A TAXONOMIC REVISION OF THE GENUS *RAFNIA* THUNB. (FABACEAE, CROTALARIEAE)

by

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> In some cases we learn more by looking
> for the answer to a question and not finding it
> than we do from learning the answer itself.
>
> Dallben, from *The Book of Three* by Lloyd Alexander (1988).

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TAXONOMIC REVISION OF THE GENUS *RAFNIA* THUNB. (FABACEAE, CROTALARIEAE)

SUMMARY

A taxonomic revision of the genus *Rafnia* Thunb. (= *Oedmannia* Thunb., *Vascoa* DC., *Pelecynthis* E. Mey), a relatively poorly known papilionoid legume genus, is presented. *Rafnia* (family Fabaceae, tribe Crotalarieae) is subendemic to the fynbos region of the Western and Eastern Cape Provinces of South Africa, with one species having a distribution area reaching into KwaZulu-Natal. The species delimitation has been unsatisfactory, and the relationships among the taxa uncertain.

Rafnia is divided into two sections and 19 species are recognized, compared with the 22 species previously distinguished by Harvey (1862). There are five new species and four species are subdivided into subspecies, eight of which are described for the first time. There are eight changes of status and one new combination is made. *Rafnia* constitutes a total of 31 taxa.

Morphological data used to investigate relationships among the species of *Rafnia* are analyzed phenetically and cladistically and keys to the sections, species and subspecies, complete nomenclature, typification, descriptions as well as the geographical distribution for each of the taxa are presented. Proposals are made to resolve troublesome uncertainties regarding the nomenclature and typification of some species. The scope of this study did not permit detailed investigation into chemical or molecular evidence, although preliminary studies showed that such data would improve the understanding of the infrageneric relationships within the genus.

Characters and character states show much variation, but an hypothesis of the phylogenetic relationships amongst the taxa is nevertheless presented. An in-depth study of morphological characters in particular has resulted in a better understanding of taxonomic relationships at the generic and infrageneric levels in *Rafnia*.

'N TAKSONOMIESE HERSIENING VAN DIE GENUS *RAFNIA* THUNB. (FABACEAE, CROTALARIEAE)

OPSOMMING

‘n Taksonomiese hersiening van die genus *Rafnia* Thunb. (= *Oedmannia* Thunb., *Vascoa* DC., *Pelecynthis* E. Mey), ‘n relatief onbekende papilionoïede peulplantgenus, word aangebied. *Rafnia* (familie Fabaceae, tribus Crotalarieae) is subendemies aan die fynbos streek van die Oostelike en Westelike Kaap Provinsies van Suid-Afrika, met een spesie wat 'n verspreidingsgebied het wat strek tot in KwaZulu-Natal. Die spesiesafbakenings was tot nou toe onbevredigend, en die verwantskappe tussen die taksons onseker.

Rafnia word in twee seksies verdeel en 19 spesies word erken, in vergelyking met die 22 spesies wat voorheen deur Harvey (1862) onderskei is. Daar is vyf nuwe spesies en vier spesies word onderverdeel in subspesies, agt waarvan vir die eerste keer beskryf word. Daar is agt veranderings van rang en een nuwe kombinasie word gemaak. *Rafnia* sluit 'n totaal van 31 taksons in.

Morfologiese data wat gebruik is om die verwantskappe tussen die spesies van *Rafnia* te bestudeer word feneties en kladisties geanaliseer en sleutels tot die seksies, spesies en subspesies, volledige nomenklatuur, tipifikasie, beskrywings sowel as die geografiese verspreiding van elke takson word aangebied. Voorstelle word gemaak om lastige probleme rondom die nomenklatuur en tipifisering van sommige spesies op te los. Die omvang van dié studie het nie omvattende ondersoeke na chemiese en molekulêre getuienis toegelaat nie, alhoewel voorlopige studies aangetoon het dat sulke

data die begrip van infrageneriese verwantskappe in die genus sou verbeter.

Kenmerke en kenmerkstate toon aansienlike variasie, maar ‘n hipotese van filogenetiese verwantskappe tussen die taksons word nietemin aangebied. ‘n Diepgaande studie van veral morfologiese kenmerke het gelei tot ‘n beter begrip van taksonomiese verwantskappe op generiese en infrageneriese vlakke in *Rafnia*.

CHAPTER 1

INTRODUCTION

Rafnia Thunb. has been a relatively poorly known legume genus of the tribe Crotalarieae, which is subendemic to the fynbos region of South Africa. *Rafnia* belongs to the 'Cape group' of the Crotalarieae, being most closely allied to *Aspalathus* L., *Lebeckia* Thunb. and *Wiborgia* Thunb. (Dahlgren, 1970; Van Wyk, 1991a).

Of the 11 genera of the mainly African Crotalarieae, only *Rafnia* and *Lebeckia* have not been revised in recent years. The most recent published treatment of *Rafnia* dates back to Harvey (1862). Dahlgren (1970) pointed out the need for *Rafnia* to be revised. The taxonomy of *Rafnia* is problematic due to the relatively poor herbarium record, the complex geographical patterns and the misleading superficial similarities between distantly related taxa. As a result, there is much confusion concerning the identity and correct nomenclature of the taxa of *Rafnia*. This is evident from the herbarium record, which shows a large percentage of misidentified specimens. A better understanding of the relationships among the taxa is important, not only for the circumscription of species and infraspecific taxa, but also for gaining insight into relationships with other genera of the Crotalarieae, in particular *Aspalathus*, which is supposedly the sister genus of *Rafnia* (Van Wyk & Schutte, 1995).

Rafnia is distinguished from the rest of the Crotalarieae by the almost complete glabrescence, even on the back of the standard petal, the simple, sessile leaves and the fact that the plants often turn black when dried (Van Wyk & Schutte, 1995). The aim of this study is a taxonomic revision, in order to update the taxonomy and nomenclature of *Rafnia*.

CHAPTER 2

MATERIAL AND METHODS

Morphological data were gathered from *in situ* studies, preserved material and herbarium specimens. Specimens were loaned from the following herbaria: BOL, NBG (including SAM and STE) and PRE (standard herbarium abbreviations as in Holmgren *et al.* 1990) and specimens housed in J and JRAU were also studied. Voucher specimens of all the material used to study the different characters are given in the tables below. Authorities for names are given in Chapter 9 and will not be repeated elsewhere in the text. This also applies to new taxa, not yet described, for which the manuscript names given in Chapter 9 are used.

Field work was undertaken in the distribution area of *Rafnia* in order to study the taxa *in situ* as well as to collect fresh and preserved vegetative, flowering, fruit and seed material at a number of different localities. Several of the populations were visited up to three times in order to obtain adequate material. All the taxa except *R. racemosa* subsp. *pumila*, *R. rostrata* subsp. *pauciflora*, *R. angulata* subsp. *ericifolia*, *R. angulata* subsp. *humilis*, *R. crispa*, *R. lancea* and *R. capensis* subsp. *elsieae* were studied in the field. At least two herbarium specimens were collected at each locality, and more were collected where isotypes of new taxa were needed. FAA [formalin-acetic acid-alcohol (Sass, 1958)] was used as a solution for the preservation of fresh material. Data concerning locality, habitat, habit, fire-survival strategy, mode of flowering, pollination syndrome and flowering and fruiting phenology were obtained from specimen labels and/or extensive field work. Plant height was recorded, and, where possible, photographs were taken to illustrate habitat, habit, leaves, flowers and pods.

The genus is morphologically highly variable and shows distinct geographical patterns, so that the herbarium material was divided into regional forms (Table 2.1), in order to facilitate investigation. These geographical forms served as operational taxonomic units. As many characters as possible were examined and the genus *Aspalathus* was included as an outgroup for various characters. As many individuals from the different taxa and localities as possible over the whole distribution area were examined in order to make provision for the often exceptional geographical variation in morphology.

Specimens were studied using a WILD M3Z dissecting microscope and line drawings of the leaves, anatomical sections, floral parts and pods were made with the aid of a *camera lucida* attachment.

During investigations of quantitative characters, the same number of measurements were made for each individual, where possible. In some cases, especially concerning the rare species, fewer measurements were made of necessity due to poor or insufficient herbarium material. Quantitative information is presented in the form of graphical summaries, showing the range and mean values for the species and some regional forms (operational taxonomic units) as listed in Table 2.1. The numbering of taxa and regional forms in these figures is given in Table 2.2. Some of the graphs showing taxonomically significant discontinuities between taxa are included in the relevant chapters for discussion. The morphometric data were used for the phenetic analysis and formal species descriptions.

Voucher specimens of material used for leaf illustrations are listed in Table 2.3. For the study of leaf size (Table 2.4), separate measurements were made for leaves on flowering branches, basal leaves and coppice leaves. The leaves of five specimens from different localities were usually measured per taxon, and two or three measurements were made per specimen, depending on the variation in size and number of mature leaves available for measuring. A total of 10 to 15 leaf measurements were made per taxon. Where the taxa are divided into regional forms, two specimens were measured per form and two measurements were made per specimen. Fewer specimens were studied and fewer leaves were measured where minimal material was available.

In order to study the stomata of the species of *Rafnia* (Table 2.5), epidermal peels were made from leaves preserved in FAA, according to the method of Kiger (1971). The epidermises were mounted in glycerol and photographed using a Leitz Wetzlar compound light microscope with a 35 mm camera attachment.

Herbarium and FAA materials were used to study midrib anatomy (Table 2.6). Transverse sections were made of the leaf lamina including the midrib. The herbarium material was rehydrated and placed in FAA for a minimum of 24 hours. The material was then treated according to the method of Feder & O'Brien (1968) for embedding in glycol methacrylate (GMA). However, a minimum of 24 hours was used for the first two infiltrations in GMA and a minimum of five days for the third infiltration. The capsules containing the material and GMA were placed in an oven at 60 °C for 24 hours. Sections of about 3–5 µm thick were cut using a Porter Blum ultramicrotome. The Periodic acid-Schiff/Toluidine blue staining method was used and photographs were taken using a Leitz Wetzlar compound light microscope with a 35 mm camera attachment.

Inflorescence structure was studied *in situ* as well as from herbarium specimens. The number of flowers per inflorescence (where more than one flower was present) and maximum inflorescence axis length (the inflorescence axis is the peduncle only, rachis only or peduncle and rachis—see Chapter 4.1.1) were measured from specimens (Table 2.7). Up to 15 measurements were taken for both these characters, depending on the number of specimens available.

Some FAA material, but mostly herbarium material, was used to study peduncle and pseudopeduncle anatomy (Table 2.8). Sections were taken from the middle of the peduncle or pseudopeduncle for those taxa where peduncles or pseudopeduncles are present. Methods employed for sectioning peduncles are as for midribs (see above).

Mature flowers were studied using mainly fixed material, but dry flowers from rich herbarium specimens were used in some cases. The latter material was rehydrated by boiling in water for two to three minutes, dissected, mounted in glycerol and drawn to scale. At least five flowers were dissected per taxon where there was little variation, and up to 30 dissections were made for variable taxa (Table 2.9). For poorly known taxa, only one or two dissections could be made. The following flower characters were measured: length of pedicel, length of bract and bracteoles, flower length, length of that part of the corolla exceeding the calyx, calyx length, length of calyx lobes and tube, width of upper, lateral and carinal calyx lobes, depth of upper, lateral and lower calyx sinuses, length and width of standard, wings and keel, length of claws of standard, wings and keel and length of basifixed, carinal and dorsifixed anthers (Tables 2.7 & 2.9). Figure 2.1 shows how calyx measurements were taken.

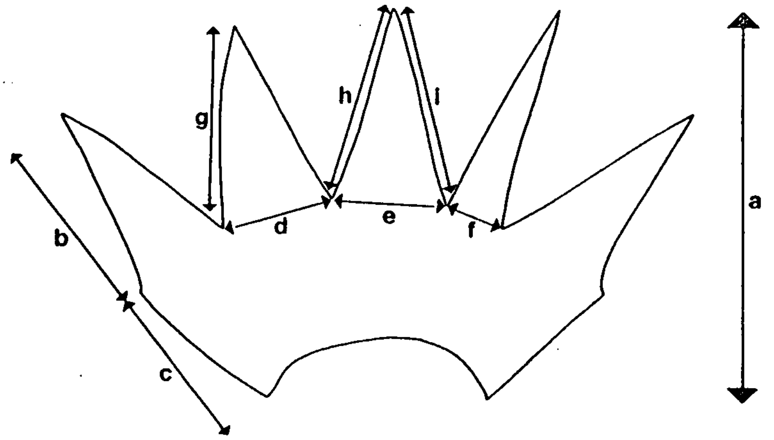


Figure 2.1 Diagram showing how the calyx was measured: **a,** calyx length; **b,** calyx lobe length; **c,** calyx tube length; **d,** upper calyx lobe width; **e,** lateral calyx lobe width; **f,** carinal calyx lobe width; **g,** upper calyx sinus depth; **h,** lateral calyx sinus depth; **i,** lower calyx sinus depth.

Pollen grains were collected from herbarium specimens for examination under a Zeiss light microscope (LM), ISI-SS60 scanning electron microscope (SEM) and Jeol 1010 transmission electron microscope (TEM) (Table 2.10). For examination under the LM, acetolyzed pollen grains were mounted on slides according to the method of Fripp (1983). Acetolyzed pollen grains were pipetted onto aluminium stubs, left to dry at room temperature for about 24 hours and coated with gold for examination under the SEM. The pollen exine patterns were examined at 10 kV. For examination under the TEM, pollen grains were rehydrated in distilled water and infiltrated with pure resin.

Mature pods were collected in the field from as many different taxa and populations as possible. Pods were drawn from herbarium specimens or field collections (Table 2.11). Maximum pod length and width were measured for all taxa, except *R. racemosa* subsp. *pumila*, *R. angulata* subsp. *humilis*, *R. crispa* and one regional form of *R. alata* (Table 2.12), for which mature pods were not available. Maximum stipe length was measured where applicable (i.e. for five species, including seven subspecies—see Chapter 4.3). Pod measurements for as many individuals per taxon as possible (up to 15) were measured from herbarium specimens and field collections, since pod material was often limited.

Mature seeds were obtained from pods collected in the field as well as from herbarium specimens if loose seeds were available. The seeds of all the species except *R. rostrata* were studied. Seed size was measured (Table 2.13) and seed shape expressed as a length:width ratio. For the examination of quantitative seed characters (size and shape), the same number of measurements were made for each taxon where possible, using callipers and a ruler. In some cases, fewer measurements were made of necessity due to the lack of sufficient material, but usually approximately 20 seeds were measured per population.

Seeds were mounted on pins for photograpy. Testa cell patterns, hilum, lens and radicular lobe structure were examined using an ISI-SS60 scanning electron microscope (SEM) (Table 2.13). Dry seeds were mounted on metal stubs using double-sided tape and sputter-coated with gold for approximately 4.5 minutes, after which they were individually examined and photographed at 10 kV.

Geographical distribution maps were compiled from specimen labels and field notes. Information concerning habitat and substrate was also obtained from these sources.

Differences in flowering time were observed in the field and information was extrapolated from herbarium specimens and represented graphically (see Figure 5.5). For each taxon, the number of specimens flowering in each month of the year was expressed as a percentage of the total number of specimens examined for that species.

During field work, material was collected for flavonoid extraction. Fresh petals and dried leaves of four distantly related species (Table 2.14) were extracted in 1 % methanolic HCl and methanol respectively. Flavonoids were studied by analytical C_{18} reverse phase HPLC, using 1 % acetic acid in water (A) and methanol (B) as mobile phases. The solvent system was a linear gradient from 30 % to 60 % of B in A (over 24 minutes) followed by a gradient to 100 % B (over 1 minute). Isoflavone compounds and their hydrolysis products were detected and identified by spectral characteristics with the aid of a diode array detector and by comparison with known isoflavones.

Fifteen leaf samples of one natural population each of *R. angulata* subsp. *angulata* and *R. schlechteriana* were collected for the enzyme electrophoresis study (Table 2.15). These taxa were selected because they represent extremes of the range of variation in *Rafnia*.

Mature and young leaves (where available) were collected in cryotubes and immediately submerged in liquid nitrogen (-196 °C). Approximately 2 g of leaf tissue were manually ground with a glass mortar and pestle in 2 ml Tris-HCl buffer (pH = 7.5) as described by Soltis *et al.* (1983). The liquid was transferred to Eppendorf test tubes and centrifuged at 4 000 x g for five minutes. The supernatant was absorbed directly onto paper wicks and recommendations by Kephart (1990) were taken into consideration to optimize electrophoretic conditions. A continuous buffer (MF) was used for four enzyme systems (AAT, LAP, LGG and LT), and a discontinuous buffer (RW) for another four (GPI, ME, PER and PHP), in order to obtain better resolution. A control was applied to ensure that any failure in the staining of an enzyme would be due to the lack of activity of the enzyme and not erroneous laboratory technique. Twelve per cent starch (Sigma: S-4501) gels were used (Figure 2.2). Locus abbreviations, monomorphic loci, buffers used and enzyme commission numbers are given in Table 5.3, and buffer systems are as described by Van der Bank *et al.* (1995a, b).

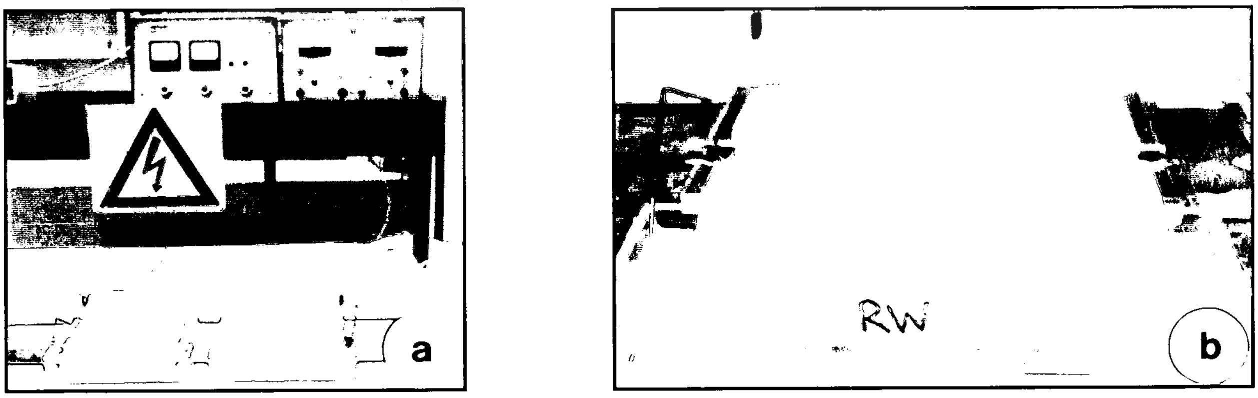


Figure 2.2 Apparatus used for enzyme gel electrophoresis: **a**, laboratory set-up; **b**, starch gel with paper wicks onto which supernatant was absorbed.

The characters and character states included in the phenetic analysis are listed in Table 6.1. A matrix of 19 species and 83 characters was used (Table 6.2) and 14 pod and seed characters for which some data were missing were omitted from the analysis. For the choice of characters, the suggestions of Sneath & Sokal (1973) were followed. Most of the characters chosen were quantitative, although some qualitative characters were encoded and included in the analysis. The programme NTSYS-PC 2.01 was used for the analysis and various coefficients of similarity were applied in order to construct several phenograms, the best result of which is included in Chapter 6 (see Figure 6.1).

Characters and character states used for the cladistic analysis are given in Table 7.1. Character states were polarized using the method of outgroup comparison. Phylogenetic analyses were conducted using the computer software package Hennig86 (Farris, 1988). The 'ie' and 'nelsen' algorithms were applied to produce trees of mimimal length. Autapomorphies for the species were omitted from the analyses, since they serve no purpose as grouping characters.

Table 2.1 List of geographically variable taxa of *Rafnia* which have distinct regional forms. These forms were used as operational taxonomic units.

R. angulata **subsp.** ***angulata*** - Form 1: Cedarberg form; Form 2: Typical form (Piquetberg, Tulbagh); Form 3: Matroosberg form; Form 4: Narrow-leaf Malmesbury form; Form 5: Broad-leaf Malmesbury form; Form 6: Boland Mountains form; Form 7: Narrow-leaf Peninsula form; Form 8: Broad-leaf Peninsula form; Form 9: Hermanus form; Form 10: Swellendam form.

R. alata - Form 1: Typical form (Swartberg); Form 2: Outeniqua Mountains form; Form 3: Bredasdorp form.

R. triflora - Form 1: Typical form; Form 2: Caledon form.

R. acuminata - Form 1: Typical form; Form 2: Northern form (Piquetberg, Cedarberg).

R. diffusa - Form 1: Northern form (Vanrhynsdorp, Nieuwoudtville, Gifberg); Form 2: Wupperthal form; Form 3: Citrusdal form; Form 4: Pakhuis Pass form; Form 5: Piquetberg form; Form 6: Malmesbury form.

