taborense</i>		✓			✓	✓	
<i>C. edwardsii</i>	✓			✓		✓	
<i>C. elaeagnoides</i>		✓			✓	✓	
<i>C. engleri</i>	✓			✓		✓	
<i>C. erythrophyllum</i>	✓			✓		✓	
<i>C. hereroëense</i> var. <i>hereroëense</i>		✓			✓	✓	
<i>C. hereroëense</i> var. <i>villosissimum</i>		✓			✓	✓	
<i>C. imberbe</i>			✓	✓		✓	
<i>C. kraussii</i>	✓			✓		✓	
<i>C. mkuzense</i>	✓			✓		✓	
<i>C. moggii</i>		✓		✓		✓	
<i>C. molle</i>		✓			✓	✓	
<i>C. nelsonii</i>	✓			✓		✓	
<i>C. padoides</i>		✓		✓		✓	
<i>C. vendae</i>	✓			✓		✓	
<i>C. woodii</i>	✓			✓		✓	
<i>C. zeyheri</i>	✓			✓		✓	

✓ character observed by the writer

**Table A.7.2** A comparison of averaged fruit characters selected for their taxonomic potential in the taxa examined

	Length (mm)			Stipe Length (mm)		Hairs		
	<20	20-35	>35	≤8	>8	glabrous to sparse	moderate	considerable to densely hairy
<i>C. albopunctatum</i>		✓		✓				✓
<i>C. apiculatum</i> ssp. <i>apiculatum</i>		✓		✓		✓	✓	
<i>C. apiculatum</i> ssp. <i>leutweinii</i>		✓		✓				✓
<i>C. caffrum</i>	✓			✓		✓		
<i>C. celastroides</i> ssp. <i>celastroides</i>	✓			✓		✓		
<i>C. celastroides</i> ssp. <i>orientale</i>	✓			✓		✓		
<i>C. collinum</i> ssp. <i>coriaceum</i>			✓	✓		✓		
<i>C. collinum</i> ssp. <i>ondongense</i>			✓	✓		✓		
<i>C. collinum</i> ssp. <i>suluense</i>			✓		✓			✓
<i>C. collinum</i> ssp. <i>taborense</i>			✓		✓	✓		
<i>C. edwardsii</i>		✓		✓		✓		
<i>C. elaeagnoides</i>	✓	▲			✓	✓		
<i>C. engleri</i>		✓		✓		✓		
<i>C. erythrophyllum</i>	✓			✓		✓		
<i>C. hereroëense</i> var. <i>hereroëense</i>	✓	▲		✓		✓	✓	
<i>C. hereroëense</i> var. <i>villosissimum</i>	✓	▲		✓		✓	✓	
<i>C. imberbe</i>	✓			✓		✓		
<i>C. kraussii</i>	✓			✓		▲	✓	
<i>C. mkuzense</i>			✓	✓		✓		
<i>C. moggi</i>	▲							▲
<i>C. molle</i>	✓			✓		✓		
<i>C. padoides</i>	✓			✓		✓		
<i>C. vendae</i>	✓			✓		▲		✓
<i>C. woodii</i>	✓			✓		✓		
<i>C. zeyheri</i>			✓	✓		✓		

✓ character observed by the writer

▲ observed by Carr (1988) (where different from the writer)

**Table A.7.3a** A comparison of averaged inflorescence characters selected for their apparent taxonomic potential in the taxa examined

	Inflorescence Type			Upper Hypanthium Shape				Sepals			
	pan- icle	elong. spike	sub capitate spike	flat	cup	inf	camp	stigma slightly ex- panded	stalked scales on style	apex ciliate	margin ciliate
<i>C. albopunctatum</i>		✓			✓		✓			✓	✓
<i>C. apiculatum</i> ssp. <i>apiculatum</i>		✓					✓			✓	
<i>C. apiculatum</i> ssp. <i>leutweinii</i>		✓					✓			✓	
<i>C. caffrum</i>			✓		✓					✓	✓
<i>C. celastroides</i> ssp. <i>celastroides</i>		✓		✓							
<i>C. celastroides</i> ssp. <i>orientale</i>		✓		✓							
<i>C. collinum</i> ssp. <i>coriaceum</i>	✓	✓					✓			✓	✓
<i>C. collinum</i> ssp. <i>ondongense</i>		✓			✓					✓	✓
<i>C. collinum</i> ssp. <i>suluense</i>		✓					✓			✓	✓
<i>C. collinum</i> ssp. <i>taborense</i>	✓	✓					✓			✓	✓
<i>C. edwardsii</i>		✓				✓				✓	✓
<i>C. elaeagnoides</i>	✓		✓			✓				✓	✓
<i>C. engleri</i> (cf.)			✓		✓		✓	✓			
<i>C. erythrophyllum</i>		✓	✓				✓			✓	✓
<i>C. hereroëns</i> var. <i>hereroëns</i>	✓		✓				✓			✓	✓
<i>C. hereroëns</i> var. <i>villosissimum</i>			✓			✓	✓			✓	✓
<i>C. imberbe</i>	✓	✓		✓					✓		
<i>C. kraussii</i>		✓			✓					✓	✓
<i>C. mkuzense</i>		✓					✓	✓		✓	✓
<i>C. moggii</i>			✓							✓	✓
<i>C. molle</i>		✓					✓			✓	✓
<i>C. padoides</i>				✓							
<i>C. vendae</i>			✓				✓			✓	✓
<i>C. woodii</i>		✓			✓					✓	✓
<i>C. zeyheri</i>		✓					✓	✓		✓	✓

✓ character observed by the writer



**Table A.7.3b** A comparison of averaged inflorescence characters selected for their apparent taxonomic potential in the taxa examined

	Petal shape					Petals ciliate		Disc Outer Hairs		Disc Inner Hairs		
	broad spath-ulate	lobed	spath-ulate	emarginate	elliptic	apex	margin	absent	dense	absent	dense	sparse
<i>C. albopunctatum</i>	✓					✓	✓		✓	✓		
<i>C. apiculatum</i> ssp. <i>apiculatum</i>	✓					✓	✓		✓	✓		
<i>C. apiculatum</i> ssp. <i>leutweinii</i>	✓					✓	✓		✓	✓		
<i>C. caffrum</i>			✓						✓	✓		
<i>C. celastroides</i> ssp. <i>celastroides</i>					✓			✓		✓		
<i>C. celastroides</i> ssp. <i>orientale</i>					✓			✓		✓		
<i>C. collinum</i> ssp. <i>coriaceum</i>	✓								✓	✓		
<i>C. collinum</i> ssp. <i>ondongense</i>	✓								✓	✓		
<i>C. collinum</i> ssp. <i>suluense</i>	✓								✓	✓		
<i>C. collinum</i> ssp. <i>taborense</i>	✓								✓	✓		
<i>C. edwardsii</i>	✓					✓	✓		✓	✓		
<i>C. elaeagnoides</i>			✓					✓		✓		
<i>C. engleri</i> (cf.)			✓						✓	✓		
<i>C. erythrophyllum</i>			✓						✓			✓
<i>C. hereroëns</i> var. <i>hereroëns</i>	✓								✓			✓
<i>C. hereroëns</i> var. <i>villosissimum</i>	✓								✓			✓
<i>C. imberbe</i>					✓				✓	✓		
<i>C. kraussii</i>			✓	✓					✓			✓
<i>C. mkuzense</i>			✓						✓		✓	
<i>C. moggii</i>	✓					✓	✓		✓	✓		
<i>C. molle</i>	✓	✓				✓	✓		✓	✓		
<i>C. padoides</i>					✓							
<i>C. vendae</i>			✓						✓	✓		
<i>C. woodii</i>			✓						✓			✓
<i>C. zeyheri</i>			✓						✓		✓	

✓ character observed by the writer

**Table A.7.3c** A comparison of averaged **inflorescence** characters selected for their apparent taxonomic potential in the taxa examined

	disc obviously notched	stamens 2 series	Sepal Inner Hairs				Bracts		
			absent	dense	moderate	sparse	linear	oblong	obovate
<i>C. albopunctatum</i>						✓	✓		
<i>C. apiculatum</i> ssp. <i>apiculatum</i>					✓		✓		
<i>C. apiculatum</i> ssp. <i>leutweinii</i>					✓		✓		
<i>C. caffrum</i>					✓		✓		
<i>C. celastroides</i> ssp. <i>celastroides</i>	✓					✓	✓		
<i>C. celastroides</i> ssp. <i>orientale</i>	✓					✓	✓		
<i>C. collinum</i> ssp. <i>coriaceum</i>					✓			✓	
<i>C. collinum</i> ssp. <i>ondongense</i>					✓			✓	
<i>C. collinum</i> ssp. <i>suluense</i>					✓		✓		
<i>C. collinum</i> ssp. <i>taborense</i>					✓			✓	
<i>C. edwardsii</i>							✓		
<i>C. elaeagnoides</i>		✓			✓			✓	
<i>C. engleri</i> (cf.)	✓		✓						✓
<i>C. erythrophyllum</i>				✓			✓		✓
<i>C. hereroëns</i> var. <i>hereroëns</i>		✓		✓			✓		
<i>C. hereroëns</i> var. <i>villosissimum</i>		✓		✓			✓		
<i>C. imberbe</i>			✓						
<i>C. kraussii</i>				✓			✓		
<i>C. mkuzense</i>	✓			✓			✓		✓
<i>C. moggii</i>				✓			✓		✓
<i>C. molle</i>						✓	✓		
<i>C. padoides</i>									
<i>C. vendae</i>				✓			✓		✓
<i>C. woodii</i>				✓			✓		
<i>C. zeyheri</i>	✓			✓			✓		✓

✓ character observed by the writer

**Table A.7.4a** A comparison of averaged leaf characters (and one branch character) selected for their apparent taxonomic potential in the taxa examined

	Length (mm)			Petiole Length (mm)		Margin	Midrib axils			Branch
	≤34	35-69	≥70	<8	≥8	margin ciliate	abaxial glands	adaxial hairs	abaxial hairs	twining
<i>C. albopunctatum</i>		✓		✓		✓		✓	✓	
<i>C. apiculatum</i> ssp. <i>apiculatum</i>		✓		✓		✓		✓	✓	
<i>C. apiculatum</i> ssp. <i>leutweinii</i>			✓	✓		✓		✓	✓	
<i>C. caffrum</i>		✓	✓	✓					✓	
<i>C. celastroides</i> ssp. <i>celastroides</i>		✓	✓	✓		✓	✓	✓	✓	
<i>C. celastroides</i> ssp. <i>orientale</i>		✓		✓		✓	✓		✓	
<i>C. collinum</i> ssp. <i>coriaceum</i>			✓		✓	✓			✓	
<i>C. collinum</i> ssp. <i>ondongense</i>		✓			✓					
<i>C. collinum</i> ssp. <i>suluense</i>			✓		✓	✓			✓	
<i>C. collinum</i> ssp. <i>taborense</i>			✓		✓					
<i>C. edwardsii</i>		✓		✓		✓			✓	✓
<i>C. elaeagnoides</i>			✓	✓		✓			✓	
<i>C. engleri</i>	✓			✓		✓	✓		✓	
<i>C. erythrophyllum</i>			✓	✓					✓	
<i>C. hereroëense</i> var. <i>hereroëense</i>	✓			✓		✓			✓	
<i>C. hereroëense</i> var. <i>villosissimum</i>	✓			✓		✓		✓	✓	
<i>C. imberbe</i>	✓			✓						
<i>C. kraussii</i>		✓	✓	✓					✓	
<i>C. mkuzense</i>		✓		✓		▲	✓		✓	
<i>C. molle</i>		✓		✓		✓				
<i>C. nelsonii</i>		✓		✓						
<i>C. padoides</i>		✓			✓	✓				
<i>C. vendae</i>		✓		✓		✓		✓	✓	
<i>C. woodii</i>			✓	✓					✓	
<i>C. zeyheri</i>			✓		✓	✓	✓		✓	

✓ character observed by the writer

▲ sometimes observed

**Table A.7.4b** A comparison of averaged leaf characters selected for their apparent taxonomic potential in the taxa examined

	Apex			Base				
	①	②	③	①	②	③	④	⑤
<i>C. albopunctatum</i>	✓	✓			✓			
<i>C. apiculatum</i> ssp. <i>apiculatum</i>	✓						✓	
<i>C. apiculatum</i> ssp. <i>leutweinii</i>	✓				✓			
<i>C. caffrum</i>	✓			✓				
<i>C. celastroides</i> ssp. <i>celastroides</i>	✓		✓			✓		
<i>C. celastroides</i> ssp. <i>orientale</i>	✓		✓			✓		
<i>C. collinum</i> ssp. <i>coriaceum</i>	✓							
<i>C. collinum</i> ssp. <i>ondongense</i>	✓					✓		
<i>C. collinum</i> ssp. <i>suluense</i>	✓						✓	
<i>C. collinum</i> ssp. <i>taborense</i>	✓					✓		
<i>C. edwardsii</i>	✓						✓	
<i>C. elaeagnoides</i>	✓						✓	
<i>C. engleri</i>	✓					✓		
<i>C. erythrophyllum</i>	✓					✓		
<i>C. hereroëns</i> var. <i>hereroëns</i>	✓		✓			✓		
<i>C. hereroëns</i> var. <i>villosissimum</i>	✓		✓			✓		
<i>C. imberbe</i>	✓	✓	✓					
<i>C. kraussii</i>	✓			✓				
<i>C. mkuzense</i>	✓		✓			✓		
<i>C. molle</i>	✓		✓		✓			
<i>C. nelsonii</i>	✓	✓						✓
<i>C. padoides</i>	✓							✓
<i>C. vendae</i>	✓							
<i>C. woodii</i>	✓			✓				
<i>C. zeyheri</i>	✓		✓			✓		

✓ character observed by the writer

- ① apiculate, acuminate or acute  
 ② retuse  
 ③ rounded or obtuse

- ① cuneate  
 ② rounded or subcordate  
 ③ obtuse or rounded

- ① oblique, subcordate or rounded  
 ⑤ obtuse, rounded or cuneate

**Table A.7.5** A comparison of averaged taxonomically important characters at species level for previously recognised species in the section *Angustimarginata*.