R. capensis **subsp.** ***capensis*** - Form 1a: Typical form (Oudtshoorn, George); Form 1b: Typical form (Laingsburg to Rooiberg); Form 2: Anysberg/Swartberg form; Form 3: Bredasdorp form; Form 4: Broad-leaf Peninsula form; Form 5: Hex River Valley form; Form 6: Ceres form.

R. capensis **subsp.** ***dichotoma*** - Form 1: Northern form (Cedarberg, Olifantsrivier Valley); Form 2: Typical form (Caledon, Jonaskop, Greyton, Genadendal); Form 3: Montagu form; Form 4: Riversdale form; Form 5: Prospect Peak form.

R. capensis **subsp.** ***ovata*** - Form 1: Nieuwoudtville form; Form 2: Ceres form (Clanwilliam, Ceres, Cedarberg, Piquetberg, Tulbagh); Form 3a: Typical form (Stellenbosch); Form 3b: Typical form (Worcester); Form 3c: Typical form (Franschhoek, Paarl); Form 4: Hermanus form.

Table 2.2 Figure caption for all graphic summaries of quantitative characters, showing range and mean values. The geographical origins of the forms are given in Table 2.1.

1, *R. racemosa* subsp. *racemosa*; **2,** *R. racemosa* subsp. *pumila*; **3,** *R. angulata* subsp. *angulata*; **4,** *R. angulata* subsp. *thunbergii*; **5,** *R. angulata* subsp. *humilis*; **6,** *R. angulata* subsp. *ericifolia*; **7,** *R. angulata* subsp. *montana*; **8,** *R. crispa*; **9,** *R. lancea*; **10,** *R. rostrata* subsp. *rostrata*; **11,** *R. rostrata* subsp. *pauciflora*; **12,** *R. vlokii*; **13,** *R. alata* Form 1; **14,** *R. alata* Form 2; **15,** *R. alata* Form 3; **16,** *R. crassifolia*; **17,** *R. elliptica*; **18,** *R. triflora* Form 1; **19,** *R. triflora* Form 2; **20,** *R. ovata*; **21,** *R. inaequalis*; **22,** *R. acuminata* Form 1; **23,** *R. acuminata* Form 2; **24,** *R. amplexicaulis*; **25,** *R. diffusa*; **26,** *R. spicata*; **27,** *R. schlechteriana*; **28,** *R. capensis* subsp. *capensis*; **29,** *R. capensis* subsp. *carinata*; **30,** *R. capensis* subsp. *calycina*; **31,** *R. capensis* subsp. *dichotoma* Form 1; **32,** *R. capensis* subsp. *dichotoma* Form 5; **33,** *R. capensis* subsp. *ovata*; **34,** *R. capensis* subsp. *elsieae*; **35,** *R. capensis* subsp. *pedicellata*; **36,** *R. globosa*.

The numbers in bold within the following tables represent the forms given in Table 2.1.

Table 2.3 Voucher specimens of *Rafnia* material used to illustrate leaves.

R. racemosa* subsp. *racemosa - *Bond 1551* (NBG); *Levyns 9111* (BOL); *McDonald 1558* (NBG); *Oliver 5455, 5550* (NBG); *Taylor 9633* (NBG); *Thorne s.n. sub NBG 14318* (NBG); *Van Wyk 2156* (JRAU); *Vlok 164* (NBG); *Wurts 1345* (NBG).

R. racemosa* subsp. *pumila - *Esterhuysen 33444* (BOL).

R. angulata* subsp. *angulata - **1:** *Barker 9648, 10332* (NBG); *Bean & Viviers 1977* (BOL); *Campbell & Van Wyk 143, 146* (JRAU); *Compton 10078, 18728* (NBG); *Esterhuysen 22143* (BOL); *Snijman 44* (NBG); *Van Wyk s.n., 3679* (JRAU); **2:** *Campbell, Van Wyk & De Castro 136* (JRAU); *Ecklon & Zeyher 1195* (SAM); *Van Wyk 3226* (JRAU); **4:** *Bolus 20934* (BOL); *Leighton 2447* (BOL); *Van Wyk 2689* (JRAU); **5:** *Campbell & Van Wyk 139* (JRAU); *Leighton 2453* (BOL); *Stirton 11195* (NBG); *Strauss 5* (NBG); *Van Niekerk 356* (BOL); *Zinn s.n. sub SAM 54233* (SAM); **6:** *Campbell & Van Wyk 132* (JRAU); *Esterhuysen 20807* (NBG); *Guthrie 188* (BOL); *Walters 1932, 2539* (NBG); **7:** *Campbell & Van Wyk 23, 29, 106* (JRAU); *Ecklon & Zeyher 1197* (SAM); *Froembling s.n. sub SAM 65269* (SAM); *Lamb 1364* (SAM); **8:** *Compton 8487, 15515, 16658* (NBG); *Purcell 399* (SAM); *Salter 9008* (NBG); *Van Wyk 2757* (JRAU); **9:** *Schutte & Vlok 762* (JRAU); **10:** *Stokoe s.n. sub SAM 68747* (SAM).

R. angulata* subsp. *thunbergii - *Campbell, Van Wyk & De Castro 130* (JRAU); *Compton 24446* (NBG); *Van Wyk 2908* (JRAU).

R. angulata* subsp. *humilis - *Guthrie 188* (BOL); *Salter 8271* (BOL).

R. angulata* subsp. *ericifolia - *Barker 8862* (NBG); *Salter 6567* (BOL); *Van Zyl 3583* (NBG); *Vlok & Schutte 108* (JRAU).

R. angulata* subsp. *montana - *Andreae 1245* (BOL); *Van Wyk & Schutte 3323* (JRAU).

R. crispa - *Stirton 8439* (PRE).

R. lancea - *Barker 1002* (NBG); *Leipoldt 4023* (NBG); *Lewis 3587* (SAM), *5739* (NBG); *Walters 948* (NBG).

R. rostrata* subsp. *rostrata - *Barker 2358* (BOL); *Bolus 8372* (BOL); *Campbell & Van Wyk 145* (JRAU); *Compton 9900, 12126, 21135, 22221* (NBG); *Van Wyk 486* (NBG).

R. rostrata* subsp. *pauciflora - *Bean & Viviers 1991* (BOL); *Esterhuysen 28833* (BOL); *Thompson 2211* (PRE); *Thorne s.n. sub SAM 50193* (SAM); *Vlok 892* (PRE).

R. vlokii - *Campbell & Van Wyk 156* (JRAU); *Vlok 534* (NBG).

R. alata - **1:** *Bolus s.n. sub BOL 61264* (BOL); *Campbell, Van Wyk & Vlok 8,154* (JRAU); *Esterhuysen 28822* (BOL); *Stokoe 8782* (BOL); *Vlok 108* (NBG); **2:** *Vlok 736* (PRE); **3:** *Burgers 1404* (PRE); *Vlok 1713* (PRE).

R. crassifolia - *Barker 3953, 4302* (NBG); *Boucher 1823* (NBG); *Campbell & Van Wyk 150* (JRAU).

R. elliptica - *Campbell & Van Wyk 157* (JRAU); *Compton 24419* (NBG); *Hugo 2010* (NBG); *Oliver 9363* (NBG); *Thode 3241* (NBG); *Van Wyk & C.M. van Wyk 1443, 2044* (JRAU).

R. triflora - **1:** *Campbell & Van Wyk 118, 123* (JRAU); *Levyns 3600* (BOL); *Purcell s.n.* (SAM); *Taylor 3730* (NBG); *Vlok 2679* (JRAU); **2:** *Burgers 1342* (NBG); *Chambers & Chambers s.n. sub NBG 85107* (NBG); *Stokoe s.n. sub SAM 61416* (SAM); *C.M. van Wyk 2090* (PRE); *Walters 1495* (NBG).

R. ovata - *Barker 9568* (NBG); *Campbell & Van Wyk 122*, *128* (JRAU); *Esterhuysen 12130* (BOL); *Levyns 1914* (BOL); *Van Wyk 3135* (JRAU).

R. inaequalis - *Campbell & Van Wyk 119* (JRAU); *Compton 23005* (NBG).

R. acuminata - **1:** *Campbell & De Castro 97* (JRAU); *Campbell & Van Wyk 22*, *129* (JRAU); *De Vos 358* (NBG); *Ecklon & Zeyher 2283* (SAM); *Levyns 10642* (BOL); *Parker 3741* (BOL); *Schlieben & Van Bredá 9935* (NBG); *Taylor 11432* (NBG); *Van Wyk 2067* (JRAU); *Walters 896* (NBG); **2:** *Esterhuysen 17909* (BOL); *Maguire 1154* (NBG).

R. amplexicaulis - *Boucher 3635* (NBG); *Campbell & Van Wyk 120* (JRAU); *Davis s.n. sub SAM 65704* (SAM); *Esterhuysen 21952* (BOL); *Levyns 3963* (BOL); *Schlieben & Van Bredá 9907* (PRE); *Taylor 11097* (NBG); *Van Wyk 2907* (JRAU); *Walters 562*, *1339* (NBG).

R. diffusa - **1:** *Barker 9776* (NBG); *Campbell & Van Wyk 44* (JRAU); *Compton 20815* (NBG); *Van Wyk 2881* (JRAU); **2:** *Leighton 21600* (BOL); *Stokoe s.n. sub SAM 61409* (SAM); *Taylor 11145* (NBG); **3:** *Campbell & Van Wyk 140* (JRAU); *Esterhuysen 17940* (BOL); *Stokoe s.n. sub SAM 55790* (SAM); **4:** *Campbell & Van Wyk 124* (JRAU); *Lewis s.n. sub BOL 50548* (BOL); *Stirton 10181* (NBG); **5:** *Maguire 1151* (NBG); **6:** *Stirton & Zantovska 11412* (NBG); *Van Rensburg 171* (NBG).

R. spicata - *Campbell & Van Wyk 127*, *141* (JRAU); *Emdon 203* (NBG); *Esterhuysen 7197*, *22458* (BOL); *Kolbe s.n. sub BOL 43069* (BOL); *Levyns 1079* (BOL); *Taylor 11295* (NBG); *Van Wyk 2308* (JRAU).

R. schlechteriana - *Barker 8125* (NBG); *Campbell & Van Wyk 33*, *117* (JRAU); *Compton 22961* (NBG); *Esterhuysen 17875* (BOL); *Oliver 6042* (NBG); *Pillans 9651* (BOL); *Thome s.n. sub SAM 51227* (SAM).

R. capensis **subsp.** ***capensis*** - **1a:** *Barker 7711* (NBG); *Compton 21765* (NBG); *Esterhuysen 19472* (BOL); *Vlok 4* (NBG); **1b:** *Compton 21106* (NBG); *Linder 4155* (BOL); *Oliver & Fellingham 9142* (NBG); *Taylor 9801* (NBG); *Vlok 154* (NBG); *Vlok & Schutte 406* (JRAU); **2:** *Campbell & Van Wyk 10* (JRAU); *Campbell, Van Wyk & Vlok 153* (JRAU); *Compton 10421* (NBG); **3:** *Boucher & Shepherd 4908* (NBG); *Esterhuysen 29361* (BOL); *Martin 354* (NBG); **4:** *Barker 3260* (NBG); *Campbell & Van Wyk 108*, *151* (JRAU); *Guthrie 142* (BOL); *Michell s.n. sub BOL 50543* (BOL); **5:** *Barker 5971* (NBG); *Campbell & Van Wyk 104* (JRAU); *Campbell, Van Wyk & De Castro 131*, *133* (JRAU); *Compton 9907* (NBG), *22839* (BOL); *Esterhuysen 14273* (BOL); *Levyns 1120* (BOL); *Walters 1044* (NBG); **6:** *Bolus s.n. sub BOL 32549* (BOL); *Compton 10000* (NBG); *Esterhuysen 1555* (BOL); *Hugo 2522* (NBG); *Van Wyk 2287* (JRAU).

R. capensis **subsp.** ***carinata*** - *Campbell & Van Wyk 126* (JRAU); *Forsyth 157* (NBG); *Shaw s.n. sub BOL 32561* (BOL); *Taylor 11917* (NBG); *Van Wyk 2304* (JRAU).

R. capensis **subsp.** ***calycina*** - *Bean & Viviers 1500* (BOL); *Bolus s.n. sub BOL 23841* (BOL); *Campbell & Van Wyk 38*, *121* (JRAU); *Esterhuysen 35798* (BOL); *Maguire 1178* (NBG); *Martin 782* (NBG); *Stokoe s.n. sub SAM 68749* (SAM).

R. capensis **subsp.** ***dichotoma*** - **1:** *Esterhuysen 14297* (BOL); *Taylor 11483* (NBG); **2:** *Bolus 372* (BOL); *Campbell & De Castro 98* (JRAU); *Campbell & Van Wyk 160* (JRAU); *Compton 12969* (NBG); *Ecklon & Zeyher 1190* (SAM); **3:** *Compton 5817* (BOL); *Esterhuysen 29061*, *29129* (BOL); **4:** *Esterhuysen 28791* (BOL); *Levyns & Levyns 635* (BOL), *636* (NBG); *McDonald 1449* (NBG); *Van der Merwe 190* (NBG); *Van Wyk 2798* (JRAU).

R. capensis **subsp.** ***ovata*** - **1:** *Barker 9201* (NBG); **2:** *Barker 8121*, *10294* (NBG); *Bolus 8429* (BOL); *Campbell & Van Wyk 32*, *37* (JRAU); *Compton 3649* (BOL), *6499*, *6715* (NBG); *Esterhuysen 2492*, *6155*, *16109*, *34389* (BOL); *Guthrie 2115* (NBG); *Lamb 428* (SAM); *Lewis 3590* (SAM); *Low 1079a* (NBG); *Oliver 3978* (NBG); *Phillips 1737* (SAM); *Pillans 8770* (BOL); *Stokoe s.n. sub SAM 55818* (SAM); *C.M. van Wyk 2554* (JRAU); *Van Zyl 3090* (NBG); **3a:** *Compton 15340* (NBG); *Forsyth 377* (NBG); *Kruger 120* (NBG); *Van der Merwe 838* (NBG); **3b:** *Boucher 5339* (NBG); *Compton 20144* (NBG); *Haynes 686* (NBG); *Lamb 114* (NBG); *Lewis 3589* (SAM); *Pillans 8401* (BOL); *Walters 1429* (NBG); **3c:** *Barker 4165* (NBG); *Bolus 2752* (BOL); *Esterhuysen 30031* (BOL); *Salter 2970* (BOL); **4:** *Barker 7620* (NBG); *Bolus 4133* (BOL); *Campbell & Van Wyk 147* (JRAU); *Compton 16513*, *20169* (NBG); *Flynn & Davis APF660* (NBG); *Orchard 369* (NBG); *Taylor 3797*, *4295* (NBG).

R. capensis **subsp.** ***elsieae*** - *Esterhuysen 28730* (BOL); *Phillips 1736* (SAM).

R. capensis **subsp.** ***pedicellata*** - *Bolus 6789*, *8534*, *9879*, *s.n. sub BOL 43019* (BOL); *Compton 3452* (BOL), *20442* (NBG); *Schutte 695* (JRAU).

R. globosa - *Campbell & Van Wyk 125* (JRAU); *Compton 4779* (NBG); *Levyns 3001* (BOL); *McDonald 1204* (NBG); *Pillans 9081* (BOL); *Taylor 2937* (NBG).

Table 2.4 Voucher specimens of *Rafnia* material used to measure leaves on flowering branches, basal leaves and coppice leaves*.

R. racemosa* subsp. *racemosa - *Campbell & Van Wyk 7* (JRAU); *Campbell, Van Wyk & Vlok 155* (JRAU); *Levyns 2098* (BOL); *Marshall 216* (NBG); *Taylor 9633* (NBG); *Van Wyk 2171, 2976, 3174* (JRAU).

R. racemosa* subsp. *pumila - *Esterhuysen 33444* (BOL).

R. angulata* subsp. *angulata - **1:** *Barker 9648, 10333* (NBG); *Compton 10078, 18728* (NBG); *Esterhuysen 22143* (BOL); *Van Wyk s.n., 3679* (JRAU); **2:** *Campbell, Van Wyk & De Castro 136* (JRAU); *Van Wyk 3226* (JRAU); **4:** *Compton 18920* (NBG); *Van Wyk 2689* (JRAU); **5:** *Compton 18918* (NBG); *Stirton 11195* (NBG); **6:** *Van Wyk 2788* (JRAU); *Walters 2539* (NBG); **7:** *Campbell & Van Wyk 29* (JRAU); *Penfold s.n. sub SAM 52756* (SAM); **8:** *Compton 8487* (NBG); *Van Wyk 3008* (JRAU); **9:** *Schutte & Vlok 762* (JRAU); **10:** *Stokoe s.n. sub SAM 68747* (SAM), *s.n. sub NBG 100842* (NBG).

R. angulata* subsp. *thunbergii - *Campbell, Van Wyk & De Castro 130* (JRAU); *Compton 24446* (NBG); *Rycroft 2094* (NBG); *Walters 147* (NBG).

R. angulata* subsp. *humilis - *Bolus 7072* (BOL); *Guthrie 188* (BOL); *Salter 2875* (BOL); *Van Warmelo 243* (PRE); *Young 176* (BOL).

R. angulata* subsp. *ericifolia - *Barker 8862* (NBG); *Boucher 3535* (PRE); *Esterhuysen 28056* (BOL); *Van Zyl 3583* (NBG); *Vlok & Schutte 108** (JRAU).

R. angulata* subsp. *montana - *Andreae 1245* (BOL); *Van Wyk & Schutte 3323* (JRAU).

R. crispa - *Stirton 8439* (PRE).

R. lancea - *Barker 1002* (NBG); *Johnson 481* (NBG); *Leipoldt 4023* (BOL); *Pillans 9259* (BOL); *Stokoe s.n. sub SAM 65707* (SAM).

R. rostrata* subsp. *rostrata - *Compton 12126* (NBG), *21135* (PRE); *Esterhuysen 3727* (BOL); *Taylor 6087* (PRE); *C.M. van Wyk 486* (PRE).

R. rostrata* subsp. *pauciflora - *Bean & Viviers 1991* (BOL); *Esterhuysen 28833* (BOL); *Thompson 2211* (NBG, PRE); *Vlok 892* (PRE).

R. vlokii - *Campbell & Van Wyk 156* (JRAU); *Van Wyk 3172* (JRAU); *Vlok 534* (NBG), *823* (PRE).

R. alata - **1:** *Campbell & Van Wyk 8* (JRAU); *Campbell, Van Wyk & Vlok 154* (JRAU); *Pocock S136* (PRE); *Vlok 108* (NBG), *1761* (PRE); **2:** *Vlok 736* (PRE); **3:** *Burgers 1404* (PRE); *Vlok 1713* (PRE).

R. crassifolia - *Bolus 8535* (BOL); *Campbell & Van Wyk 150* (JRAU); *Compton 6089, 23224* (NBG); *Vlok & Schutte 258* (JRAU).

R. elliptica - *Bayliss 3078* (NBG); *Campbell & Van Wyk 157, 158* (JRAU); *Guthrie 4300* (NBG); *Hugo 2010* (NBG); *Oliver 1263* (NBG); *Thode 3240* (NBG); *Van Wyk & C.M. van Wyk 1066* (JRAU).

R. triflora - **1:** *Barker 5345* (NBG); *Campbell & Van Wyk 118* (JRAU); *Fourcade 707* (BOL); *Leighton 2472* (BOL); *MacOwan 2748* (SAM); *Purcell s.n. sub SAM 89679* (SAM); *Van Wyk 2885* (JRAU); *Walters 1375* (NBG); **2:** *Bohnen 8112* (NBG); *Chambers & Chambers s.n. sub NBG 85107* (NBG); *Compton 6082* (NBG); *C.M. van Wyk 2090* (NBG, PRE).

R. ovata - *Campbell & Van Wyk 34, 122, 128* (JRAU); *Esterhuysen 12130* (BOL); *Levyns 2184* (BOL); *Pillans 9093* (BOL).

R. inaequalis - *Campbell & Van Wyk 119** (JRAU).

R. acuminata - **1:** *Barker 4164, 7619* (NBG); *Campbell & Van Wyk 22, 129* (JRAU); *Compton 14224* (NBG); *Gray 26048* (BOL); *Leighton 332* (BOL); *Walters 896* (NBG); **2:** *Compton 4786* (NBG); *Esterhuysen 17909* (BOL); *Loubser 799* (BOL); *Maguire 1154* (NBG); *Pillans 7355* (BOL).