(Only personally observed characters have been used in the table construction. For *C. nelsonii*, only the isotype, *Nelson 91*, has been used owing to incorrectly labelled specimens and time restraints. Inflorescence and fruit characters for this taxon are thus omitted).

	<i>C. erythro- phyllum</i>	<i>C. caffrum</i>	<i>C. woodii</i>	<i>C. vendae</i>	<i>C. nelsonii</i>	<i>C. kraussii</i>
<b>Inflorescence</b>						
<i>Type</i>	spike	spike	spike	spike	not observed	spike
<i>Upper hypanthium shape</i>	campanulate	cupuliform	cupuliform	campanulate	not observed	cupuliform
<i>Sepals ciliate</i>	ciliate	ciliate	ciliate	ciliate	not observed	ciliate
<i>Petals ciliate</i>	non-ciliate	non-ciliate	non-ciliate	non-ciliate	not observed	non-ciliate
<i>Petal shape</i>	spathulate (not broadly)	spathulate (not broadly)	spathulate (not broadly)	spathulate (not broadly)	not observed	spathulate (not broadly)
<i>Petals emarginate</i>	non- emarginate	non- emarginate	non- emarginate	non- emarginate	not observed	often emarginate
<i>Disc outer hairs</i>	dense	dense	dense	dense	not observed	dense
<b>Scales</b>						
<i>Diameter</i>	45–80 µm	45–80 µm	45–80 µm	45–80 µm	45–80µm	45–80 µm
<i>No. of cells per scale</i>	9–16	9–16	9–16	9–16	9–16	8
<i>No. of radial walls in surface view</i>	9–16	9–16	9–16	9–16	9–16	8
<i>No. of tangential walls in surface view</i>	9–16	9–16	9–16	9–16	9–16	8
<i>Scale outline</i>	smooth or slightly scalloped	smooth or slightly scalloped	smooth or slightly scalloped	smooth or slightly scalloped	smooth or slightly scalloped	smooth or slightly scalloped
<b>Fruits</b>						
<i>Length</i>	10–20mm	10–20mm	10–20mm	10–20mm	not observed	10–20mm
<i>Wing and body hair distribution</i>	sparse	sparse	sparse	moderate or considerable	not observed	moderate

**Note:** the section *Angustimarginata* includes variations of upper hypanthium shape from infundibular to cupuliform to campanulate.

**Table A.7.6** A comparison of averaged taxonomically important characters at species level for *C. zeyheri* and *C. mkuzense*.

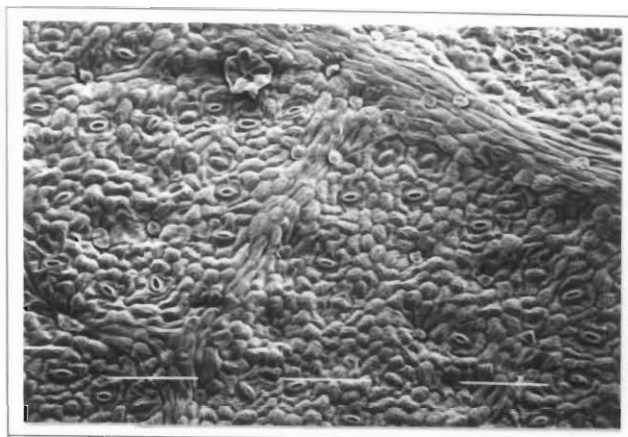
(Only personally observed characters have been used in the table construction).

	<i>C. zeyheri</i>	<i>C. mkuzense</i>
<b><i>Inflorescence</i></b>		
<i>Type</i>	elongated spike	elongated spike
<i>Upper hypanthium shape</i>	campanulate	campanulate
<i>Sepals ciliate</i>	ciliate	ciliate
<i>Petals ciliate</i>	non-ciliate	non-ciliate
<i>Petal shape</i>	spathulate (not broadly)	spathulate (not broadly)
<i>Petal distal margin</i>	rounded, pointed, toothed or truncated	rounded, pointed, toothed or truncated
<i>Stigma</i>	slightly expanded	slightly expanded
<i>Disc outer hairs</i>	dense	dense
<b><i>Scales</i></b>		
<i>Diameter</i>	60–80 µm	60–90 µm
<i>No. of cells per scale</i>	± 15	± 16
<i>No. of radial walls in surface view</i>	± 9	± 10
<i>No. of tangential walls in surface view</i>	± 15	± 15–18
<i>Scale outline</i>	smooth or slightly scalloped	smooth or slightly scalloped
<b><i>Fruits</i></b>		
<i>Length</i>	>35 mm	>35 mm
<i>Wing and body hair distribution</i>	sparse	sparse

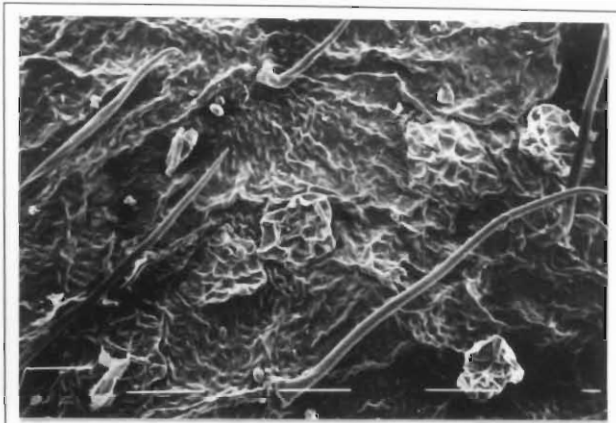
# Plates

## Plate 1

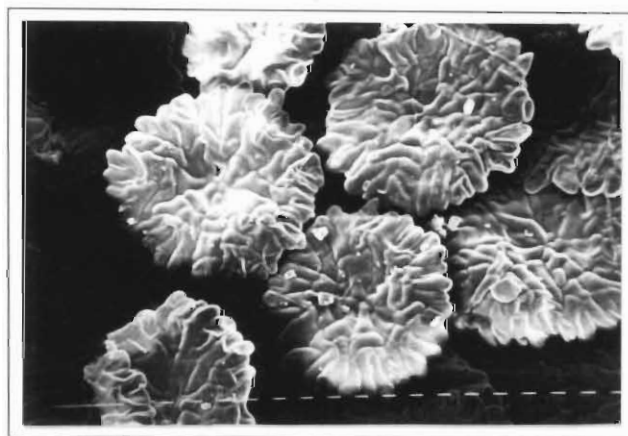
### *Combretum* scale characters & distribution



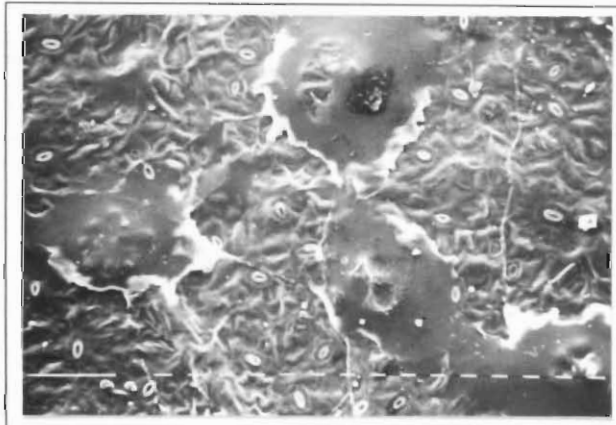
**Plate 1.1:** Sparse distribution of scales on lamina abaxial surface of *C. apiculatum* ssp. *apiculatum* (bar = 100µm); Burke 520.



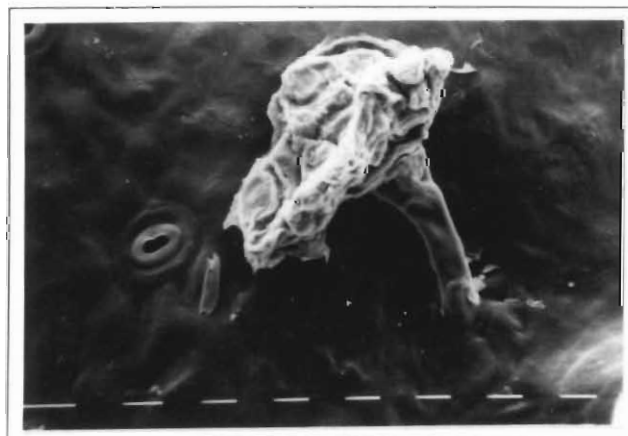
**Plate 1.2:** Considerable distribution of scales on lamina adaxial surface of *C. molle* (bar = 100µm); Ward 832.



**Plate 1.3:** Dense distribution of scales on lamina abaxial surface of *C. collinum* ssp. *ondongense* (bar = 10µm); Leistner, Oliver, Steenkamp & Vorster 39.



**Plate 1.4:** Exudate covering scales of *C. apiculatum* ssp. *apiculatum* (bar = 10µm); Moll 5632.



**Plate 1.5:** Side view of scale showing stalk on lamina abaxial surface of *C. edwardsii* (bar = 10µm); Rogers s.n. sub Hennessy 453.

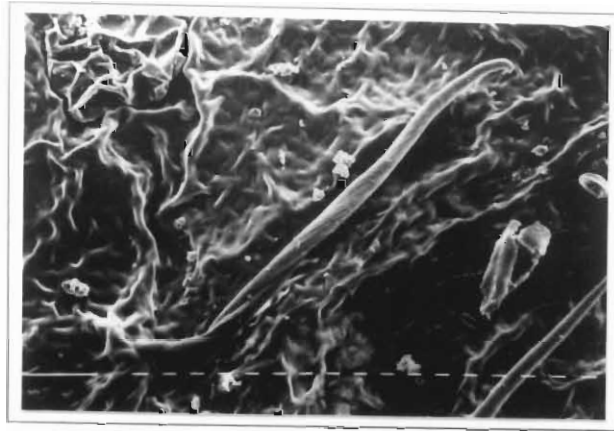


**Plate 1.6:** Surface view of scale on lamina abaxial surface of *C. edwardsii* (bar = 10µm); Rogers s.n. sub Hennessy 453.

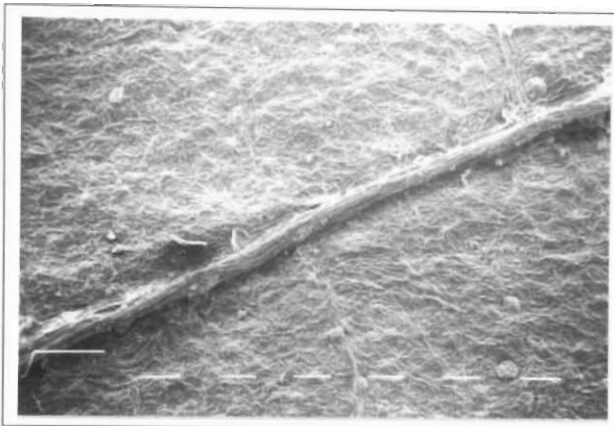


## Plate 2

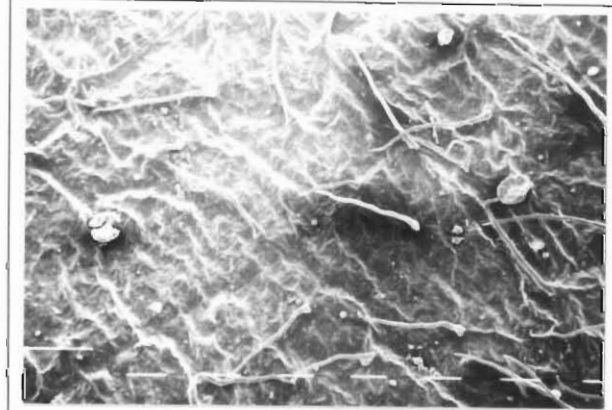
### *Combretum* hair characters & distribution



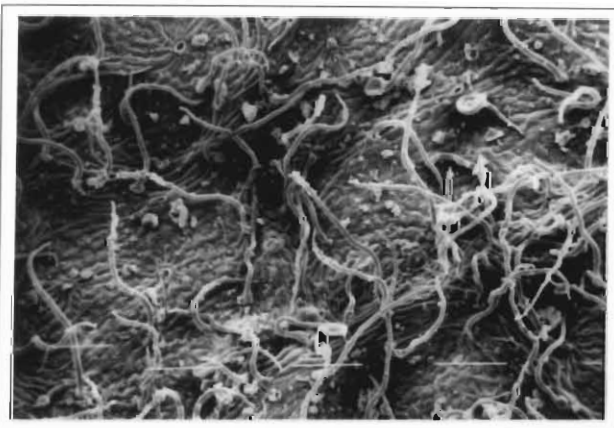
**Plate 2.1:** Hair structure on lamina adaxial surface of *C. molle* (bar = 10 $\mu$ m); Ward 832.



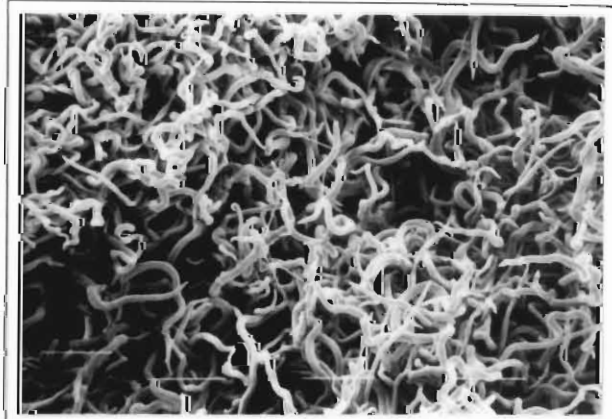
**Plate 2.2:** Sparse hair distribution on lamina abaxial surface of *C. edwardsii* (bar = 100 $\mu$ m); Ward 3608.



**Plate 2.3:** Moderate hair distribution on lamina adaxial surface of *C. edwardsii* (bar = 100 $\mu$ m); Abbott 1377.



**Plate 2.4:** Considerable hair distribution on lamina abaxial surface of *C. collinum* ssp. *bajonense* (bar = 100 $\mu$ m); Keet 1646.