R. amplexicaulis - *Campbell & Van Wyk 40, 120* (JRAU); *Compton 8330* (BOL); *Herre 8914* (NBG); *Perry 3246* (NBG); *Rycroft 3307* (NBG); *Van Wyk 2440* (JRAU); *Walters 1064* (NBG).

R. diffusa - **1:** *Barker 9776* (NBG); *Campbell & Van Wyk 44* (JRAU); *Compton 20815* (NBG); **2:** *Leighton 21600** (BOL); *Taylor 11145** (NBG); **3:** *Pillans 8726* (BOL); *Stokoe s.n. sub SAM 55790* (SAM); **4:** *Bond 606* (NBG); *Campbell & Van Wyk 124* (JRAU); **5:** *Maguire 1194* (NBG); **6:** *Compton 16367* (NBG); *Leighton 698* (BOL).

R. spicata - *Campbell & Van Wyk 127, 141, 142* (JRAU); *Emdon 203* (NBG); *Kolbe s.n. sub BOL 43069* (BOL); *Taylor 4068a, 6136* (NBG); *Van Wyk 2308* (JRAU).

R. schlechteriana - *Campbell & Van Wyk 117* (JRAU); *Compton 22961* (NBG); *Esterhuysen 17875* (BOL); *Pillans 9651* (BOL); *Thorne s.n. sub SAM 51277* (SAM).

R. capensis* subsp. *capensis - **1a:** *Barker 7711* (NBG); **1b:** *Vlok & Schutte 406* (JRAU); **2:** *Campbell, Van Wyk & Vlok 153* (JRAU); *Compton 10421* (NBG); **3:** *Parker 3949* (BOL); *Taylor 7181* (NBG); **4:** *Campbell & Van Wyk 108* (JRAU); *Guthrie 142* (BOL); **5:** *Campbell & Van Wyk 104* (JRAU); *Walters 1044* (NBG); **6:** *Levyns 1120* (BOL); *Parker 3949* (NBG).

R. capensis* subsp. *carinata - *Campbell & Van Wyk 126* (JRAU); *Compton 24283* (NBG); *Forsyth 157*

(NBG); *Stirton 9182* (PRE); *C.M. van Wyk 2549* (PRE).

R. capensis* subsp. *calycina - *Bolus 8428* (BOL); *Campbell & Van Wyk 38* (JRAU); *Esterhuysen 35798* (BOL); *Maguire 1178* (NBG); *Stokoe s.n. sub SAM 68749* (PRE).

R. capensis* subsp. *dichotoma - **1:** *Esterhuysen 13467, 14297* (BOL); **2:** *Campbell & De Castro 98* (JRAU); *Campbell & Van Wyk 160* (JRAU); *Compton 12969* (NBG); **3:** *Compton 5817* (BOL); *Esterhuysen 29061* (BOL); *Lewis s.n. sub BOL 32558* (BOL); **4:** *Esterhuysen 28791* (BOL); *Hugo 2736* (NBG); **5:** *Esterhuysen 15960* (BOL, NBG).

R. capensis* subsp. *ovata - **1:** *Barker 9201* (NBG); **2:** *Barker 10294* (NBG); *Bolus s.n. sub BOL 43014* (BOL); *Phillips 1737* (SAM); *Pillans 8770* (BOL); **3a:** *Forsyth 377* (NBG); *McDonald 947* (NBG); **3b:** *Pillans 8401* (BOL); *Viviers 691* (NBG); **3c:** *Barker 4165* (NBG); *Gray s.n. sub BOL 50526* (BOL); **4:** *Flynn & Davis APF660* (NBG); *Rycroft 3182* (NBG).

R. capensis* subsp. *elsieae - *Esterhuysen 8308, 9927, 14858* (PRE), *28730* (NBG); *Forsyth 312* (PRE).

R. capensis* subsp. *pedicellata - *Bolus 9879* (BOL); *Compton 6087, 23688* (NBG); *Stokoe s.n. sub SAM 59608* (SAM); *Williams 2605* (NBG).

R. globosa - *Campbell & Van Wyk 125* (JRAU); *Levyns 3001* (BOL); *McDonald 1204* (NBG); *Story 2957* (PRE); *Taylor 11568* (NBG).

Table 2.5 Voucher specimens of *Rafnia* material used to study stomata.

R. racemosa* subsp. *racemosa - *Campbell & Van Wyk 7* (JRAU).
R. angulata* subsp. *angulata - *Campbell & Van Wyk 20* (JRAU).
R. alata - *Campbell & Van Wyk 8* (JRAU).
R. acuminata - *Campbell & Van Wyk 22* (JRAU).
R. amplexicaulis - *Campbell & Van Wyk 26* (JRAU).
R. diffusa - *Campbell & Van Wyk 41, 44* (JRAU).
R. schlechteriana - *Campbell & Van Wyk 33* (JRAU).
R. capensis* subsp. *capensis - *Campbell & Van Wyk 10, 29, 30* (JRAU).
R. capensis* subsp. *dichotoma - *Campbell & Van Wyk 38* (JRAU).
R. capensis* subsp. *ovata - *Campbell & Van Wyk 32* (JRAU).

Table 2.6 Voucher specimens of *Rafnia* material used to study midrib anatomy.

R. racemosa* subsp. *racemosa - *Campbell & Van Wyk 7* (JRAU).
R. angulata* subsp. *angulata - *Campbell & Van Wyk 20* (JRAU).
R. alata - *Campbell & Van Wyk 8* (JRAU).
R. elliptica - *Van Wyk, Winter & Tilney 3501* (JRAU).
R. acuminata - *Campbell & Van Wyk 17, 22* (JRAU).
R. amplexicaulis - *Campbell & Van Wyk 26* (JRAU).
R. diffusa - *Campbell & Van Wyk 41, 44* (JRAU).
R. schlechteriana - *Campbell & Van Wyk 33* (JRAU).
R. capensis* subsp. *capensis - *Campbell & Van Wyk 10, 30* (JRAU).
R. capensis* subsp. *dichotoma - *Campbell & Van Wyk 38* (JRAU).
R. capensis* subsp. *ovata - *Campbell & Van Wyk 32* (JRAU).

Table 2.7 Voucher specimens of *Rafnia* material used to measure number of flowers per inflorescence and lengths of inflorescence axis, flower and pedicel.

R. racemosa* subsp. *racemosa - *Bond 242* (NBG); *Campbell, Van Wyk & Vlok 155* (JRAU); *Goldblatt 8038* (NBG); *Levyns 2098* (BOL); *Lewis 760* (SAM); *McDonald 1558* (NBG); *Oliver 5307* (NBG); *Stokoe 1756* (BOL); *Van Wyk 2172, 2971, 2976, 3174* (JRAU); *C.M. van Wyk 531* (NBG); *Wurts 1641* (NBG).

R. racemosa* subsp. *pumila - *Esterhuysen 33444* (BOL).

R. angulata* subsp. *angulata - **1:** *Barker 9648, 10333* (NBG); *Esterhuysen 7310, 22143* (BOL); *Leighton 2214* (BOL); *Snijman 44* (NBG); *Van Wyk 3679* (JRAU); **2:** *Campbell, Van Wyk & De Castro 136* (JRAU); *Compton 12669* (NBG); **4:** *Compton 18920* (NBG); *Leighton 2447* (BOL); **5:** *Campbell & Van Wyk 139* (JRAU); *Compton 18918* (NBG); *Penfold 241* (NBG); **6:** *Campbell, Van Wyk & De Castro 132* (JRAU); *Compton 10371* (NBG); *Walters 1932* (NBG); **7:** *Campbell & Van Wyk 152* (JRAU); *Salter 9008* (SAM); **8:** *Campbell & Van Wyk 106* (JRAU); *Penfold 186* (NBG); **9:** *Schutte & Vlok 762* (JRAU); **10:** *Stokoe s.n. sub SAM 68747* (SAM).

R. angulata* subsp. *thunbergii - *Compton 24446* (NBG); *Rycroft 2094* (NBG); *Van Wyk 2908* (JRAU); *Walters 147, 677* (NBG).

R. angulata* subsp. *humilis - *Guthrie 188* (BOL); *Leighton 1474* (BOL); *Salter 2875, 8271* (BOL).

R. angulata* subsp. *ericifolia - *Esterhuysen 28056* (BOL); *Salter 6567* (BOL); *Van Zyl 3583* (NBG).

R. angulata* subsp. *montana - *Andreae 1245* (BOL); *Van Wyk & Schutte 3323* (JRAU).

R. crispa - *Stirton 8439* (PRE).

R. lancea - *Johnson 481* (NBG); *Leipoldt 4023* (BOL); *Pillans 9259* (BOL); *Stokoe s.n. sub SAM 65707* (SAM); *Walters 948* (NBG).

R. rostrata* subsp. *rostrata - *Campbell & Van Wyk 145* (JRAU); *Compton 9900, 22221* (NBG); *Esterhuysen 3727* (BOL); *Taylor 6087* (NBG).

R. rostrata* subsp. *pauciflora - *Bean & Viviers 1991* (BOL); *Esterhuysen 28833* (BOL); *Oliver 5640* (NBG); *Thompson 2211* (NBG).

R. vlokii - *Vlok 534* (NBG).

R. alata - **1:** *Campbell, Van Wyk & Vlok 154* (JRAU); *Esterhuysen 28822* (BOL); *Stokoe s.n. sub SAM 55811, 68744* (SAM); **2:** *Vlok 736* (PRE); **3:** *Burgers 1404* (PRE).

R. crassifolia - *Barker 3953, 4302* (NBG); *Compton 12516* (NBG); *Stokoe s.n. sub STE 32071* (NBG); *Vlok & Schutte 258* (JRAU).

R. elliptica - *Bolus 8645* (BOL); *Campbell & Van Wyk 158* (JRAU); *Compton 24119* (NBG); *Thode 3240* (NBG); *Van der Bÿl s.n. sub SAM 52008* (SAM); *Van der Merwe 162* (NBG); *Van Wyk & C.M. van Wyk 1066* (JRAU).

R. triflora - **1:** *Barker 5345* (NBG); *Compton 18958* (NBG); *Ellis 45* (NBG); *Henderson 1403* (NBG); *Purcell 259* (SAM); **2:** *Burgers 1342* (NBG); *Walters 1495* (NBG).

R. ovata - *Barker 9568* (NBG); *Campbell & Van Wyk 128* (JRAU); *Gray s.n.* (NBG); *Levyns 1914* (BOL); *Walters 528* (NBG).

R. inaequalis - *Campbell & Van Wyk 119* (JRAU); *Compton 23005* (NBG).

R. acuminata - **1:** *Compton 18690, 22309* (NBG); *Phillips 1100* (NBG); *Taylor 5860* (NBG); *Zeyher s.n. sub SAM 15201* (SAM); **2:** *Maguire 1154b* (NBG); *Pillans 7355* (BOL); *Loubser 799* (BOL).

R. amplexicaulis - *Campbell & Van Wyk 111, 120* (JRAU); *MacOwan 2903b* (SAM); *Stokoe s.n. sub SAM 56856* (SAM); *Tyson 677* (SAM).

R. diffusa - **1:** *Barker 9776* (NBG); *Compton 20815* (NBG); *Van Wyk 2881* (JRAU); **2:** *Barker 10332* (NBG); *Leipoldt 537* (BOL); *Taylor 11145* (NBG); **3:** *Campbell & Van Wyk 140* (JRAU); *Pillans 8726* (BOL); *Stokoe 7830* (NBG); **4:** *Lewis s.n. sub BOL 50548* (BOL); *Taylor 10754* (NBG); **5:** *Maguire 1151* (NBG); **6:** *Compton 16367* (NBG); *Winkler 169* (NBG).

R. spicata - *Bean & Viviers 1961* (BOL); *Campbell & Van Wyk 127* (JRAU); *Levyns s.n. sub SAM 31650* (SAM); *Oliver 6093* (NBG); *Taylor 11627* (NBG).

R. schlechteriana - *Campbell & Van Wyk 117* (JRAU); *Esterhuysen 17875* (BOL); *Oliver 6042* (NBG); *Pillans 7225* (BOL); *Van Zyl 3095* (NBG).

R. capensis* subsp. *capensis - **1a:** *Lewis 5413* (NBG); *Vlok 371* (NBG); **1b:** *Barker 6778* (NBG); *Vlok & Schutte 406* (JRAU); **2:** *Oliver 5551* (NBG); *Vlok 37* (NBG); **3:** *C.M. van Wyk 2022* (NBG); *Wurts 547* (NBG); **4:** *Barker 3260* (NBG); *Campbell & Van Wyk 108* (JRAU); **5:** *Campbell, Van Wyk & De Castro 133* (JRAU); *Compton 22839* (BOL); *Walters 898, 1337* (NBG); **6:** *Phillips 1930* (SAM).

R. capensis* subsp. *carinata - *Campbell & Van Wyk 126* (JRAU); *Haynes 1325* (NBG); *Taylor 11257* (NBG); *Van Wyk 2304, 3680* (JRAU).

R. capensis* subsp. *calycina - *Bolus 8428* (BOL); *Campbell & Van Wyk 121* (JRAU); *Maguire 1178* (NBG); *Martin 782* (NBG); *Stokoe s.n. sub SAM 68749* (SAM).

R. capensis* subsp. *dichotoma - **1:** *Esterhuysen 17867* (BOL); **2:** *Oliver 9077* (NBG); *Stokoe s.n. sub SAM 57819* (NBG); *Van Wyk 2999* (JRAU); **3:** *Lewis s.n. sub BOL 32558* (BOL); **4:** *Hugo 2736* (NBG); *Van der Merwe 190* (NBG).

R. capensis* subsp. *ovata - **1:** *Barker 9201* (NBG); **2:** *Campbell & Van Wyk 37* (JRAU); *Compton 11963* (NBG); *Davis s.n. sub SAM 65716* (SAM); *Martin 784* (NBG); *Rycroft 2632* (NBG); *Stokoe s.n. sub SAM 55818* (SAM); *C.M. van Wyk 2554* (JRAU); **3a:** *Forsyth 377* (NBG); *Haynes 118* (NBG); *Viviers 691* (NBG); **3b:** *Barker 7165* (NBG); *Esterhuysen 33367* (BOL); *McDonald 1732a* (NBG); **3c:** *Barker 4165* (NBG); **4:** *Campbell & Van Wyk 147* (JRAU); *De Vos 460* (NBG).

R. capensis* subsp. *elsieae - *Esterhuysen 8308* (NBG), *14858*, *28730* (BOL).

R. capensis* subsp. *pedicellata - *Barker 1614* (NBG); *De Vos 1406* (NBG); *Schutte 436* (JRAU); *Stokoe s.n. sub SAM 59608* (SAM); *Walters 1935* (NBG); *Williams 2065* (NBG).

R. globosa - *Campbell & Van Wyk 125* (JRAU); *Levyns 2197* (BOL); *McDonald 1204* (NBG); *Pillans 9081* (BOL); *Salter 7565* (NBG).

Table 2.8 Voucher specimens of *Rafnia* material used to study peduncle and pseudopeduncle anatomy.

R. racemosa* subsp. *racemosa - *Van Wyk 2172* (JRAU).
R. angulata* subsp. *angulata - *Salter 9008* (SAM).
R. angulata* subsp. *thunbergii - *Van Wyk 2908* (JRAU).
R. lancea - *Bolus s.n.* (BOL).
R. rostrata* subsp. *rostrata - *Van Wyk 2175* (JRAU).
R. elliptica - *Van Wyk & C.M. van Wyk 2044* (JRAU).
R. triflora - *Van Wyk 2885* (JRAU).
R. ovata - *Van Wyk 3135* (JRAU).
R. amplexicaulis - *Campbell & Van Wyk 26* (JRAU).
R. diffusa - *Van Wyk 2881* (JRAU).
R. spicata - *Van Wyk 2308* (JRAU).
R. schlechteriana - *Van Wyk 3228* (JRAU).
R. capensis* subsp. *capensis - *Stirton 10289* (NBG).
R. capensis* subsp. *ovata - *Campbell & Van Wyk 37* (JRAU).
R. capensis* subsp. *pedicellata - *Van Wyk 2085* (JRAU).

Table 2.9 Voucher specimens of *Rafnia* material used to illustrate and measure floral parts.

Illustrations were made of the pedicel with bract and bracteoles, flower, calyx, standard, wings, keel, stamens and pistil. Measurements were taken of lengths of pedicel, bract, bracteoles, flower, calyx, calyx lobes and tube, widths of calyx lobes, depth of calyx sinuses, lengths and widths of standard, wings and keel, lengths of claws of standard, wings and keel and anther length.

R. racemosa* subsp. *racemosa - *Campbell, Van Wyk & Vlok 155* (JRAU); *Thompson 3176* (JRAU); *Van Wyk 2156*, *2172*, *3174* (JRAU); *Wurts 1641* (NBG).

R. racemosa* subsp. *pumila - *Esterhuysen 33444* (BOL).

R. angulata* subsp. *angulata - **1:** *Barker 9648*, *10333* (NBG); *Bean & Viviers 1977* (BOL); *Campbell & Van Wyk 146* (JRAU); *Compton 10078*, *18728* (NBG); *Esterhuysen 22143* (BOL); *Snijman 44* (NBG); *Van Wyk 3679* (JRAU); **2:** *Campbell, Van Wyk & De Castro 136* (JRAU); *Compton 12669* (NBG); **4:** *Bolus 20934* (BOL); **5:** *Campbell & Van Wyk 138* (JRAU); *Rycroft 1810* (NBG); *Stirton 11165* (NBG); *Van Wyk 2689* (JRAU); **6:** *Campbell & Van Wyk 20*, *132* (JRAU); *Compton 8366* (NBG); *Esterhuysen 20807* (NBG); *Walters 1932*, *2539* (NBG); **7:** *Campbell & Van Wyk 106* (JRAU); *MacOwan 52* (SAM); *Penfold 186* (NBG); **8:** *Campbell & Van Wyk 152* (JRAU); *Compton 16937* (NBG); *Purcell 334* (SAM);

9: *Schutte & Vlok 762* (JRAU); **10:** *Stokoe s.n. sub SAM 68747* (SAM).

R. angulata* subsp. *thunbergii - *Campbell, Van Wyk & De Castro 130* (JRAU); *Compton 24446* (NBG); *Thorne s.n. sub NBG 14263* (NBG); *Van Wyk 2908* (JRAU); *Walters 147* (NBG).

R. angulata* subsp. *humilis - *Guthrie 188* (BOL); *Leighton 1474* (BOL); *Salter 2875* (BOL); *Young s.n. sub TM 27329* (PRE).

R. angulata* subsp. *ericifolia - *Barker 8862* (NBG); *Esterhuysen 28056* (BOL).

R. angulata* subsp. *montana - *Andreae 1245* (BOL); *Van Wyk & Schutte 3323* (JRAU).

R. crispa - *Stirton 8439* (PRE).

R. lancea - *Esterhuysen 11936* (BOL); *Johnson 481* (NBG); *Stokoe s.n. sub SAM 65707* (PRE); *Walters 948* (NBG).

R. rostrata* subsp. *rostrata - *Barker 2358* (BOL); *Bean & Viviers 1976* (BOL); *Campbell & Van Wyk 145* (JRAU); *Compton 9900* (NBG); *Esterhuysen 3727* (BOL).

R. rostrata* subsp. *pauciflora - *Bean & Viviers 1991* (BOL); *Esterhuysen 28833* (BOL); *Thompson 2211* (NBG).

R. vlokii - *Vlok 534* (NBG).

R. alata - **1:** *Campbell, Van Wyk & Vlok 154* (JRAU); *Stokoe s.n. sub SAM 68744* (SAM); **2:** *Vlok 736* (PRE); **3:** *Burgers 1404* (PRE).

R. crassifolia - *Bond 1525* (NBG); *Campbell & Van Wyk 150* (JRAU); *Compton 23224* (NBG); *Vlok & Schutte 258* (JRAU); *Walters 595* (NBG).

R. elliptica - *Bolus 8645* (BOL); *Campbell & Van Wyk 157, 158* (JRAU); *Fourcade 4800* (NBG); *Taylor 10060* (BOL); *Van der Merwe 162* (NBG); *Van Wyk & C.M. van Wyk s.n.* (JRAU); *Vlok & Schutte 352* (JRAU).

R. triflora - **1:** *Barker 5345* (NBG); *Campbell & Van Wyk 118* (JRAU); *Ellis 45* (NBG); *Purcell 259* (SAM); *Van Wyk 2885* (JRAU); **2:** *Burgers 1342* (NBG); *Stokoe s.n. sub SAM 61416* (SAM); *Van Wyk 2887* (JRAU); *Van Wyk, Winter & Tilney 3501* (JRAU); *Walters 1495* (NBG).