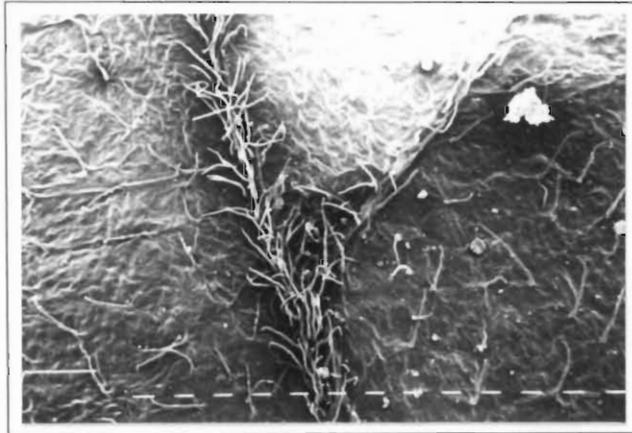
**Plate 2.5:** Dense hair distribution on lamina abaxial surface of *C. erythrophyllum* ssp. *vendae* (bar = 100 $\mu$ m); Van Wyk 3913.

### Plate 3

*Combretum* hair concentration in axils of midribs & primary lateral veins



**Plate 3.1:** Hairs absent in midrib axils on lamina abaxial surface of *C. molle* (bar = 100 $\mu$ m); *De Smidt 91*.



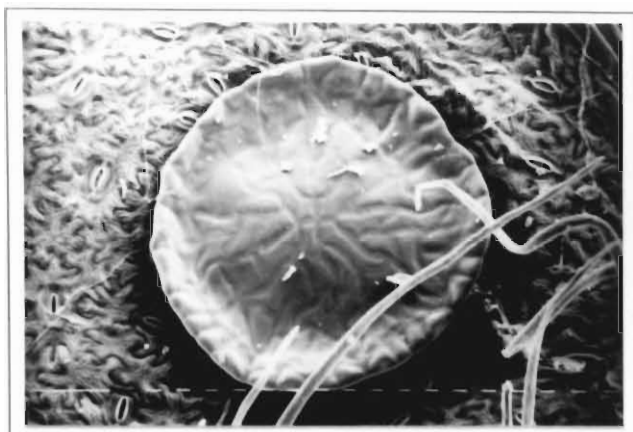
**Plate 3.2:** Sparse hair concentration in midrib axil of lamina adaxial surface of *C. edwardsii* (bar = 100 $\mu$ m); *Abbott 1377*.



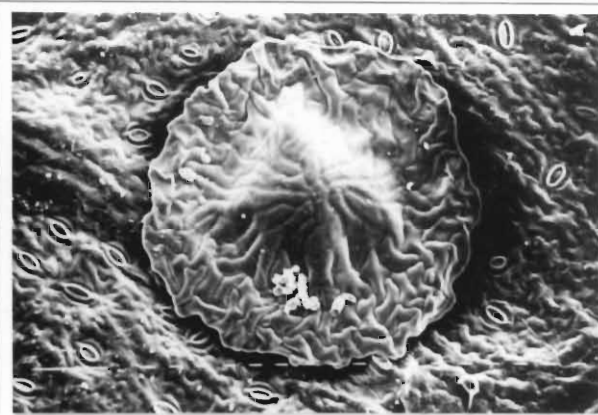
**Plate 3.3:** Dense hair concentration in midrib axil of lamina abaxial surface of *C. edwardsii* (bar = 100 $\mu$ m); *Ward 3608*.

## Plate 4

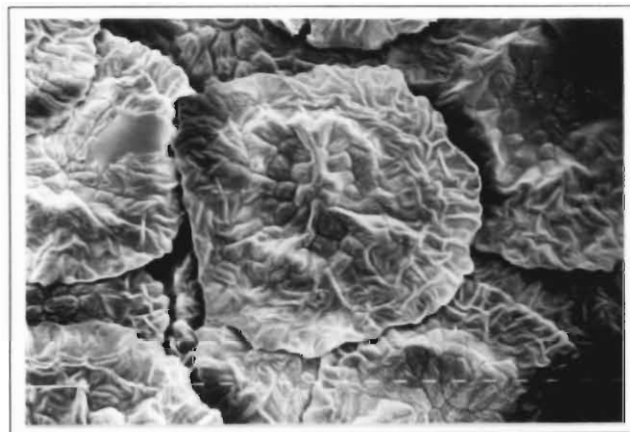
### Section *Hypocrateropsis*



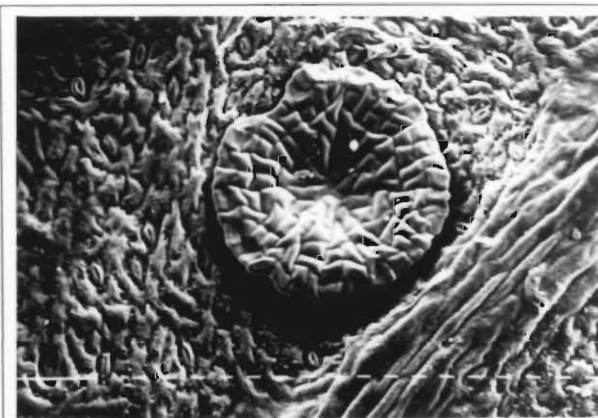
**Plate 4.1:** Scale from lamina abaxial surface of *C. celastroides* ssp. *celastroides* (bar = 10 $\mu$ m); *Hines* 533.



**Plate 4.2:** Scale from lamina abaxial surface of *C. celastroides* ssp. *orientale* (bar = 10 $\mu$ m); *Moll & Muller* 5688.



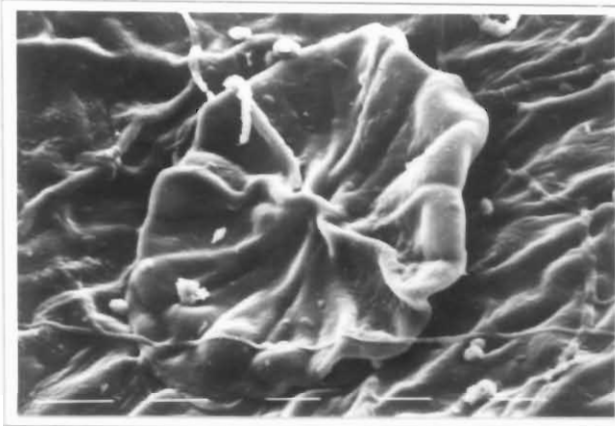
**Plate 4.3:** Scales from lamina abaxial surface of *C. imberbe* (bar = 10 $\mu$ m); *Allen* 231.



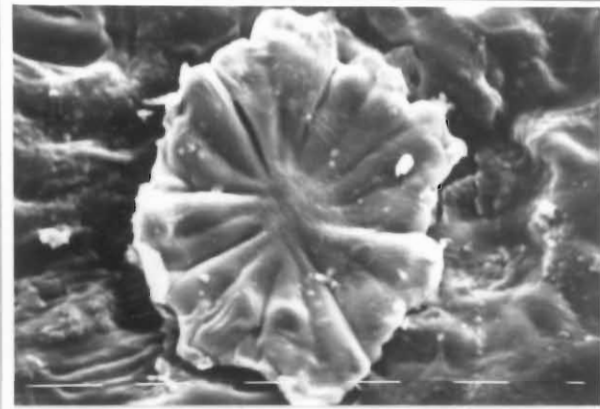
**Plate 4.4:** Scale from lamina abaxial surface of *C. padoides* (bar = 10 $\mu$ m); *Galpin* 885.

## Plate 5

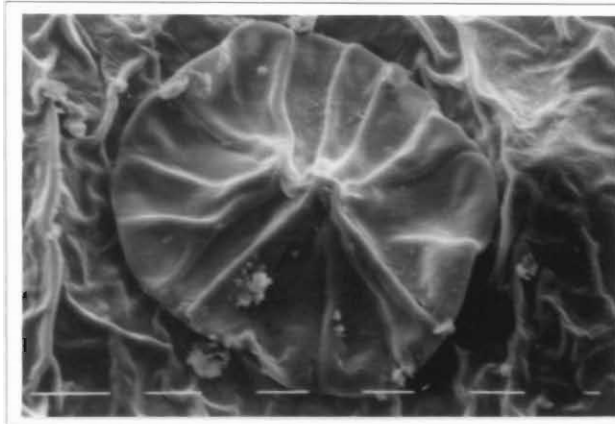
### Section *Angustimarginata*



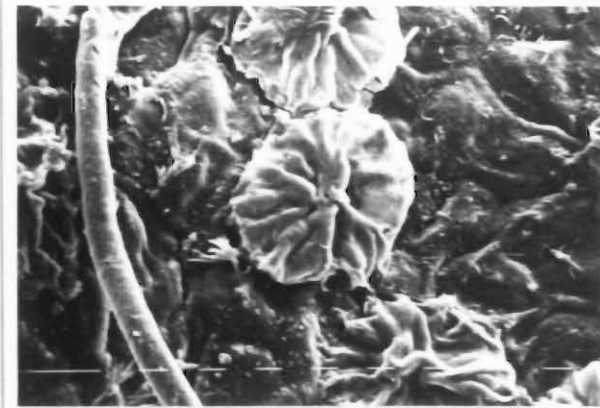
**Plate 5.1:** Scale from lamina abaxial surface of *C. erythrophyllum* ssp. *erythrophyllum* (bar = 10µm); *Gerstner 3173*.



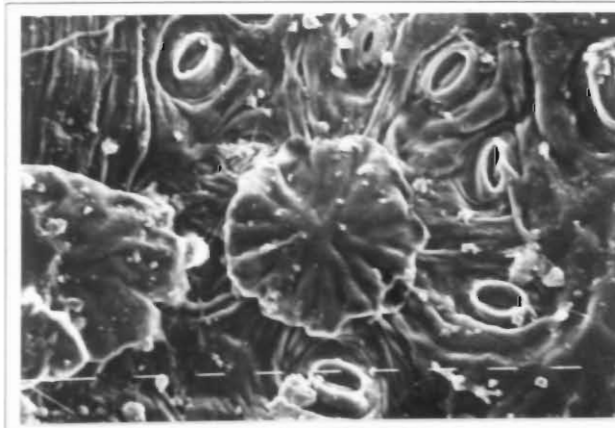
**Plate 5.2:** Scale from lamina abaxial surface of *C. caffrum* (synonym of *C. erythrophyllum* ssp. *erythrophyllum*) (bar = 10µm); *Meyer 106*.



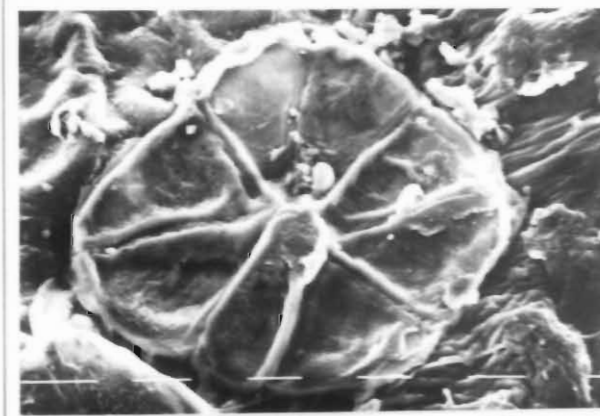
**Plate 5.3:** Scale from lamina abaxial surface of *C. woodii* (synonym of *C. erythrophyllum* ssp. *erythrophyllum*) (bar = 10µm); *Galpin 1176*.



**Plate 5.4:** Scales from lamina adaxial surface of *C. erythrophyllum* ssp. *vendae* (bar = 10µm); *Van Wyk 3913*.



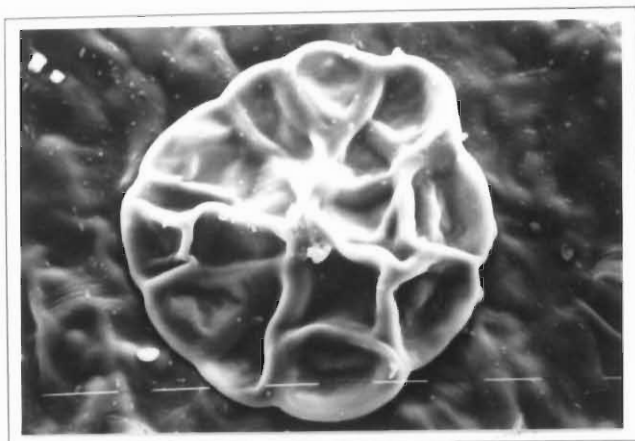
**Plate 5.5:** Scale from lamina abaxial surface of *C. nelsonii* (bar = 10µm); *Nelson 91*.



**Plate 5.6:** Scale from lamina abaxial surface of *C. kraussii* (bar = 10µm); *Moll 4945*.

## Plate 6

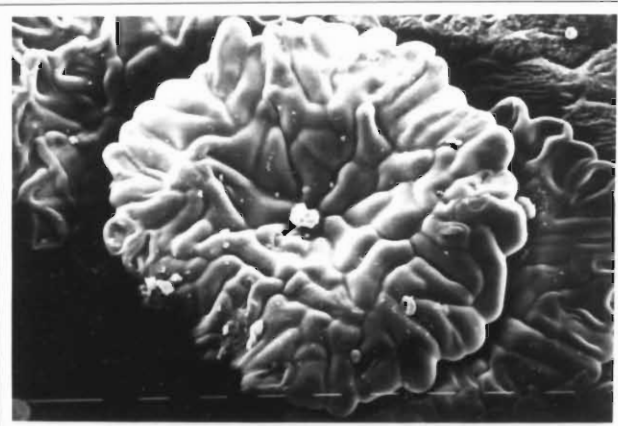
### Sections *Macrostigmatea* & *Metallicum*



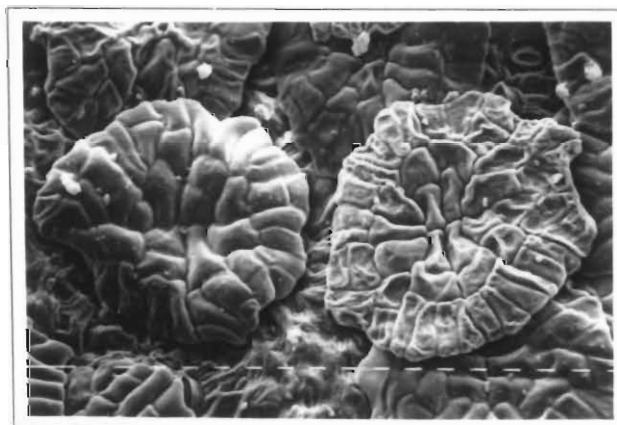
**Plate 6.1:** Scale from lamina abaxial surface of *C. engleri*  
(bar = 10µm); Maguire 1597.