R. ovata - *Barker 9568* (NBG); *Campbell & Van Wyk 128* (JRAU); *Compton 18813* (NBG); *Gray s.n.* (NBG); *Walters 528* (NBG).

R. inaequalis - *Campbell & Van Wyk 119* (JRAU); *Compton 23005* (NBG).

R. acuminata - **1:** *Barker 4164* (NBG); *Bayer 3360* (NBG); *Campbell & De Castro 97* (JRAU); *Campbell & Van Wyk s.n.* (JRAU); *Compton 22309* (NBG); *Schutte 437* (JRAU); *Van Wyk 2067* (JRAU); **2:** *Maguire 1154* (NBG); *Pillans 7355* (BOL).

R. amplexicaulis - *Campbell & Van Wyk 105, 120* (JRAU); *Jones s.n. sub NBG 28505* (NBG); *Salter 2760* (BOL); *Van Wyk s.n., 2440* (JRAU); *Walters 1869* (NBG).

R. diffusa - **1:** *Barker 9776* (NBG); *Compton 20815* (NBG); *Van Wyk 2881* (JRAU); **2:** *Barker 10332* (NBG); *Leighton 21600* (BOL); *Stokoe s.n. sub SAM 61409* (SAM); *Taylor 11145* (NBG); **3:** *Campbell & Van Wyk 140* (JRAU); *Esterhuysen 17940, 17945* (BOL); *Leipoldt 11713* (BOL); *Pillans 8726* (BOL); *Stokoe s.n. sub SAM 55790* (NBG); **4:** *Campbell & Van Wyk 124* (JRAU); *Goldblatt 3081* (NBG); *Taylor 11098* (NBG); **5:** *Maguire 1151* (NBG); *Van Wyk 3508* (JRAU); **6:** *Bachmann 5976* (BOL); *Stirton & Zantovska 11412* (NBG); *Winkler 169* (NBG).

R. spicata - *Campbell & Van Wyk 127, 141, 142* (JRAU); *Emdon 203* (NBG); *Esterhuysen 7197, 13468* (BOL); *Levyns 1079* (BOL); *Oliver 6093, 9042* (NBG); *Taylor 11405, 11627* (NBG); *Van Wyk 2308* (JRAU).

R. schlechteriana - *Campbell & De Castro s.n.* (JRAU); *Campbell & Van Wyk 117* (JRAU); *Compton 16672, 22961* (NBG); *Esterhuysen 13421, 17875* (BOL); *Goldblatt s.n. sub NBG 97432* (NBG); *Oliver 6042* (NBG).

R. capensis* subsp. *capensis - **1a:** *Compton 21765* (NBG); *Esterhuysen 19472* (BOL); *Lewis 5413* (NBG); *Stokoe s.n. sub SAM 68745* (SAM); *Thompson 1389* (NBG); *Vlok 371* (NBG); **1b:** *Barker 6778* (NBG); *Compton 21106* (NBG); *Lewis 5707* (NBG); *Matthews 1110* (NBG); *Thompson 3381* (NBG); *Vlok 154* (NBG); *Vlok & Schutte 406* (JRAU); **2:** *Campbell & Van Wyk 11* (JRAU); *Campbell, Van Wyk & Vlok 153* (JRAU); **3:** *Esterhuysen 29361* (BOL); *Fellingham 812* (NBG); *Taylor 7181* (NBG); *Stokoe s.n. sub SAM 61412* (SAM); *Wurts 547* (NBG); **4:** *Barker 3260* (NBG); *Campbell & Van Wyk 108, 151* (JRAU); *Compton 13800* (NBG); **5:** *Barker 5971* (NBG); *Campbell & Van Wyk 104* (JRAU); *Campbell, Van Wyk & De Castro 131, 133* (JRAU); *Compton 22839* (NBG); *Esterhuysen 19819* (BOL); *Walters 898* (NBG); **6:** *Anon. s.n. sub STE 31489* (NBG); *Bolus s.n. sub BOL 61275* (BOL); *Compton 10000* (NBG); *Schutte & Van Wyk 563* (JRAU); *Van Wyk 2287* (JRAU).

R. capensis* subsp. *carinata - *Campbell & Van Wyk 126* (JRAU); *Compton 24283* (NBG); *Esterhuysen 18035* (BOL); *Kruger KR956* (PRE); *Stirton 9182* (PRE); *Taylor 10516, 11917* (PRE); *Van Wyk 2304, 3680* (JRAU); *C.M. van Wyk 2549* (JRAU).

R. capensis subsp. _calycina_ - *Bean & Viviers 1500* (BOL); *Bolus s.n. sub BOL 23841* (BOL); *Campbell & Van Wyk 121* (JRAU); *Compton 22963* (NBG); *Esterhuysen 35798* (BOL); *Maguire 1178* (NBG); *Van Wyk 3225* (JRAU).

R. capensis subsp. _dichotoma_ - **1:** *Esterhuysen 17867* (BOL); **2:** *Campbell & De Castro 98* (JRAU); *Campbell & Van Wyk160* (JRAU); *Compton 12969* (NBG); *Stokoe s.n. sub SAM 57819* (NBG); **3:** *Rycroft 2200* (NBG); **4:** *Van der Merwe 190* (NBG); **5:** *Esterhuysen 15960* (BOL).

R. capensis subsp. _ovata_ - **1:** *Barker 9201* (NBG); **2:** *Barker 8121* (NBG); *Bond 623* (NBG); *Campbell & Van Wyk 32, 37* (JRAU); *Compton 6715, 12729, 22968* (NBG); *Esterhuysen 6155, 34389* (BOL); *Low 1079a* (NBG); *Phillips 1737* (SAM); *C.M. van Wyk 2554* (JRAU); *Van Zyl 3090* (NBG); **3a:** *Forsyth 377* (NBG); *McDonald 947* (NBG); **3b:** *Barker 7165* (NBG); *Haynes 686* (NBG); *Walters 890, 1429* (NBG); **3c:** *Barker 4165* (NBG); *Esterhuysen 30031* (BOL); *Salter 2970* (BOL); **4:** *Burman 1016* (BOL); *Campbell & Van Wyk 147* (JRAU); *Compton 20169* (NBG); *Taylor 4295* (NBG).

R. capensis subsp. _elsieae_ - *Esterhuysen 8308, 14858, 28730* (BOL).

R. capensis subsp. _pedicellata_ - *Campbell & De Castro 85* (JRAU); *Compton 20442* (NBG); *Van Wyk 2085* (JRAU); *Vlok, Van Wyk & Schutte 45* (JRAU); *Walters 1135, 1935* (NBG).

R. globosa - *Campbell & Van Wyk 125* (JRAU); *Le Maitre 262* (NBG); *McDonald 1204* (PRE); *Pillans 9081* (BOL); *Salter 7565* (BOL).

Table 2.10 Voucher specimens of *Rafnia* material used to study pollen.

R. racemosa subsp. _racemosa_ - *Van Wyk 2172* (JRAU) S, T.
R. angulata subsp. _angulata_ - *Van Wyk 2788* (JRAU) S.
R. angulata subsp. _thunbergii_ - *Walters 1440* (NBG) S, T.
R. lancea - *Walters 948* (NBG) S.
R. rostrata subsp. _rostrata_ - *Bean & Viviers 1975* (BOL); *Campbell & Van Wyk125* (JRAU) S, T.
R. crassifolia - *Schutte 438* (JRAU) S, T.
R. elliptica - *Van Wyk 2887* (JRAU) T; *Van Wyk & C.M. van Wyk 2044* (JRAU) S.
R. triflora - *Van Wyk 2885* (JRAU) S, T.
R. ovata - *Van Wyk 3135* (JRAU) S, T.
R. acuminata - *Schutte 444* (JRAU) T; *Van Wyk 2067* (JRAU) S.
R. amplexicaulis - *Van Wyk 2440* (JRAU) S, T.
R. schlechteriana - *Van Wyk 3228* (JRAU) S, T.
R. capensis subsp. _dichotoma_ - *Van Wyk 2999* (JRAU) S.
R. capensis subsp. _ovata_ - *Van Wyk 2985* (JRAU) S.

S = Scanning electron microscopy; T = Transmission electron microscopy.

Table 2.11 Voucher specimens of *Rafnia* material used to illustrate pods.

R. racemosa subsp. _racemosa_ - *Campbell & Van Wyk 155* (JRAU); *Levyns 2098* (BOL); *Van Wyk 2976* (JRAU).

R. angulata subsp. _angulata_ - **1:** *Campbell & Van Wyk 146* (JRAU); *Esterhuysen 22143* (BOL); *Van Wyk s.n.* (JRAU); **2:** *Compton 12669* (NBG); *Esterhuysen 7134* (BOL); **4:** *Compton 18920* (NBG); **5:** *Campbell & Van Wyk 139* (JRAU); *Penfold 241* (NBG); **6:** *Compton 8366, 14191* (NBG); **8:** *Wolley-Dod 724* (BOL).

R. angulata subsp. _thunbergii_ - *Campbell, Van Wyk & De Castro 130* (JRAU).

R. angulata subsp. _ericifolia_ - *Barker 8862* (NBG).

R. angulata subsp. _montana_ - *Van Wyk & Schutte 3323* (JRAU).

R. lancea - *Acocks 24519* (PRE).

R. rostrata subsp. _rostrata_ - *Campbell & Van Wyk 145* (JRAU).

R. rostrata subsp. _pauciflora_ - *Esterhuysen 28833* (BOL).

R. vlokii - *Van Wyk 3172* (JRAU).

R. alata - **1:** *Van Wyk s.n.* (JRAU); **3:** *Vlok 1713* (PRE).

R. crassifolia - *Campbell & Van Wyk 150* (JRAU); *Leighton 868* (BOL).

R. elliptica - *Campbell & Van Wyk 157* (JRAU); *Oliver 9363* (NBG).

R. triflora - **1:** *Henderson 1403* (NBG); *Purcell s.n. sub SAM 89679* (SAM); **2:** *Willemse 19* (NBG).

R. ovata - *Campbell & Van Wyk 122* (JRAU).

R. inaequalis - *Campbell & Van Wyk 119* (JRAU).

R. acuminata - **1:** *Bayer 3360* (NBG); *Thode 5288* (NBG); **2:** *Esterhuysen 17909* (BOL).

R. amplexicaulis - *Isaac s.n. sub BOL 32555* (BOL); *Kruger M180* (NBG); *Van Wyk 3030* (JRAU).

R. diffusa - **2:** *Leipoldt 537* (BOL); *Stokoe s.n. sub SAM 55913* (SAM); **3:** *Campbell & Van Wyk 140* (JRAU).

R. spicata - *Campbell & Van Wyk 141, 142* (JRAU).

R. schlechteriana - *Campbell & Van Wyk 117* (JRAU); *Esterhuysen 17875* (BOL).

R. capensis subsp. _capensis_ - **1a:** *Linder 4155* (BOL); *Vlok 4, 371* (NBG); **1b:** *Oliver & Fellingham 9142* (NBG); *Vlok & Schutte 406* (JRAU); **2:** *Campbell & Van Wyk 11* (JRAU); *Compton 10421* (NBG); **3:** *Burgers 2666* (NBG); *Compton 20409* (NBG); **4:** *Campbell & Van Wyk 151* (JRAU); **5:** *Campbell, Van Wyk & De Castro 133* (JRAU); *Esterhuysen 10936* (BOL); *Walters 1337* (NBG); **6:** *Bolus 8371* (BOL); *Compton 4847* (NBG).

R. capensis subsp. _carinata_ - *Haynes 1325* (NBG); *Van Wyk 2304* (JRAU).

R. capensis subsp. _calycina_ - *Campbell & Van Wyk 121* (JRAU); *Goldblatt 6515* (PRE); *Maguire 1178* (NBG).

R. capensis subsp. _dichotoma_ - **1:** *Esterhuysen 17867* (BOL); *Taylor 11483* (NBG); **2:** *McDonald 1732* (NBG); *Oliver 9077* (NBG); *Van Wyk 2999* (JRAU); **4:** *Phillips 325* (SAM); *Thorne s.n. sub SAM 38932* (SAM); *Van Wyk 2798* (JRAU).

R. capensis subsp. _ovata_ - **3a:** *Van der Merwe 838* (NBG); **3b:** *Pillans 8401* (BOL); *Stokoe s.n. sub SAM 65712* (SAM); **3c:** *Compton 4832* (NBG); *Esterhuysen 30031* (BOL); **4:** *De Vos 460* (NBG).

R. capensis subsp. _elsieae_ - *Esterhuysen 28730* (BOL).

R. capensis subsp. _pedicellata_ - *Gray s.n. sub BOL 26050* (BOL); *Walters 287, 1135* (NBG).

R. globosa - *Campbell & Van Wyk 125* (JRAU); *Levyns 2197* (BOL).

Table 2.12 Voucher specimens of *Rafnia* material used to measure pod length and width and stipe length*.

R. racemosa subsp. racemosa - *Campbell, Van Wyk & Vlok 155* (JRAU); *Levyns 2098* (BOL); *Oliver 5550* (NBG); *Van Wyk 2976* (JRAU); *Vlok 35* (NBG).

R. angulata subsp. _angulata_ - *Campbell & Van Wyk 138, 139, 146* (JRAU); *Compton 8366, 10371, 12669, 18920* (NBG); *Esterhuysen 7134, 22143* (BOL); *Leighton 2447* (BOL); *Parker 3643* (NBG); *Penfold 241* (NBG).

R. angulata subsp. _thunbergii_ - *Campbell, Van Wyk & De Castro 130* (JRAU).

R. angulata subsp. _ericifolia_ - *Barker 8862* (NBG); *Esterhuysen 28056* (BOL); *Salter 6567* (BOL).

R. angulata subsp. _montana_ - *Van Wyk & Schutte 3323* (JRAU).

R. lancea - *Salter 7669* (BOL); *Zeyher s.n. sub SAM 15207* (SAM).

R. rostrata subsp. _rostrata_ - *Bolus 8372* (BOL); *Campbell & Van Wyk 145* (JRAU); *Compton 9900* (NBG).

R. rostrata subsp. _pauciflora_ - *Esterhuysen 28833* (BOL); *Oliver 5640* (NBG); *Thompson 2211* (NBG).

R. vlokii - *Van Wyk 3172* (JRAU).

R. alata - *Van Wyk s.n.* (JRAU); *Vlok s.n.* (JRAU); *Vlok 1713* (PRE).

R. crassifolia - *Barker 3953* (NBG); *Bolus 8535* (NBG); *Boucher 1039* (NBG); *Campbell & Van Wyk 150* (JRAU); *Minicki s.n. sub SAM 51791* (SAM).

R. elliptica - *Campbell & Van Wyk 157* (JRAU); *Gillett 1581* (NBG); *Oliver 9363* (NBG); *Thode 3240* (NBG); *Van der Bÿl s.n. sub SAM 52008* (SAM); *Vlok s.n.* (JRAU).

R. triflora - *Barker 5345* (NBG); *Campbell & Van Wyk 118* (JRAU); *Henderson 1403* (NBG); *Purcell 259, s.n. sub SAM 89679b* (SAM); *Taylor 7030* (NBG).

_R. ovata_* - *Campbell & Van Wyk 122* (JRAU); *Compton 12726* (NBG).

_R. inaequalis_* - *Campbell & Van Wyk 119* (JRAU).

R. acuminata - *Campbell & Van Wyk 129* (JRAU); *Compton 14224, 14263, 22309* (NBG); *Esterhuysen*

17909 (BOL).

R. amplexicaulis - *Campbell & Van Wyk 105* (JRAU); *Compton 10351* (NBG); *Esterhuysen 11273* (BOL); *Isaac s.n. sub BOL 32555* (BOL); *Van Wyk 3030* (JRAU); *Walters 1339* (NBG).

R. diffusa* - *Barker 10332* (NBG); *Campbell & Van Wyk 140* (JRAU); *Leipoldt 537* (BOL); *Stokoe s.n. sub SAM 55913* (SAM); *Taylor 10754* (NBG).

R. spicata* - *Bean & Viviers 1961* (BOL); *Campbell & Van Wyk 141, 142* (JRAU).

R. schlechteriana - *Campbell & Van Wyk 117* (JRAU); *Esterhuysen 17875* (BOL); *Lewis 906* (SAM).

R. capensis* subsp. *capensis* - *Barker 7711* (NBG); *Bolus 8371* (NBG), *13089* (BOL); *Burgers 2666* (NBG); *Campbell & Van Wyk 151* (JRAU); *Campbell, Van Wyk & De Castro 133* (JRAU); *Compton 4847, 20409* (NBG); *Hugo 2522* (NBG); *Oliver 5551* (NBG); *Vlok 4, 37* (NBG); *Vlok & Schutte 406* (JRAU); *Walters 1337* (NBG).

R. capensis* subsp. *carinata* - *Forsyth 157* (NBG); *Haynes 1325* (NBG); *Taylor 11257* (NBG); *Van Wyk 2304* (JRAU).

R. capensis* subsp. *calycina* - *Campbell & Van Wyk 121* (JRAU); *Maguire 1178* (NBG).

R. capensis* subsp. *dichotoma* - *Bolus 372* (SAM); *Esterhuysen 17867* (BOL); *Hugo 2736* (NBG); *Oliver 9077* (NBG); *Taylor 11483* (NBG); *Thorne s.n. sub SAM 38932* (SAM); *Van Wyk 2999* (JRAU).

R. capensis* subsp. *ovata* - *Campbell & Van Wyk 135* (JRAU); *De Vos 460* (NBG); *Le Maitre 48* (NBG); *McDonald 1732a* (NBG); *Rycroft 2632* (NBG).

R. capensis* subsp. *elsieae* - *Esterhuysen 28730* (BOL).

R. capensis* subsp. *pedicellata* - *Walters 287, 1135, 1935* (NBG).

R. globosa* - *Campbell & Van Wyk 125* (JRAU); *Levyns 2197* (BOL); *Taylor 6201* (NBG).

Mature pods unknown: *R. racemosa* subsp. *pumila*, *R. angulata* subsp. *humilis*, *R. crispa*, *R. alata* Form 2.

Table 2.13 Voucher specimens of *Rafnia* material used to measure seed length and width and to study seeds using scanning electron microscopy.

R. racemosa* subsp. *racemosa - *Van Wyk 2971* (JRAU); *Vlok 35* (NBG).

R. angulata* subsp. *angulata - *Campbell & Van Wyk 35, 138, 139* (JRAU).

R. angulata* subsp. *thunbergii - *Compton 10371* (NBG).

R. vlokii - *Van Wyk 3172* (JRAU).

R. alata - *Vlok s.n.* (JRAU).

R. crassifolia - *Schlechter 7303* (BOL); *Wolley-Dod s.n. sub BOL 42925* (BOL).

R. elliptica - *Oliver 9363* (NBG); *Vlok s.n.* (JRAU).

R. triflora - *Campbell & Van Wyk 118* (JRAU); *Van Wyk 3010* (JRAU).

R. ovata - *Campbell & Van Wyk 122* (JRAU).

R. inaequalis - *Campbell & Van Wyk 119* (JRAU).

R. acuminata - *Compton 6091* (NBG); *Van Wyk 2994* (JRAU).

R. amplexicaulis - *Campbell & Van Wyk 105* (JRAU); *Van Wyk 3030* (JRAU).

R. diffusa - *Campbell & Van Wyk 124, 140* (JRAU); *Pillans 18797* (BOL).

R. spicata - *Campbell & Van Wyk 141* (JRAU).

R. schlechteriana - *Campbell & Van Wyk 117* (JRAU).

R. capensis* subsp. *capensis - *Bolus 13089* (BOL); *Campbell, Van Wyk & De Castro 131, 133* (JRAU); *Van Wyk 2972* (JRAU); *Vlok & Schutte 406* (JRAU).

R. capensis* subsp. *calycina - *Campbell & Van Wyk 121* (JRAU).

R. capensis* subsp. *dichotoma - *Van Wyk 2798, 2999* (JRAU).

R. capensis* subsp. *ovata - *Campbell & Van Wyk 135, 159* (JRAU).

R. capensis* subsp. *pedicellata - *Gray s.n. sub BOL 26050* (BOL).

R. globosa - *Campbell & Van Wyk 125* (JRAU).

Mature seeds unknown: *R. racemosa* subsp. *pumila*, *R. angulata* subsp. *humilis*, *R. angulata* subsp. *ericifolia*, *R. angulata* subsp. *montana*, *R. crispa*, *R. lancea*, *R. rostrata* subsp. *rostrata*, *R. rostrata* subsp. *pauciflora*, *R. capensis* subsp. *carinata* and *R. capensis* subsp. *elsieae*.