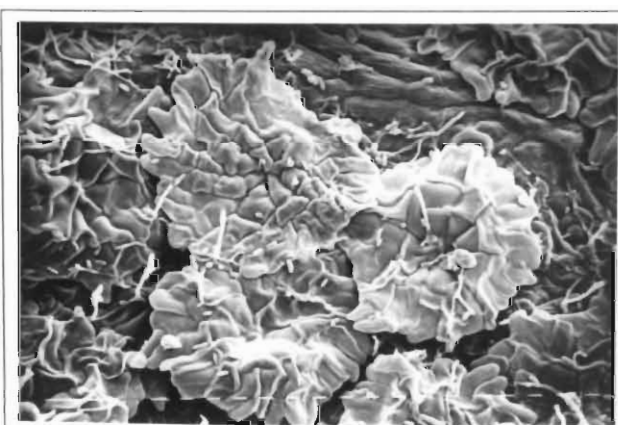
**Plate 6.2:** Scales from lamina abaxial surface of *C. collinum* ssp. *coriaceum*  
(bar = 10µm); Keet 1646.



**Plate 6.3:** Scale from lamina abaxial surface of *C. collinum* ssp. *ondongense*  
(bar = 10µm); Leistner, Oliver, Steenkamp & Vorster 39.



**Plate 6.4:** Scales from lamina abaxial surface of *C. collinum* ssp. *suluense*  
(bar = 10µm); Greenwood 12.

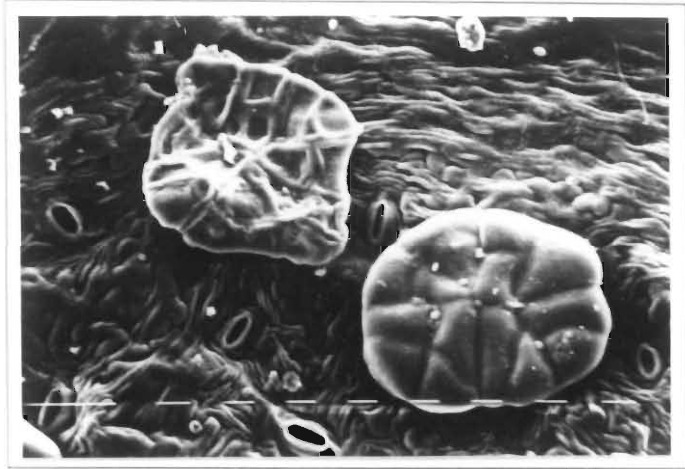


**Plate 6.5:** Scales from lamina abaxial surface of *C. collinum* ssp. *taborense*  
(bar = 10µm); Brass 17443.

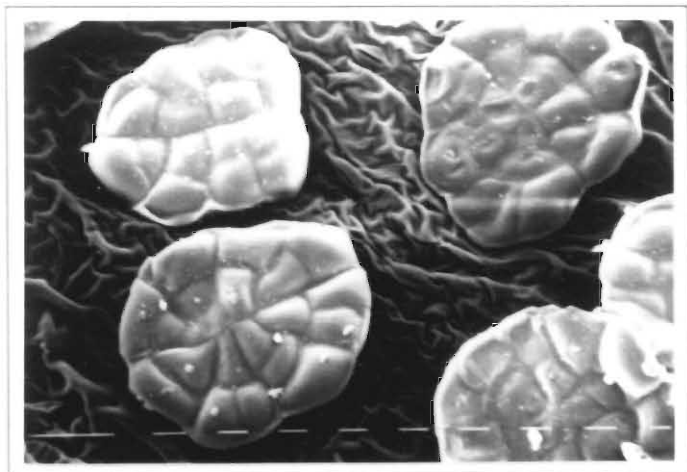


## Plate 7

### Section *Spathulipetala*



**Plate 7.1:** Scales from lamina abaxial surface of *C. mkuzense* (synonym of *C. zeyheri*) (bar = 10 $\mu$ m); Carr 187.



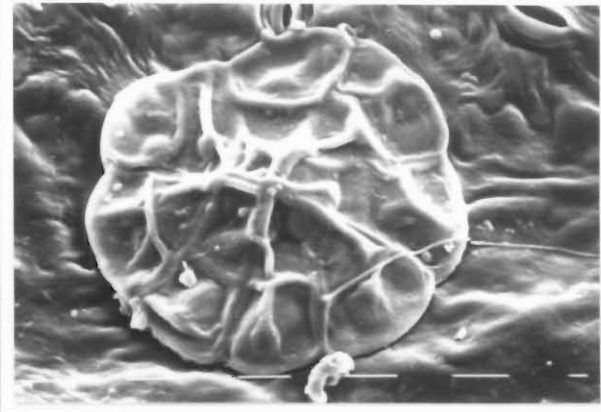
**Plate 7.2:** Scales from lamina abaxial surface of *C. zeyheri* (bar = 10 $\mu$ m); Ward 3165.

## Plate 8

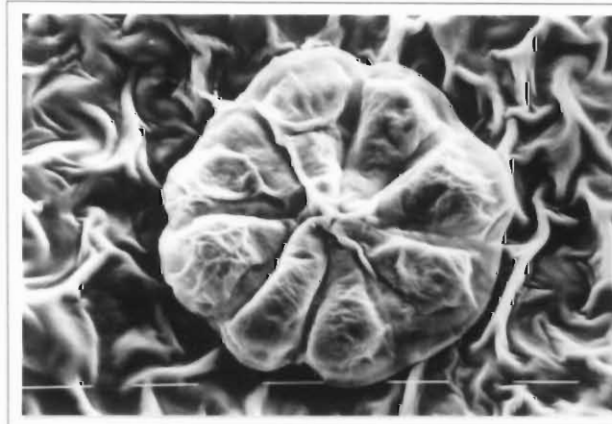
### Section *Ciliatipetala*



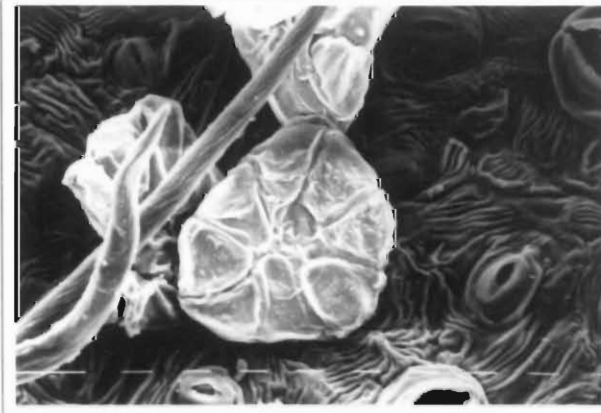
**Plate 8.1:** Scales from lamina abaxial surface of *C. albopunctatum* (bar = 10µm); *De Winter 4337*.



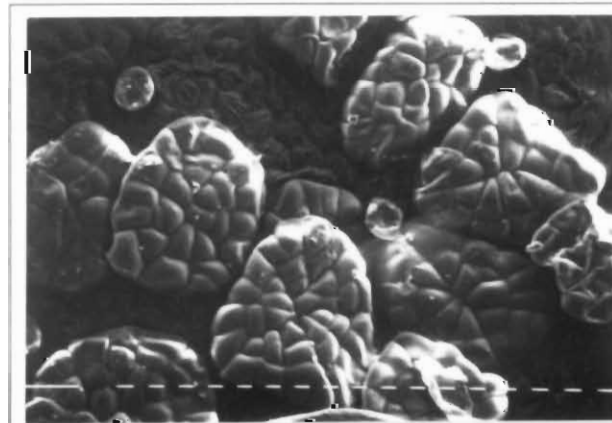
**Plate 8.2:** Scale from lamina abaxial surface of *C. edwardsii* (bar = 10µm); *White 10388*.



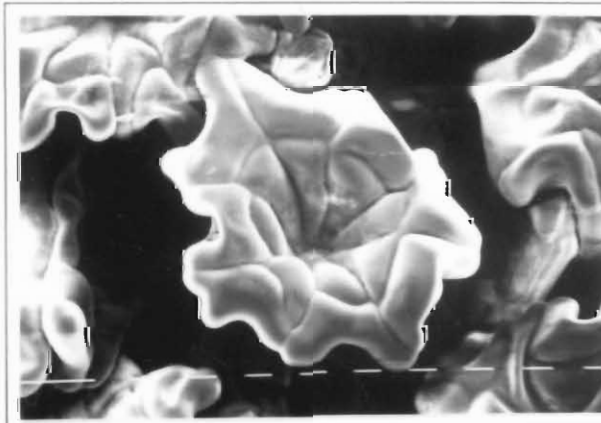
**Plate 8.3:** Scale from lamina abaxial surface of *C. apiculatum* ssp. *apiculatum* (bar = 10µm); *Balkwill 692*.



**Plate 8.4:** Scale from lamina abaxial surface of *C. apiculatum* ssp. *leutweinii* (bar = 10µm); *Boss TM 34970*.



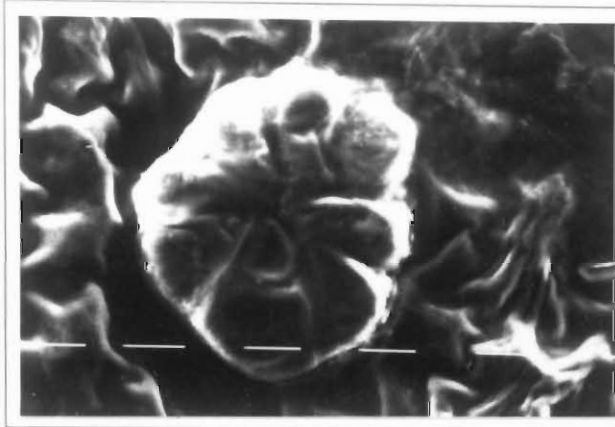
**Plate 8.5:** Scales from lamina adaxial surface of *C. moggii* (bar = 10µm); *Mogg 22400*.



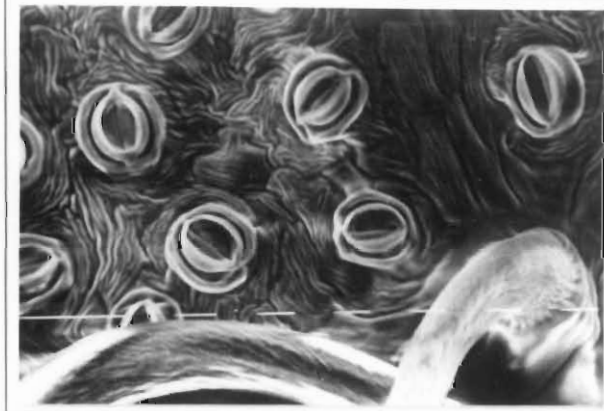
**Plate 8.6:** Scale from lamina abaxial surface of *C. molle* (bar = 10µm); *Ward 832*.

## Plate 9

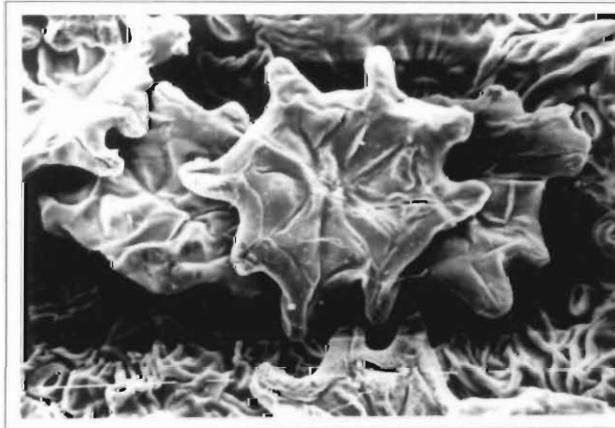
Sections *Ciliatipetala*, *Breviramea* & *Elaeagnoida*



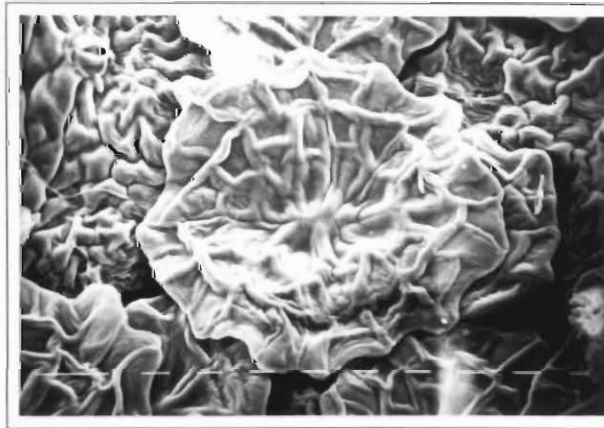
**Plate 9.1:** Scale from lamina abaxial surface of *C. petrophilum* (bar = 10µm); Carr 203.



**Plate 9.2:** Stomata from lamina abaxial surface of *C. psidioides* ssp. *psidioides* (bar = 10µm); Steyl 21.



**Plate 9.3:** Scales from lamina abaxial surface of *C. hereroëns* ssp. *hereroëns* var. *hereroëns* (bar = 10µm); Schlechter 11772.



**Plate 9.4:** Scale from lamina abaxial surface of *C. elaeagnoides* (bar = 10µm); Tinley 1425.



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