Table 2.14 Voucher specimens of *Rafnia* material used to study flavonoids.

R. angulata* subsp. *angulata - *Campbell & Van Wyk 106* (JRAU).
R. triflora - *Campbell & Van Wyk 118* (JRAU).
R. amplexicaulis - *Campbell & Van Wyk 105* (JRAU).
R. schlechteriana - *Campbell & Van Wyk 117* (JRAU).

Table 2.15 Voucher specimens of *Rafnia* material used to study enzymes.

R. angulata* subsp. *angulata - *Campbell & De Castro 76* (JRAU).
R. schlechteriana - *Campbell & De Castro s.n.* (JRAU).

CHAPTER 3

VEGETATIVE MORPHOLOGY

3.1 Habit

The morphology and complex relationships within the Crotalarieae have been studied by Dahlgren (1963a, 1967, 1970, 1975), Polhill (1976), Van Wyk (1991a) and Van Wyk & Schutte (1989, 1995). According to Van Wyk (1991a), few characters in the Crotalarieae are mutually exclusive or really characteristic for any specific genus, hence morphological patterns may be confusing.

The shrubby habit is diversely modified in the Crotalarieae (Polhill, 1976; Van Wyk & Schutte, 1995). The change from a shrubby to herbaceous habit is associated with geographical distribution in dry summer rainfall regions (Polhill, 1976; Van Wyk & Schutte, 1995), and has been considered a convergent response to high fire frequencies in grassland habitats (Van Wyk & Schutte, 1989) and increasing drought interactions (Rundel, 1989). Variation in habit represents the adaptive response, which is either that the aerial parts resist drought and fire or that extensive rootstocks develop which produce new stems during favourable growing conditions (Polhill, 1976).

The Crotalarieae are small trees, shrubs, perennial herbs, or sometimes annuals (only in *Crotalaria* L., *Lotononis* (DC.) Eckl. & Zeyh. and allies, *Argyrolobium* Eckl. & Zeyh. and *Lupinus* L.) and the branches are differentiated into long and very short shoots mainly in *Aspalathus*, *Lebeckia* and *Rafnia* (Polhill, 1976).

In *Rafnia*, the taxa are all resprouting shrubs (see Chapter 3.2) with many stems or flowering shoots developing from underground lignotubers. Habit is very variable in *Rafnia* (Figure

3.1). The taxa may be robust, much-branched woody shrubs, such as *R. triflora* (Figure 3.1, 12a) and *R. amplexicaulis* (Figure 3.1, 16), and particularly the northern forms of *R. capensis* subsp. *ovata* are also woody shrubs. Large suffrutices include some Cedarberg forms of *R. angulata* subsp. *angulata* (Figure 3.1, 2a) and *R. vlokii* (Figure 3.1, 8), for example. *R. angulata* subsp. *angulata* (Figure 3.1, 2b), *R. angulata* subsp. *thunbergii* (Figure 3.1, 3), *R. elliptica* (Figure 3.1, 11) and *R. ovata* (Figure 3.1, 13) are large virgate suffrutices (often more than 1 m tall), usually with all the stems herbaceous, sometimes becoming woody towards the base with age.

The remaining taxa are herbaceous rather than woody shrublets, varying in branching pattern. They may be erect and virgate like *R. capensis* subsp. *capensis* (Figure 3.1, 20b), erect, like *R. inaequalis* (Figure 3.1, 14) and *R. globosa* (Figure 3.1, 23) or procumbent, such as *R. lancea* (Figure 3.1, 6) and *R. alata* (Figure 3.1, 9). *R. racemosa* subsp. *pumila*, *R. angulata* subsp. *montana* (Figure 3.1, 5) and *R. spicata* (Figure 3.1, 18) may form dense, widely spreading clumps and *R. capensis* subsp. *elsieae* (Figure 3.1, 22) is a small, prostrate shrublet. *R. acuminata* (Figure 3.1, 15) is unusual in that it is prostrate and trailing.

Branching is generally alternate in the Crotalarieae, but in *Rafnia* branching may be opposite (Polhill, 1976). The woody taxa are often much-branched, e.g. *R. racemosa* subsp. *racemosa*, *R. triflora* and *R. amplexicaulis*. The stems may be unbranched for most of their length, for example *R. angulata* subsp. *thunbergii* (Figure 3.1, 3) and they may be chiefly branched from the base, as in *R. lancea* (Figure 3.1, 6).

Branching is often dichotomous in the upper parts and this is pronounced in *R. inaequalis*, *R. acuminata*, *R. amplexicaulis*, *R. schlechteriana* (Figure 3.1, 19), *R. capensis* subsp.

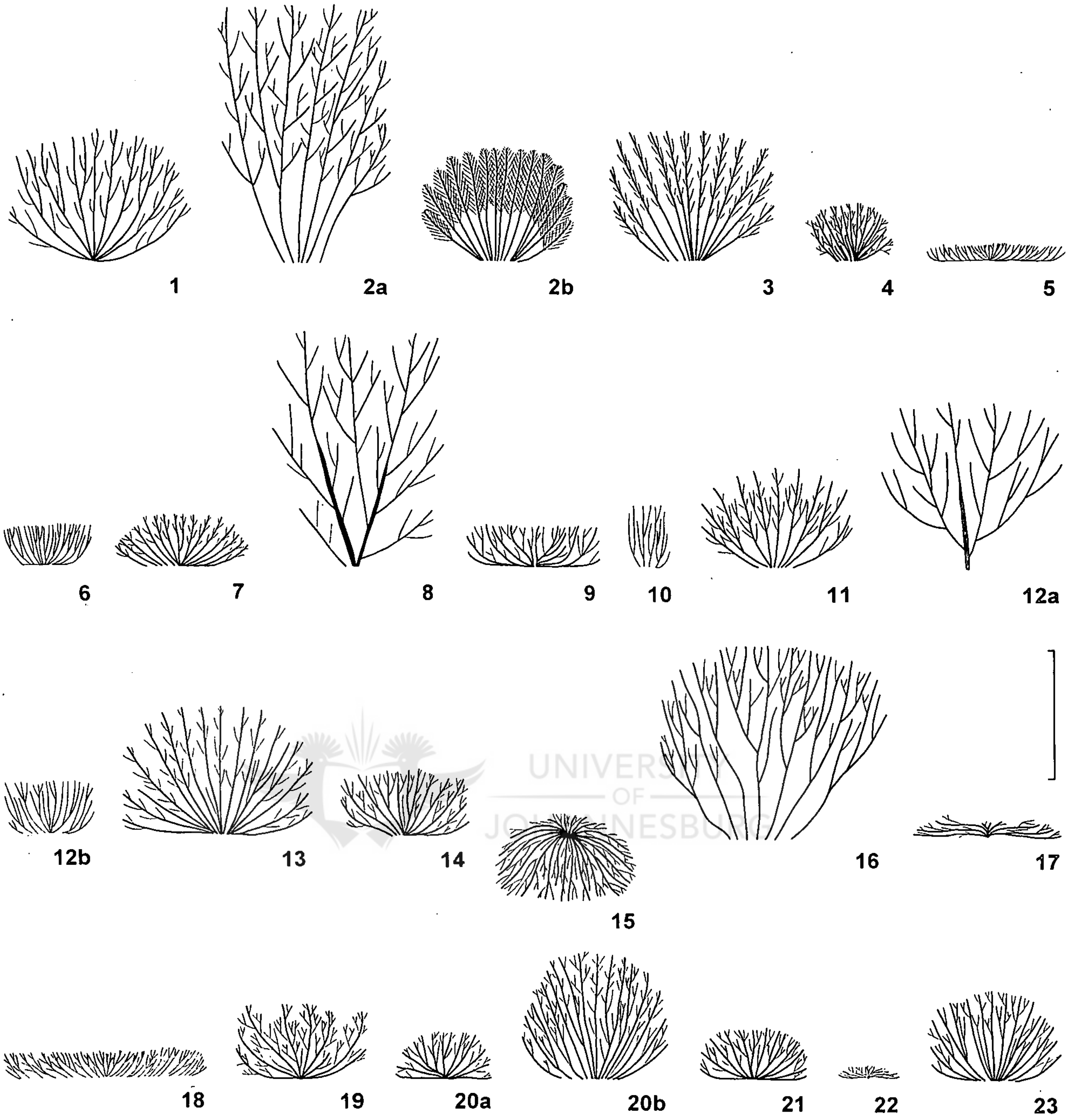


Figure 3.1 Variation in habit in *Rafnia*, showing differences in size and branching pattern: **1,** *R. racemosa* subsp. *racemosa*—robust, woody; **2,** *R. angulata* subsp. *angulata*: **a,** Form 1—robust, herbaceous; **b,** Form 2—virgate; **3,** *R. angulata* subsp. *thunbergii*—virgate, not much-branched; **4,** *R. angulata* subsp. *ericifolia*—virgate; **5,** *R. angulata* subsp. *montana*—prostrate, clump-forming; **6,** *R. lancea*—erect, much-branched from base; **7,** *R. rostrata* subsp. *rostrata*—erect; **8,** *R. vlokii*—robust, much-branched; **9,** *R. alata*—procumbent, clump-forming; **10,** *R. crassifolia*—erect, not much-branched; **11,** *R. elliptica*—robust, herbaceous; **12,** *R. triflora*: **a,** Form 1—robust, woody; **b,** Form 2—erect, herbaceous; **13,** *R. ovata*—robust, not much-branched; **14,** *R. inaequalis*—erect; **15,** *R. acuminata*—prostrate, trailing; **16,** *R. amplexicaulis*—woody, much-branched; **17,** *R. diffusa*—procumbent, spreading; **18,** *R. spicata*—procumbent, clump-forming; **19,** *R. schlechteriana*—virgate, dichotomously branched; **20,** *R. capensis* subsp. *capensis*: **a,** Form 1a—procumbent; **b,** Form 2—large, much-branched; **21,** *R. capensis* subsp. *dichotoma* (most of the subspecies of *R. capensis* have this form)—erect, dichotomously branched; **22,** *R. capensis* subsp. *elsieae*—prostrate, decumbent; **23,** *R. globosa*—erect, herbaceous. Scale = 1 m.

dichotoma (Figure 3.1, 21) and *R. globosa* (Figure 3.1, 23).

Different regional forms or populations within species may have distinct recognizable growth forms. For example, the Cedarberg form of *R. angulata* subsp. *angulata* may be a low-growing shrublet (0.3 m tall) or a large suffrutex up to 1.5 m tall. The typical form of *R. triflora* (Figure 3.1, 12a) is a large, much-branched woody shrub, while the Caledon form (Figure 3.1, 12b) is an erect shrublet.

The large, woody habit may be considered less derived in the genus and the reduction in size and lesser degree of woodiness may be adaptations to a drier climate. The taxa situated at the basal part of the cladogram (see Figure 7.1) are large shrubs and the supposedly more advanced taxa are mostly smaller suffrutices or shrublets. Despite the variation in *Rafnia*, habit is useful for distinguishing between some species which appear to be very similar on herbarium sheets, but differ markedly in habit (Figure 3.2).

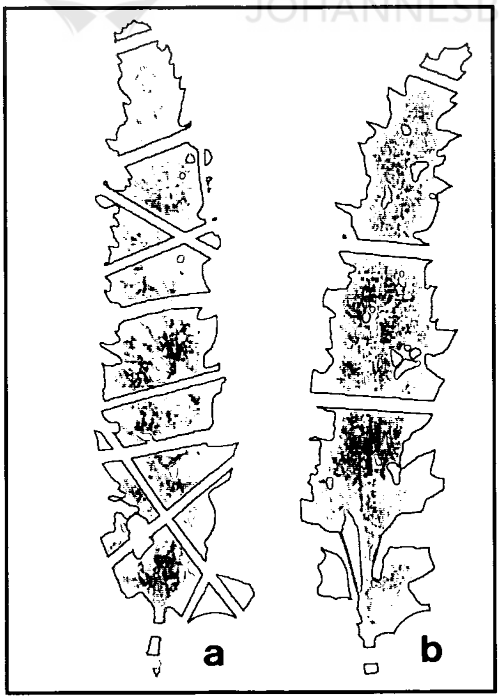


Figure 3.2 Herbarium specimens of two superficially similar species which differ markedly in habit: **a,** *R. ovata*—large, multi-stemmed suffrutex which is not much-branched; **b,** *R. schlechteriana*—virgate, much-branched shrub.

R. ovata (Figure 3.2a) and *R. schlechteriana* (Figure 3.2b) appear similar as dried specimens but differ in habit. *R. acuminata* (Figure 3.1, 15) and *R. amplexicaulis* (Figure 3.1, 16), are easily confused on herbarium sheets, but differ in that *R. acuminata* is prostrate and trailing while *R. amplexicaulis* is a large erect woody shrub. Character states for habit could not be logically polarized for inclusion in the cladistic analysis.

3.2 Fire-survival strategy

The importance of fire-survival strategy as a character of taxonomic, ecological and evolutionary importance in fynbos legumes has been discussed in detail by Schutte *et al.* (1995), as well as authors cited therein.

The taxa of *Rafnia*, like many other fynbos taxa, are adapted to survive fires. Resprouters sprout from a woody rootstock after fire, while non-sprouters reproduce by seed after fire (Schutte *et al.* 1995). In sprouting taxa, coppice shoots are produced from an underground lignotuber causing the plants to appear multi-stemmed at ground level. Non-sprouting taxa can only regenerate from seed after fire and are recognizable by a single main stem at least at ground level. All the taxa of *Rafnia* appear to be resprouters. Many of the populations visited during field excursions occurred in areas that had been recently burnt and the plants were resprouting profusely in such areas.

The fact that all *Rafnia* species are resprouters is unusual in the Fabaceae, especially since the sprouter:non-sprouter ratio for fynbos legumes has been reported as less than 25 % (Schutte *et al.* 1995). *Aspalathus*, for example, has more non-sprouters than sprouters. The resprouting habit could be considered an advanced adaptation to fire-survival, but the polarity of this character is not clear. Sprouting has been described as an ancestral character by James (1984), but this does not automatically mean that lignotubers are 'primitive', because their evolutionary history is unknown. There is evidence, however, suggesting that some species with lignotubers may have originated relatively recently (James, 1984).

Results from population genetic studies in *Aspalathus linearis* (Van der Bank *et al.* in prep) imply that seeders are ancestral and that sprouting has developed from seeding as a fire-survival strategy. It is possible that a switch to sprouting and back to seeding may occur. In *Aspalathus*, it has yet to be proven whether the change from seeding to sprouting was a single evolutionary event.

3.3 Mode of flowering

The mode of flowering is intricately linked to habit in *Rafnia* and is especially interesting since a number of species may have flowering branches that persist as vegetative structures in the following season. In these species, the flowering branch has a distinct architecture, e.g. globose in *R. globosa* (Figure 3.3) and conical in *R. schlechteriana*, resulting from the secondary aggregation of the synflorescence. The whole structure remains on the plant after flowering and fruiting, so that vegetative and flowering branches can be distinguished.

The taxonomic value of this character (i.e. mode of flowering) is particularly evident in *R. globosa* (Figure 3.3) because of the initial globose arrangement of flowers, followed by a globular arrangement of the leaves in the next season. Other examples include *R. angulata* subsp. *thunbergii*, *R. rostrata* subsp. *rostrata*, *R. elliptica*, *R. ovata*, *R. inaequalis* and *R. capensis* subsp. *pedicellata*. Species that do not display this mode of flowering are either small to prostrate perennials or woody shrubs, in which case the new growth arises from existing branches (above the ground) rather than from the lignotuber.

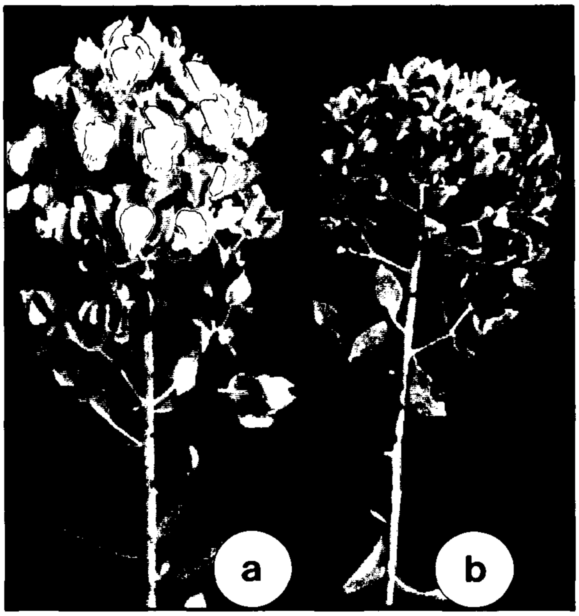


Figure 3.3 The distinctive mode of flowering in *R. globosa*: **a,** globose pseudoracemes; **b,** pseudoracemes persisting as leafy stuctures in the following season.

3.4 Leaves

3.4.1 Leaf morphology

The leaves in the Crotalarieae are mostly digitately 3(–7)-foliolate (Polhill, 1976, 1981a) or sometimes simple or unifoliolate. Stipules are often present, but may be absent where the leaves are reduced. Two leaf characters useful at the generic level in the Crotalarieae include the simple or unifoliolate leaves and the absence of a petiole and stipules (Van Wyk & Schutte, 1995). In *Rafnia*, the leaves are simple, sessile, estipulate and very variable. The margins are entire and often cartilaginous. The plants may turn black upon drying, as in some *Aspalathus* (Dahlgren, 1963a) and *Cyclopia* Vent. (Schutte, 1997) species due to the presence of phenolic compounds in the leaves (see Figure 3.2). The leaves are mostly glaucous (Figure 3.5) (or distinctly grey in *R. rostrata* subsp. *rostrata*), or they may rarely be bright green and remain so, even when dry (e.g. *R. crassifolia* and sometimes *R. spicata*).

In terms of leaf morphology, *Rafnia* is apparently related to *Aspalathus* and both genera appear to be more derived within the Crotalarieae (Polhill, 1976). The leaves in *Aspalathus* are usually trifoliolate and sessile, but in some species they may be simple [species formerly in *Borbonia* L. (Dahlgren, 1970)]. The simple leaves in *Aspalathus* probably correspond to a leaflet of the trifoliolate leaf (Dahlgren, 1963a, 1970). In *Rafnia*, the simple leaves probably correspond to a phyllode which in turn corresponds to a leaf petiole (Dahlgren, 1970). The phyllodinous simple leaf may be deduced from a long petiolate trifoliolate leaf by reduction of all the leaflets (Dahlgren, 1963a). Petiolate digitate leaves are supposedly more primitive, while reduced simple leaves may be a derived response to habitat conditions in the Cape region (Polhill, 1976), as seen in many genera with sclerophyllous leaves.

A number of leaf characters were useful in the phenetic and cladistic analyses of *Rafnia* (see Tables 6.1 & 7.1). The important characters will be discussed below.

Leaf arrangement is alternate or rarely opposite or whorled in the Crotalarieae (Polhill, 1976, 1981a). In *Rafnia*, leaf arrangement may be invariably alternate, in which case the cauline leaves and the leaves on the flowering branches are alternate. This usually occurs in species with multi-flowered racemes, e.g. *R. racemosa* subsp. *racemosa* and *R. capensis* subsp. *pedicellata*. Most commonly, the cauline leaves are alternate, while the leaves on the flowering branches are subopposite or opposite, or the leaves on the flowering branches may be invariably opposite. The latter condition is less common, and is associated with single-flowered racemes, as in *R. inaequalis*, *R. acuminata*, *R. amplexicaulis*, *R. schlechteriana* and *R. globosa*. The more derived condition seems to be that in which the leaves are invariably opposite.

When the leaves on the flowering branches are subopposite or opposite, they form leaf pairs which subtend the single-flowered inflorescences, superficially resembling large bracts (see Chapter 4.1.1). These bract-like leaves may be similar to the vegetative leaves or they may be highly reduced (*R. ovata*) or absent (*R. crispa* and *R. lancea*). The state of these leaves ("pseudobracts") proved to be a useful character in the phenetic and cladistic analyses.

Leaf size and shape are taxonomically valuable to some extent and the variation is shown in Figure 3.4. In *Rafnia*, the leaves of mature plants may differ markedly from those of coppicing plants or seedlings [this is pronounced in *R. inaequalis*, *R. diffusa* (Figure 3.4, 19a & b), *R. schlechteriana*, *R. capensis* subsp. *dichotoma* (Figure 3.5a & b) and some forms of *R. capensis* subsp. *ovata*]. Much of the taxonomic confusion of the past was due to a poor understanding of the difference between coppice and mature leaves, so that many herbarium specimens have been misidentified. The character is too variable to reveal any significant discontinuities for it to be logically polarized for the cladistic analysis.

The basal cauline leaves are often much larger than the leaves higher up on the flowering branches and they may also differ in shape, as in *R. triflora* (Figure 3.4, 14a & b) and *R. schlechteriana* (Figure 3.4, 21a–c). The basal leaves may, however, be smaller than the leaves higher up, e.g. *R. rostrata* subsp. *pauciflora*. This may be comparable with the heterophylly described in *Aspalathus* (Dahlgren, 1963a), defined as the condition in which vegetative leaves of different parts or on different types of branches differ in size or appearance. In *Aspalathus*, for example, the leaves of the long shoots may differ from those of the short shoots.

Size ranges from very small, e.g. 10 mm long and 1 mm wide in *R. angulata* subsp. *ericifolia* (Figure 3.4, 5b) to very large in *R. ovata* (Figure 3.4, 15), in which the leaves are up to 60 mm long and 40 mm wide. The largest leaves in *Rafnia* are the basal leaves of *R. triflora*, which may be up to 121 mm long and 110 mm wide. Leaf size was useful in the cladistic analysis. The width of the basal leaves was polarized as either narrow or broad

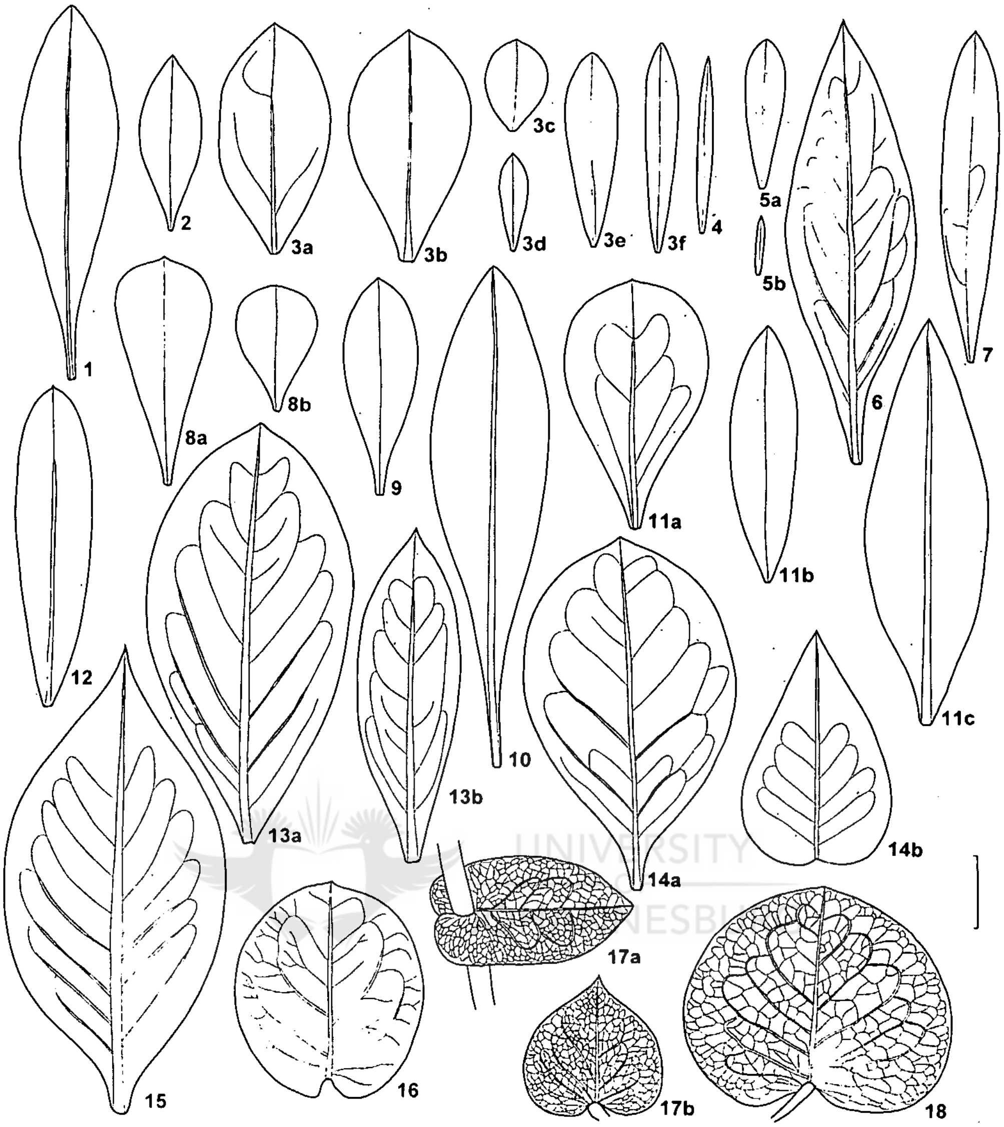


Figure 3.4 Variation in leaves in the species, subspecies and regional forms of *Rafnia*, showing differences in size, shape and venation patterns. Leaves for which no leaf type is specified are typical, mature leaves. 1–18 = section *Rafnia* (taxa with rostrate keels); 19–29 = section *Colobotropis* (taxa with obtuse or truncate to emarginate keels, overleaf): **1,** *R. racemosa* subsp. *racemosa* (*Levyns 9111*); **2,** *R. racemosa* subsp. *pumila* (*Esterhuysen 33444*); **3,** *R. angulata* subsp. *angulata*: **a,** basal leaf (*Van Wyk 3679*); **b,** basal leaf (*Van Wyk s.n.*); **c,** leaf of flowering branch (*Esterhuysen 22143*); **d,** leaf of flowering branch (*Compton 18728*); **e,** basal leaf (*Compton 15515*); **f,** basal leaf (*Barker 10333*); **4,** *R. angulata* subsp. *thunbergii* (*Van Wyk 2908*); **5,** *R. angulata* subsp. *ericifolia*: **a,** coppice leaf (*Vlok & Schutte 108*); **b,** leaf of flowering branch (*Barker 8862*); **6,** *R. crispa* (*Stirton 8439*); **7,** *R. lancea* (*Barker 1002*); **8,** *R. rostrata* subsp. *rostrata*: **a,** basal leaf (*Campbell & Van Wyk 145*); **b,** leaf of flowering branch (*Compton 21135*); **9,** *R. rostrata* subsp. *pauciflora* (*Thorne s.n. sub SAM 50193*); **10,** *R. vlokii* (*Campbell & Van Wyk 156*); **11,** *R. alata*: **a,** (*Campbell & Van Wyk 8*); **b,** (*Vlok 736*); **c,** (*Burgers 1404*); **12,** *R. crassifolia* (*Campbell & Van Wyk 150*); **13,** *R. elliptica*: **a,** (*Van Wyk & C.M. van Wyk 1443*); **b,** leaf of flowering branch (*Van Wyk & C.M. van Wyk 2044*); **14,** *R. triflora*: **a,** basal leaf (*Levyns 3600*); **b,** leaf of flowering branch (*Campbell & Van Wyk 123*); **15,** *R. ovata* (*Van Wyk 3135*); **16,** *R. inaequalis* (*Campbell & Van Wyk 119*); **17,** *R. acuminata*: **a,** (*Parker 3741*); **b,** leaf of flowering branch (*Van Wyk 2067*); **18,** *R. amplexicaulis* (*Van Wyk 2907*). Scale = 10 mm.

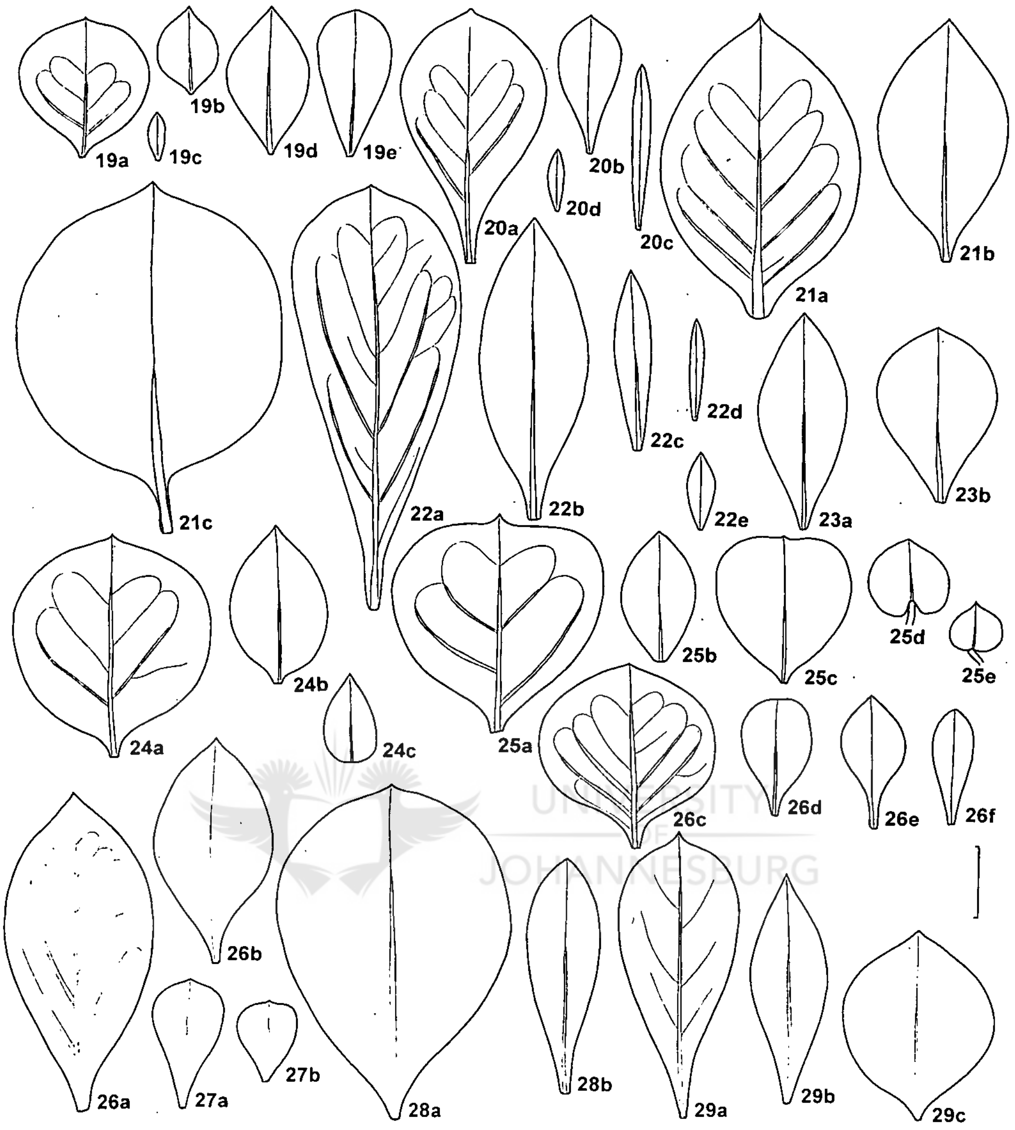


Figure 3.4 Continued: **19,** *R. diffusa*: **a,** coppice leaf, **b,** leaf of flowering branch (*Compton 20815*); **c,** leaf of flowering branch (*Taylor 11145*); **d,** basal leaf (*Van Rensburg 171*); **e,** (*Stokoe s.n. sub SAM 55790*); **20,** *R. spicata*: **a,** coppice leaf, **b,** (*Campbell & Van Wyk 141*); **c,** (*Levyns 1079*); **d,** leaf of flowering branch (*Esterhuysen 22458*); **21,** *R. schlechteriana*: **a,** (*Campbell & Van Wyk 117*); **b,** leaf of flowering branch (*Oliver 6042*); **c,** basal leaf (*Thorne s.n. sub SAM 51227*); **22,** *R. capensis* subsp. *capensis*: **a,** basal leaf (*Guthrie 142*); **b,** (*Linder 4155*); **c,** (*Van Wyk 2287*); **d,** (*Esterhuysen 14273*); **e,** leaf of flowering branch (*Compton 10421*); **23,** *R. capensis* subsp. *carinata*: **a,** (*Taylor 11917*); **b,** (*Shaw s.n. sub BOL 3256*); **24,** *R. capensis* subsp. *calycina*: **a,** coppice leaf (*Stokoe s.n. sub SAM 68749*); **b,** (*Maguire 1178*); **c,** leaf of flowering branch (*Van Wyk 3225*); **25,** *R. capensis* subsp. *dichotoma*: **a,** coppice leaf, **b,** leaf of flowering branch (*Campbell & Van Wyk 160*); **c,** coppice leaf (*Taylor 11483*); **d & e,** leaf of flowering branch (*Esterhuysen 15960*); **26,** *R. capensis* subsp. *ovata*: **a,** basal leaf (*Kruger 120*); **b,** (*Low 1079*); **c,** coppice leaf (*Campbell & Van Wyk 32*); **d,** leaf of flowering branch (*Walters 1429*); **e,** leaf of flowering branch (*Esterhuysen 2492*); **f,** leaf of flowering branch (*Barker 9201*); **27,** *R. capensis* subsp. *elsieae*: **a & b,** leaf of flowering branch (*Esterhuysen 28730*); **28,** *R. capensis* subsp. *pedicellata*: **a,** basal leaf (*Bolus 9879*); **b,** leaf of flowering branch (*Van Wyk 2085*); **29,** *R. globosa*: **a,** (*McDonald 1204*); **b,** leaf of flowering branch, **c,** (*Campbell & Van Wyk 125*). Scale = 10 mm.

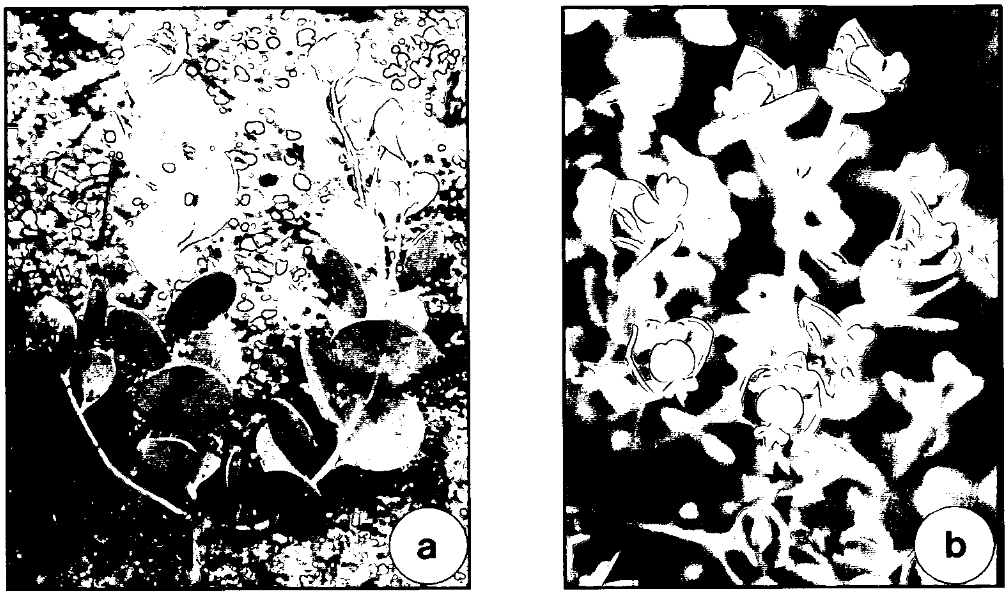


Figure 3.5 Juvenile and adult plants of *R. capensis* subsp. *dichotoma*, showing the difference between **a,** coppice leaves and **b,** mature leaves.

(broad leaves are considered apomorphic) (Figure 3.6). This character was also useful in the phenetic analysis.

The leaves in *Rafnia* may be ericoid, e.g. *R. angulata* subsp. *ericifolia* (Figure 3.4, 5b), linear, e.g. *R. angulata* subsp. *thunbergii* (Figure 3.4, 4), elliptic, as in *R. elliptica* (Figure 3.4, 13b), acuminate, e.g. *R. ovata* (Figure 3.4, 15), obovate, as in *R. alata* (Figure 3.4, 11a) or rarely cordate in *R. inaequalis* (Figure 3.4, 16), *R. acuminata* (Figure 3.4, 17a & b) and *R. amplexicaulis* (Figure 3.4, 18). Cordate leaf shape is a useful synapomorphy for the latter three species (see Figure 7.1). This leaf shape is shared with some species of the group Borboniae of *Aspalathus* (Dahlgren, 1988). Leaf shape in *Rafnia* was expressed as a length:width ratio (Figure 3.7), the results of which (basal leaves) showed marked discontinuity between a narrow-leaved group (mainly *R. angulata*) and a broad-leaved group (most of the remaining species).

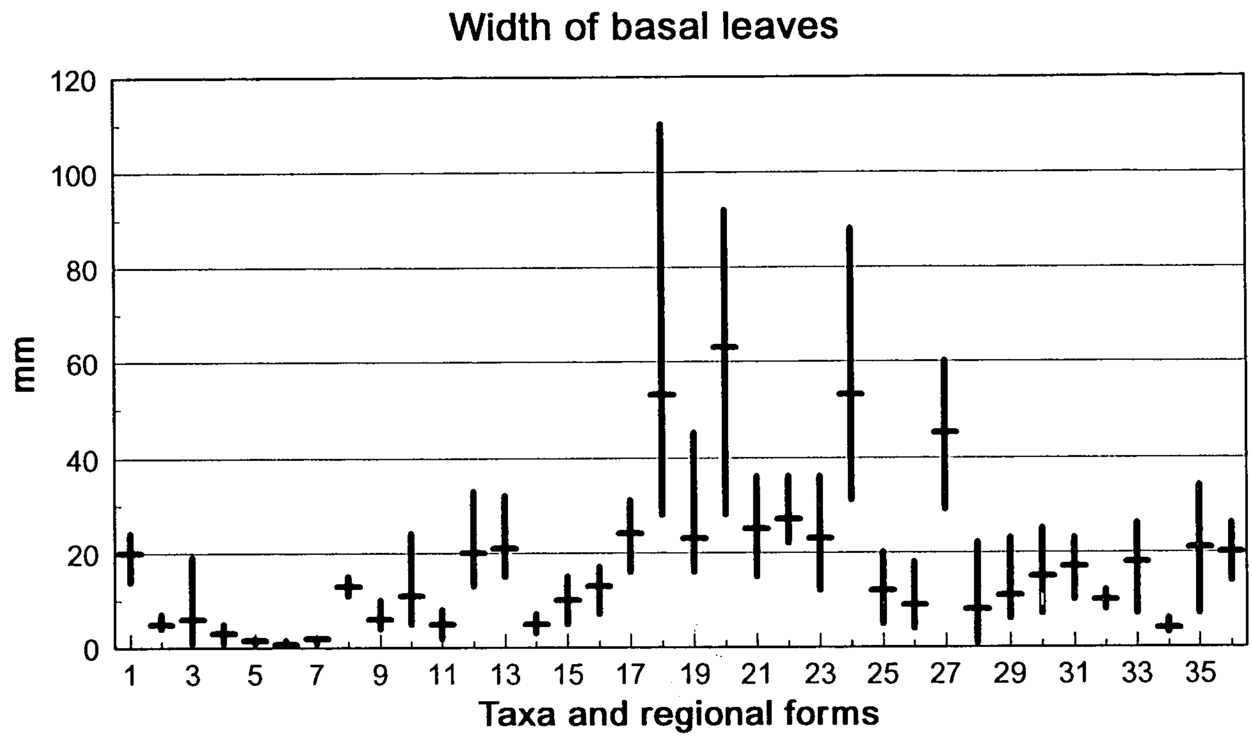


Figure 3.6 Range and mean values for width of basal leaves of taxa and some regional forms of *Rafnia*. The basal leaves are mostly narrow in *Rafnia* (mean less than 40 mm), but the leaves are broad (mean more than 40 mm) in *R. triflora* Form 1 (18), *R. ovata* (20), *R. amplexicaulis* (24) and *R. schlechteriana* (27). (Taxa and regional forms are numbered as in Table 2.2.)

Leaf venation is usually indistinct in *Rafnia* or sometimes penninerved, as in *R. crispa* (Figure 3.4, 6), *R. elliptica* (Figure 3.4, 13a & b), *R. triflora* (Figure 3.4, 14a & b), and *R. schlechteriana* (Figure 3.4, 21a). Reticulate venation is a useful synapomorphy for *R. acuminata* (Figure 3.4, 17a & b) and *R. amplexicaulis* (Figure 3.4, 18). The latter character was also used in the phenetic analysis.

In the Crotalarieae, the leaf base is usually pulvinate and a prominent leaf base occurs in *Aspalathus* (Polhill, 1976, 1981a) and other genera. The leaves of *Rafnia* do not have raised persistent bases. The basal part of the sessile leaves may be elongate so that the leaves of some species are pseudopetiolate, for example *R. racemosa* subsp. *racemosa* (Figure 3.4, 1), *R. vlokii* (Figure 3.4, 10) and *R. capensis* subsp. *capensis* (Figure 3.4, 22b). The prolonged leaf base is not homologous to a petiole. Leaf base shape was useful in the

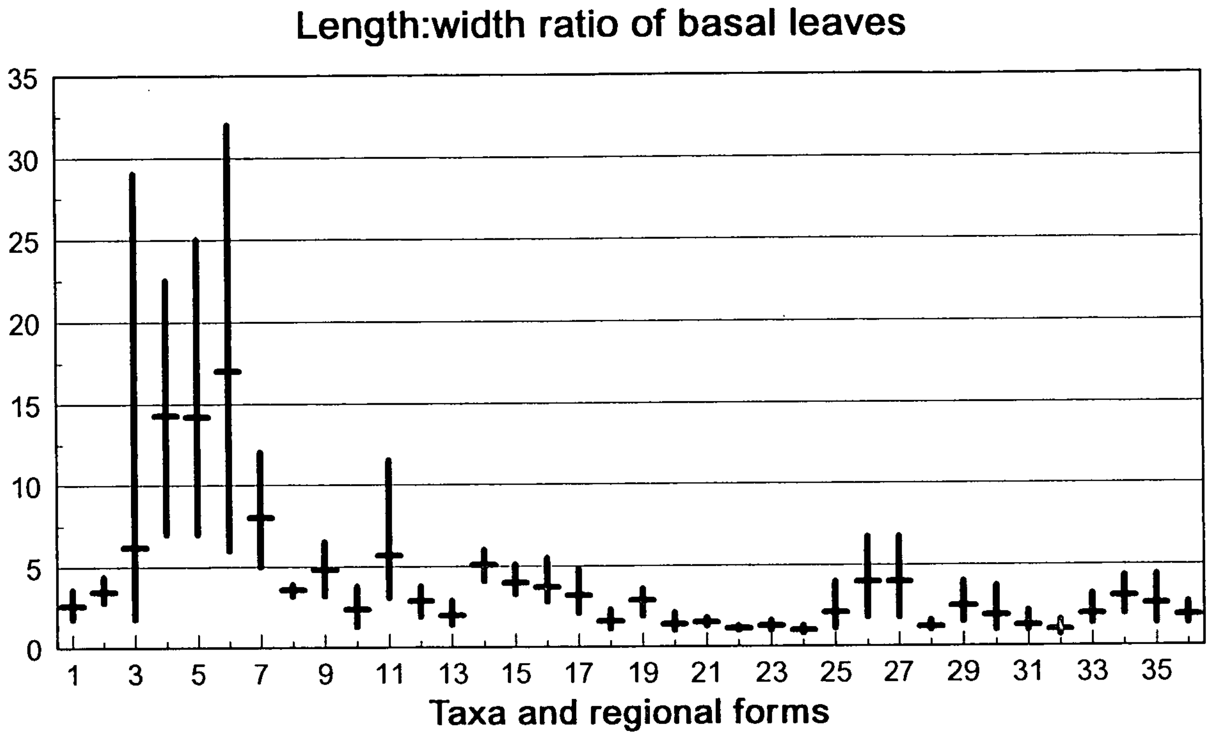


Figure 3.7 Range and mean values for lengh:width ratio of basal leaves of taxa and some regional forms of *Rafnia*. Narrow leaves (mean ratio equal to or more than 5) occur in *R. angulata* subsp. *angulata* (3), *R. angulata* subsp. *thunbergii* (4), *R. angulata* subsp. *humilis* (5), *R. angulata* subsp. *ericifolia* (6), *R. angulata* subsp. *montana* (7), *R. lancea* (9), *R. rostrata* subsp. *pauciflora* (11) and *R. alata* Form 2 (14). (Taxa and regional forms are numbered as in Table 2.2.)

phenetic analysis. The base may be cuneate in *R. angulata* subsp. *angulata* (Figure 3.4, 3e) and *R. crassifolia* (Figure 3.4, 12), angustate, as in *R. rostrata* subsp. *pauciflora* (Figure 3.4, 9) and *R. capensis* subsp. *pedicellata* (Figure 3.4, 28b), rounded in *R. triflora* (Figure 3.4, 14b), or cordate as in *R. acuminata* (Figure 3.4, 17a).

The leaf arrangement, size, shape and venation patterns are useful taxonomic characters and are helpful for distinguishing the regional forms in some species.

3.4.2 Stomata

A pilot study of leaf surfaces of 10 species of *Rafnia* (see Table 2.5) showed that the distribution of stomata is amphistomatic, since stomata occur on both the adaxial and abaxial surfaces. The stomata are more numerous on the abaxial surface of the leaf. The stomata are anisocytic (Figure 3.8), i.e. they are surrounded by three cells of which one is distinctly smaller than the other two (Radford, 1974). This pattern is uniform throughout the genus. Guard cells are symmetrical and the same size on both adaxial and abaxial surfaces. There is some variation in size and number of stomata between species, but these are not sufficiently variable to show any clear discontinuities to be of taxonomic significance. Detailed analyses of all the taxa were thus not undertaken.

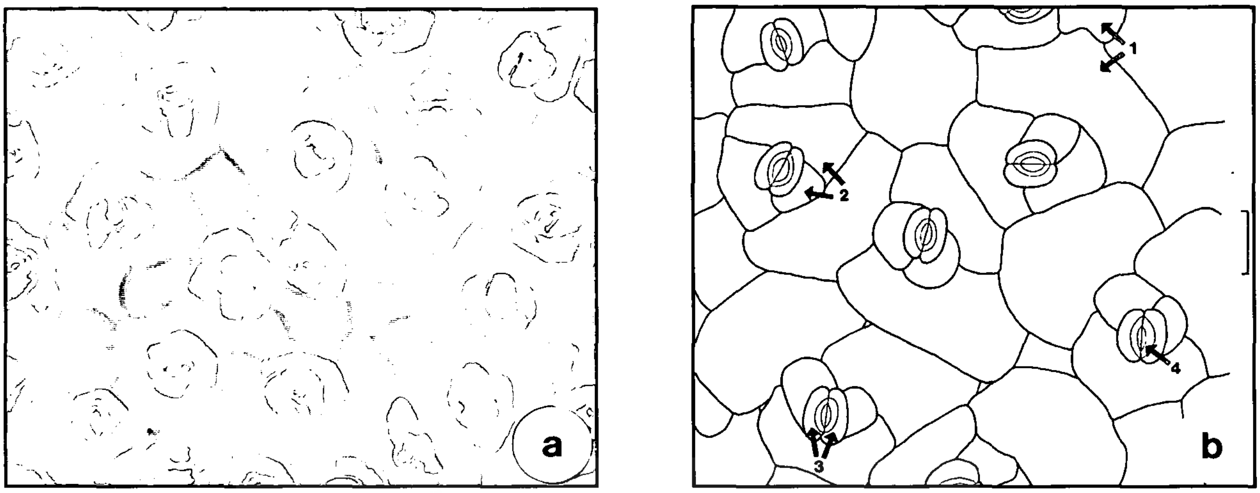


Figure 3.8 Adaxial leaf epidermises of *Rafnia*, showing the typical anisocytic stomata: **a,** epidermis of *R. amplexicaulis* (*Campbell & Van Wyk 26*); **b,** epidermis of *R. alata* (*Campbell & Van Wyk 8*): 1, ordinary epidermal cells; 2, subsidiary cells; 3, guard cells; 4, stoma. Scale = 0.05 mm.

3.4.3 Midrib anatomy

A survey of the leaf midribs of 11 taxa of *Rafnia* (see Table 2.6) showed that the cuticle is relatively thick, and the lamina is isolateral, having two double layers of palisade parenchyma on the abaxial and adaxial sides of the leaf. The midrib may be raised, surrounded by much collenchyma tissue, as in *R. amplexicaulis* (Figure 3.9a). Mucilage cells, which vary in size and number, are present in the epidermis of *Rafnia*, as in *Aspalathus*, *Dichilus* DC., *Crotalaria* and other genera of the Genisteae *sensu lato* (Gregory & Baas, 1989). It has been suggested that these cells serve for water storage or reduce transpiration by acting like a gelatinous layer over a water surface, and are thus of adaptive significance in dry habitats. Mucilage cells have been used in plant identification, but their occurrence is often very variable (Gregory & Baas, 1989). In the species of *Rafnia* studied, these cells are most prominent in *R. alata* (Figure 3.9b). Leaf anatomy provided no distinct discontinuities among the taxa studied, hence this character was considered to be of limited taxonomic value.

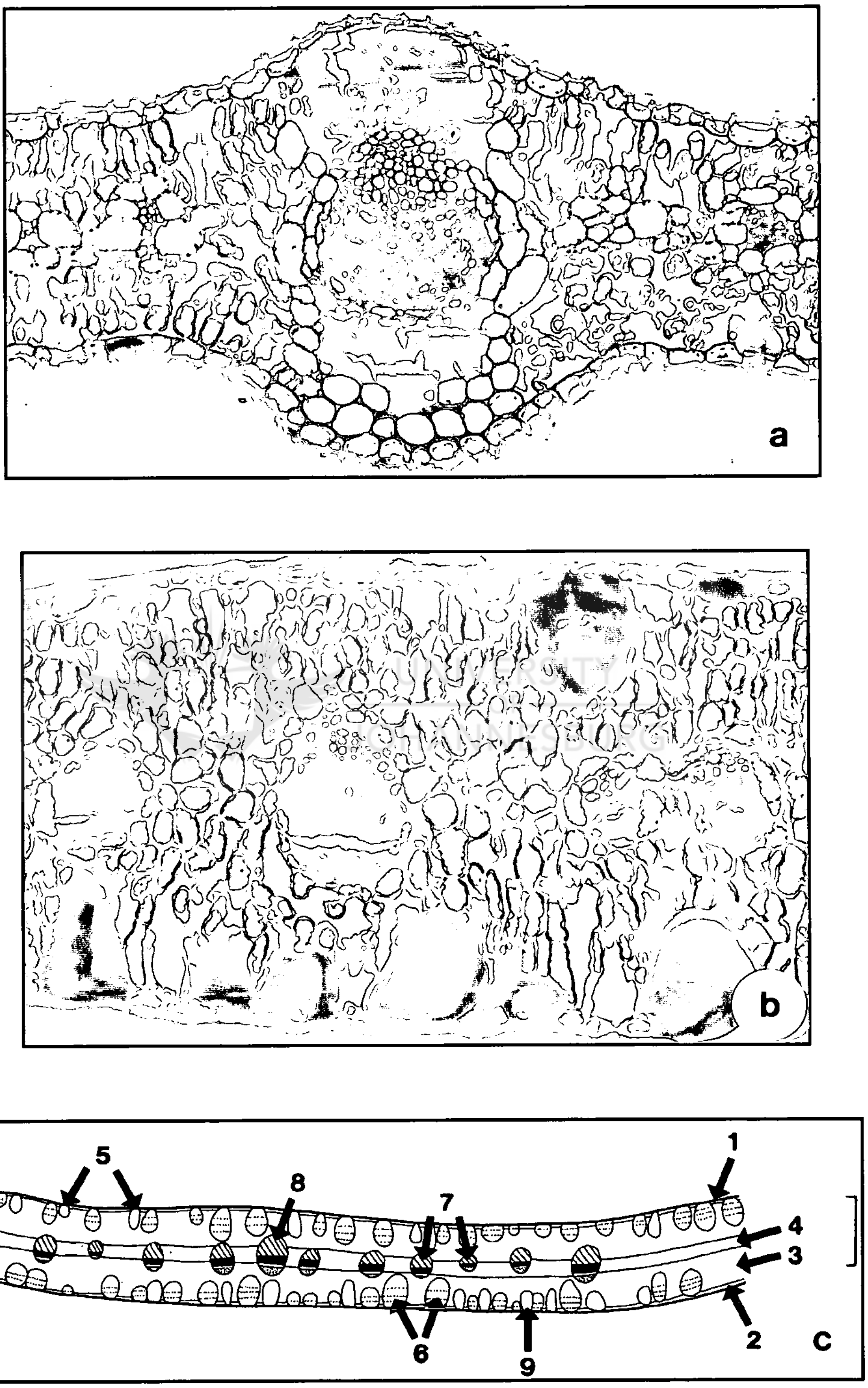


Figure 3.9 Variation in leaf anatomy in *Rafnia* shown in transverse sections through the midrib and part of the lamina: **a,** *R. amplexicaulis* (*Campbell & Van Wyk 26*)—raised midrib; **b,** *R. alata* (*Campbell & Van Wyk 8*)—large and numerous mucilage cells; **c,** *R. alata*: 1, cuticle; 2, epidermis; 3, double layer of palisade parenchyma; 4, spongy parenchyma; 5, stomata; 6, mucilage cells; 7, vascular bundles; 8, midrib; 9, substomatal air space. Scale = 1 mm.

CHAPTER 4

REPRODUCTIVE MORPHOLOGY

4.1 Inflorescence

4.1.1 Inflorescence structure

Racemes or panicles (compound racemes) are most common in the Papilionoideae (Tucker, 1987b), and spikes and umbels, which are modified racemes, are also present. Pseudoracemes occur in about five papilionoid tribes (Tucker, 1987a).

The inflorescences in the Crotalarieae are commonly terminal or leaf-opposed, either single-flowered or arranged in lax to condensed racemes (Polhill, 1976, 1981a; Van Wyk & Schutte, 1989). Like the leaves, the inflorescences in the Cape genera of the Crotalarieae are often highly modified (Polhill, 1976).

In *Rafnia*, inflorescence structure is variable. The basic type of inflorescence is a raceme which may be single-flowered, multi-flowered or intermediate between these two. The various structural types of racemes (Figure 4.1) may each have numerous modifications, specializations or degrees of reduction.

Some species have a multi-flowered raceme which is terminal, or sometimes growth may continue from the apex of the multi-flowered raceme (e.g. *R. racemosa* subsp. *racemosa*). In *R. capensis* subsp. *pedicellata*, the inflorescence usually consists of 35 or more flowers with elongated pedicels (Figure 4.1, 1a). The number of flowers per inflorescence was a useful phenetic character (see Table 6.1) but there were no distinct discontinuities hence it was not useful in the cladistic analysis.

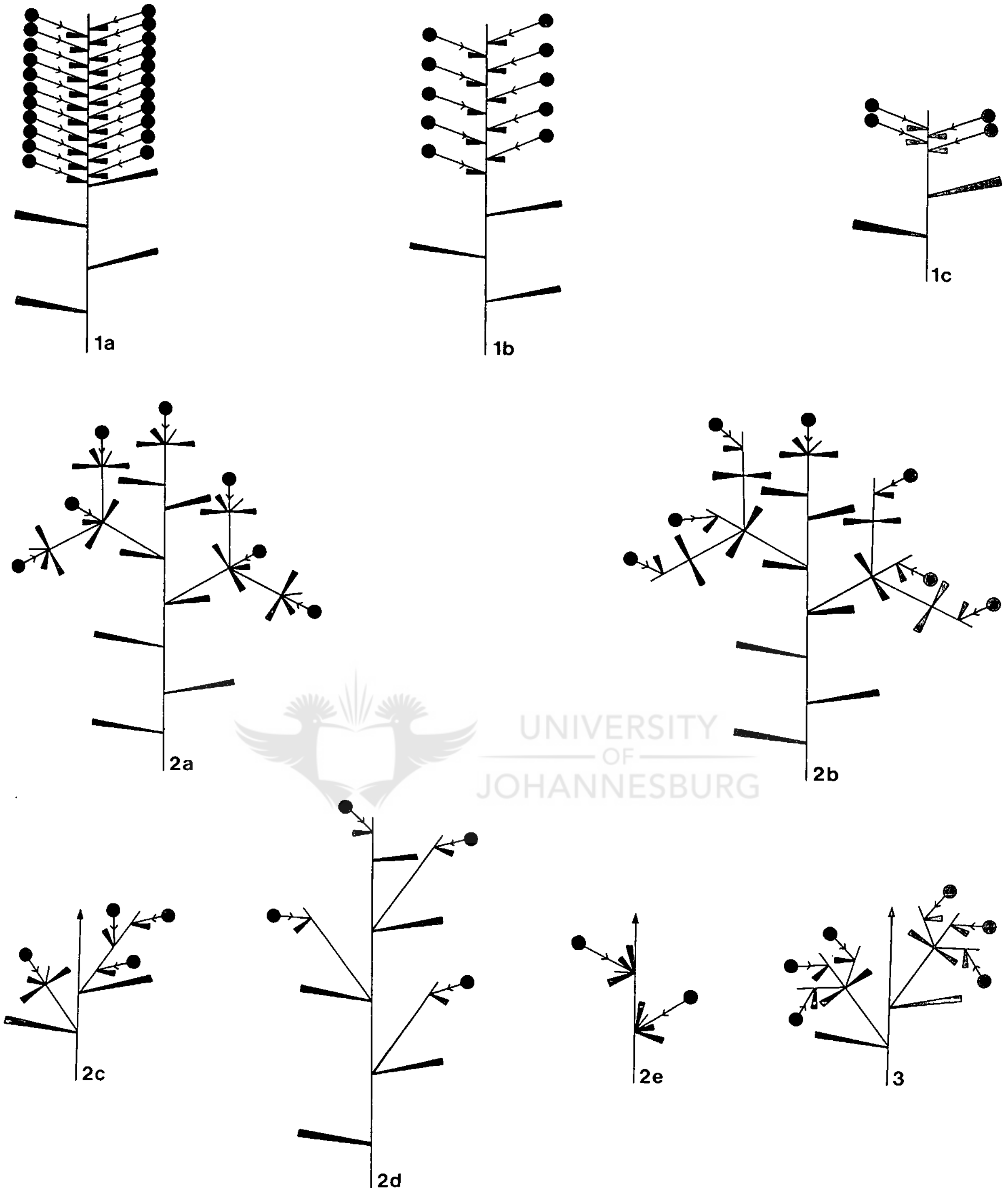


Figure 4.1 Variation in inflorescence structure in *Rafnia*: **1a–c,** terminal, multi-flowered racemes: **a,** 35 flowers or more, e.g. *R. capensis* subsp. *pedicellata*; **b,** elongated inflorescence axis, e.g. *R. racemosa*; **c,** compressed inflorescence axis, e.g. *R. capensis* subsp. *ovata*; **2a–e,** terminal, axillary, single-flowered racemes: **a,** pseudopedunculate, e.g. *R. amplexicaulis*; **b,** pedunculate, with the peduncle arising beyond the subtending leaves, e.g. *R. vlokii*; **c,** pedunculate, with more than one flower per axillary peduncle, e.g. *R. elliptica*; **d,** pedunculate, with the subtending leaves highly reduced or absent, e.g. *R. crispa* and *R. lancea*; **e,** axillary flower, resulting from complete suppression of the inflorescence axis, e.g. *R. crassifolia*; **3,** three axillary, pedunculate single-flowered racemes of *R. triflora*.

The inflorescence axis may be somewhat elongated, as in *R. racemosa* subsp. *pumila* (5–8-flowered) (Figure 4.1, 1b) and is longest in *R. racemosa* subsp. *racemosa* (up to 19-flowered) and *R. capensis* subsp. *pedicellata*, which also have the largest number of flowers per inflorescence in *Rafnia*.

A compressed axis, in which the flowers are very close together on the rachis, occurs in *R. rostrata* subsp. *pauciflora*, some forms of *R. angulata* subsp. *angulata*, *R. capensis* subsp. *dichotoma*, *R. capensis* subsp. *ovata* and *R. capensis* subsp. *elsieae*, in which there are usually 2–6 flowers per inflorescence (Figure 4.1, 1c), or rarely up to nine flowers in *R. capensis* subsp. *ovata*. The length of the inflorescence axis was a useful character for the phenetic analysis (see Table 6.1), but not for the cladistic analysis, since no meaningful discontinuities could be found.

The inflorescence axis is variously defined in *Rafnia*. The axis may consist of a rachis and a peduncle, as in the multi-flowered raceme of *R. racemosa* subsp. *racemosa* (Figure 4.1, 1b). Alternatively, the axis may constitute a rachis only, in which case the peduncle is absent, e.g. *R. capensis* subsp. *pedicellata* (Figure 4.1, 1a), or a peduncle only, in which case the rachis is suppressed, e.g. *R. vlokii* (Figure 4.1, 2b).

The multi-flowered raceme may be reduced to a single-flowered raceme (Polhill, 1976), which is terminal and axillary and may be variously modified or reduced (Figure 4.1, 2a–e & 3). This is also the most common type of inflorescence in *Rafnia*.

In *Rafnia*, the last internode of the stem, directly below the single-flowered raceme, may be elongated to form a so-called 'pseudopeduncle', which varies in length (Figure 4.1, 2a). In pseudopedunculate taxa such as *R. acuminata* and *R. diffusa*, an inflorescence axis is technically lacking, since the pseudopeduncle is actually a short-shoot and non-homologous with the true peduncle common in other genera (Van Wyk & Schutte, 1989). Single-flowered racemes may also be pedunculate, in which case the peduncle arises beyond the pair of subtending leaves, below the flower, e.g. *R. vlokii* (Figure 4.1, 2b), or directly from the axil of the leaf on the flowering branch, as in *R. elliptica* (Figure 4.1, 2c) and *R. crispa* and *R. lancea* (Figure 4.1, 2d).

Flowers may emerge directly from the axils of leaves on the flowering branches, as a result of the partial or complete suppression of the peduncle in single-flowered racemes, e.g. *R. crassifolia* (Figure 4.1, 2e).

The peduncle or pseudopeduncle often continues as a short, sterile process beyond the point of attachment of the pedicel of the flower. In Figure 4.1 (2a), the pseudopeduncle may terminate in a single-flowered raceme, in which case a sterile process is present, or growth may continue from the axils of the leaves subtending the inflorescence, in which case a sterile process is absent. This continued growth gives rise to a dichotomous branching pattern, which, when extensively developed, may form a pseudoraceme. The pseudoraceme as described here is a large, terminal, leafy structure formed by the secondary aggregation of the single-flowered racemes and differs from that defined by Tucker (1987a). The term 'pseudoraceme' is here used for a flowering branch and ontogenetic development is not implied. Pseudoracemes occur in *Aspalathus* (Dahlgren, 1970) and in some forms of *R. angulata* subsp. *angulata*, *R. schlechteriana* and *R. globosa* (see Figure 3.3).

R. elliptica and *R. ovata* usually have an axillary, single-flowered, pseudopedunculate raceme, but the inflorescence may sometimes have 2–4 flowers which are borne on an axillary peduncle (Figure 4.1, 2c).

The inflorescences in *Rafnia* are often subtended by a pair of leaves, which may be opposite or subopposite (Figure 4.1, 2a & b), and they may be similar to the leaves of the main stem (see Chapter 3.4.1) or variously reduced (Polhill, 1976). When reduced in size, these leaves may simulate bracts and have also been mistaken for foliaceous bracteoles (Polhill, 1976). This pair of leaves is highly reduced in *R. triflora* and *R. ovata* and sometimes *R. elliptica* and is absent in *R. crispa* and *R. lancea* (Figure 4.1, 2d).

R. triflora has an unusual inflorescence (Figure 4.1, 3), the ontogenetic development of which is unclear. It seems that three to five single-flowered inflorescences emerge from the axils of a pair of reduced opposite leaves. The central inflorescence tends to emerge first, followed by two or rarely four lateral inflorescences. It thus appears to be a lateral axillary inflorescence, in turn with two axillary inflorescences developing from it. This inflorescence is so highly derived that it is difficult to interpret the exact origin (homology) of the lateral inflorescences.

As was shown by cladistic analyses, the inflorescence is more valuable at the species level than at the sectional level, because terminal racemes (interpreted as plesiomorphic) are sporadically present in distantly related species (e.g. in forms of *R. angulata* and *R. capensis*). This implies that the reduction of the multi-flowered raceme to a few- or single-flowered inflorescence was not a single event in *Rafnia*, but occurred repeatedly in several different lineages, or, perhaps less likely, reversed in some lineages.

4.1.2 Peduncle anatomy

Peduncle anatomy in *Rafnia* is rather uniform, with the main variation being in size and shape. The conducting tissue may be arranged as separate vascular bundles interspersed with medullary rays, as in *R. racemosa* subsp. *racemosa* (Figure 4.2a) and *R. capensis* subsp. *ovata* (Figure 4.2d). These peduncles are terete. The vascular bundles may be central, in which case the peduncle is rather flattened, as in *R. ovata* (Figure 4.2c). *R. triflora* (Figure 4.2b) is a variation of the terete type of peduncle. Numerous mucilage cells may be present in the epidermises of some peduncles, e.g. *R. capensis* subsp. *ovata* (Figure 4.2d). Peduncle anatomy in *Rafnia* is not particularly useful taxonomically, since there are no distinct discontinuities. Also, not all the taxa in *Rafnia* have true peduncles, they may have pseudopeduncles or lack an inflorescence axis, and this makes homologous comparisons difficult.

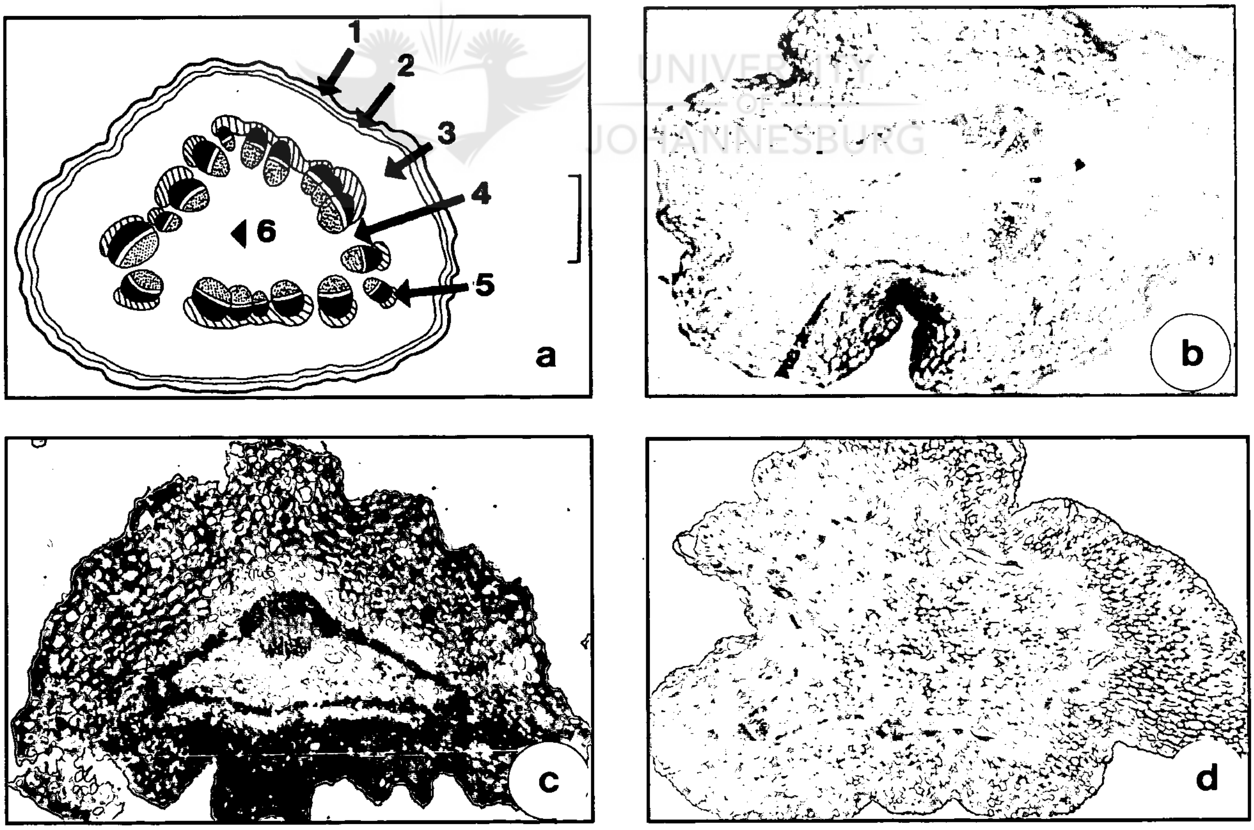


Figure 4.2 Variation in peduncle anatomy in *Rafnia*: **a,** *R. racemosa* subsp. *racemosa* (*Van Wyk 2172*)—terete type: 1, epidermis; 2, collenchyma layer; 3, cortex; 4, medullary ray; 5, vascular bundle; 6, pith; **b,** *R. triflora* (*Van Wyk 2885*)—terete type; **c,** *R. ovata* (*Van Wyk 3135*)—flattened type; **d,** *R. capensis* subsp. *ovata* (*Campbell & Van Wyk 37*)—note the mucilage cells in the epidermis.

4.2 Flowers

The flowers in *Rafnia* are typically papilionoid, i.e. composed of a median standard petal (vexillum), two lateral wing petals (alae), and a keel (carina) composed of the two lower petals, the blades of which are joined for at least part of their lower margins (Dahlgren, 1963a). Variation in flower structure in *Rafnia* is given in Figure 4.3.

In the flowers of *Rafnia*, the pedicel gradually merges with the calyx base and is not intrusive as in some Podalyrieae. The pedicel is generally short (shorter than the flower), ranging from 2 to 10 mm long. The pedicel is elongated in *R. crassifolia* (Figure 4.3, 11) and *R. capensis* subsp. *pedicellata* (Figure 4.3, 27), in which it is 15 mm long or more.

Flower size in *Rafnia* (Figure 4.4) has some value at sectional level, since the flowers of section *Rafnia* are usually large (15 mm long or more) and those of section *Colobotropis* are usually smaller.

The flowers are totally glabrous in *Rafnia*, except for the invariable presence of hairs on the inner surfaces of the calyces and minute cilia on the upper and/or lower margins of the wing petals of some species and the keel petals of most species.

Rafnia flowers are always yellow, ranging from lemon-yellow in *R. ovata*, to a deeper shade in *R. globosa*. The flowers may remain yellow, or fade to various shades of orange, pink or reddish-brown with age, and this is said to discourage flower visits to already pollinated flowers. Venation in the petals is generally very distinct.

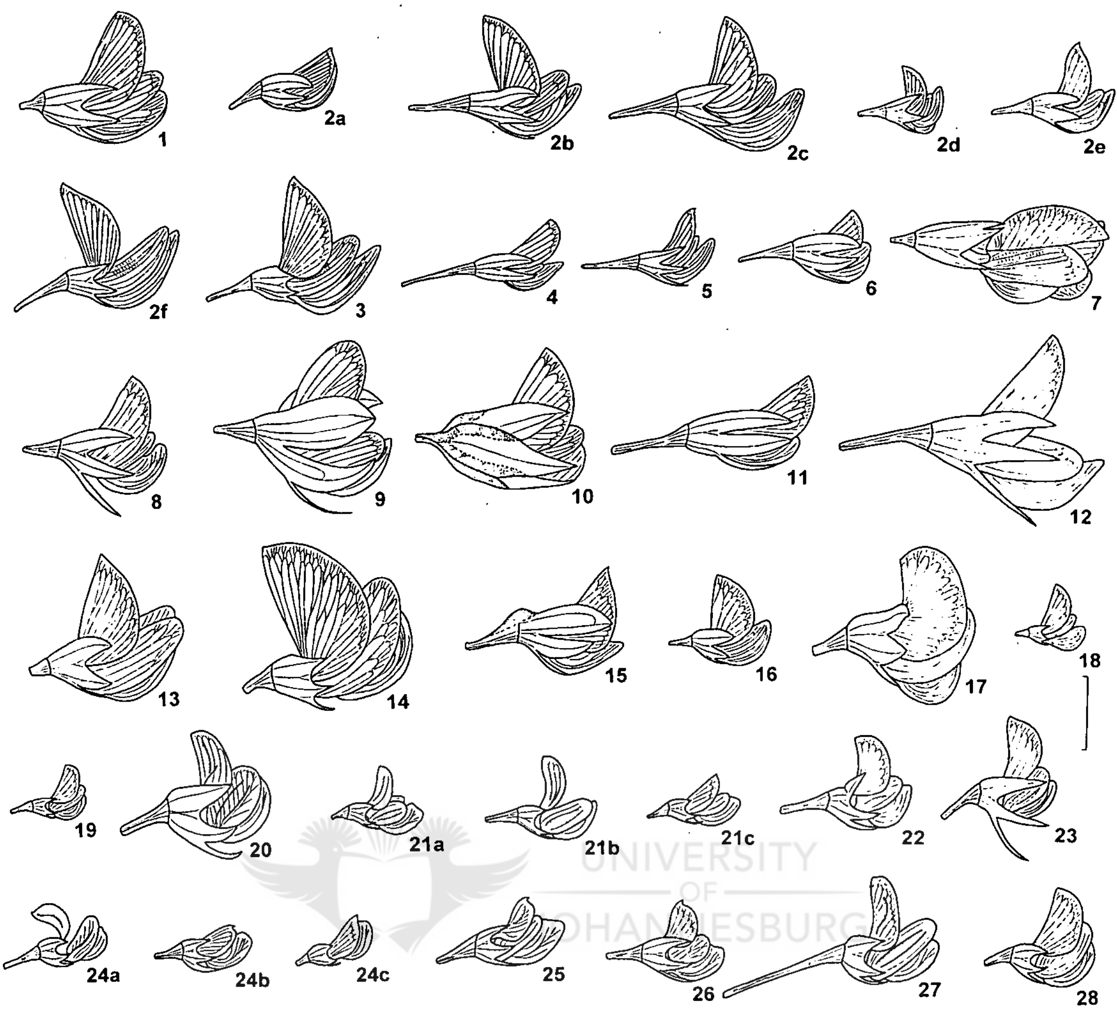


Figure 4.3 Variation in the flowers of *Rafnia*, showing differences in size and structure. 1–17 = section *Rafnia* (larger flowers with rostrate keels); 18–28 = section *Colobotropis* (smaller, more specialized flowers with obtuse, truncate or emarginate keels): **1,** *R. racemosa* subsp. *racemosa* (*Thompson 3176*); **2,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Esterhuysen 22143*); **b,** Form 1 (*Van Wyk 3679*); **c,** Form 1 (*Compton 18728*); **d,** Form 4 (*Bolus 20934*); **e,** Form 7 (*MacOwan 52*); **f,** Form 9 (*Schutte & Vlok 762*); **3,** *R. angulata* subsp. *thunbergii* (*Walters 147*); **4,** *R. angulata* subsp. *humilis* (*Guthrie 188*); **5,** *R. angulata* subsp. *ericifolia* (*Barker 8862*); **6,** *R. angulata* subsp. *montana* (*Andreae 1245*); **7,** *R. lancea* (*Johnson 481*)—standard reflexed at anthesis; **8,** *R. rostrata* subsp. *rostrata* (*Barker 2358*); **9,** *R. vlokii* (*Vlok 534*)—calyx almost as long as that part of corolla exceeding it; **10,** *R. alata* Form 1 (*Campbell et al. 154*); **11,** *R. crassifolia* (*Schutte 258*); **12,** *R. elliptica* (*Bolus 8645*); **13,** *R. triflora* Form 1 (*Campbell & Van Wyk 118*); **14,** *R. ovata* (*Campbell & Van Wyk 128*); **15,** *R. inaequalis* (*Campbell & Van Wyk 119*); **16,** *R. acuminata* Form 1 (*Barker 4164*); **17,** *R. amplexicaulis* (*Campbell & Van Wyk 120*); **18,** *R. diffusa* Form 2 (*Taylor 11145*); **19,** *R. spicata* (*Taylor 11405*); **20,** *R. schlechteriana* (*Goldblatt s.n. sub NBG 97432*); **21,** *R. capensis* subsp. *capensis*: **a,** Form 2 (*Campbell et al. 153*); **b,** Form 4 (*Campbell & Van Wyk 151*); **c,** Form 5 (*Campbell et al. 131*); **22,** *R. capensis* subsp. *carinata* (*Stirton 9182*); **23,** *R. capensis* subsp. *calycina* (*Van Wyk 3225*); **24,** *R. capensis* subsp. *dichotoma*: **a,** Form 2 (*Walters 2359*); **b,** Form 2 (*Van Wyk 2999*); **c,** Form 5 (*Esterhuysen 15960*); **25,** *R. capensis* subsp. *ovata* Form 4 (*Campbell & Van Wyk 147*); **26,** *R. capensis* subsp. *elsieae* (*Esterhuysen 14858*); **27,** *R. capensis* subsp. *pedicellata* (*Walters 1935*); **28,** *R. globosa* (*Campbell & Van Wyk 125*). Scale = 10 mm.

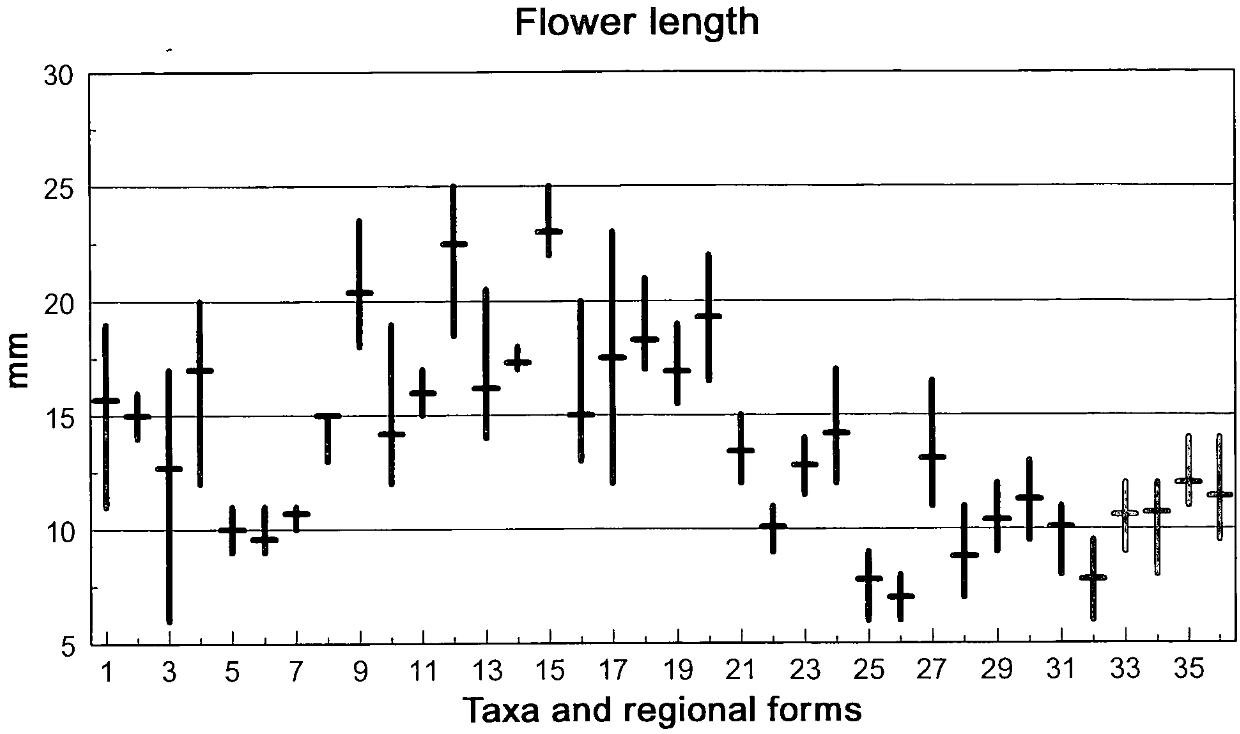


Figure 4.4 Range and mean values for flower length of taxa and regional forms of *Rafnia*, calculated as total length of calyx and corolla. Large flowers (15 mm long or more) occur in most taxa of section *Rafnia* (1–24), whereas most taxa of section *Colobotropis* (25–36) have small to medium-sized flowers (less than 15 mm long). The largest flowers are those of *R. vlokii* (12) and *R. alata* Form 3 (15) and the smallest, those of *R. diffusa* (25), *R. spicata* (26) and *R. capensis* subsp. *dichotoma* Form 5 (32). (Taxa and regional forms are numbered as in Table 2.2.)

In *Rafnia*, the petals are free from each other, except for the connate margins of the keel blades, as in most species of *Aspalathus* (Dahlgren, 1963a). In certain species of *Aspalathus*, the inside of the wing and keel claws are adnate to the outside of the staminal sheath for a variable part of their length, but in *Rafnia* and *Wiborgia* (Dahlgren, 1975), the claws are attached to the staminal sheath only at the base and are not adnate to it.

There is a general tendency for thickenings to develop at the base of the standard blade in the Crotalarieae and related tribes (Polhill, 1976). These modifications presumably protect the nectary and in their greater development, increase the activity needed by the pollinator to reach the nectar legitimately.

Polhill (1976) recognizes two basic types of flower structure in the Crotalarieae, which are variously specialized. The unspecialized type of flower has a non-intrusive calyx, thin petals, a narrow standard and a non-rostrate keel (without a beak). The specialized type is more strongly constructed and is adapted to pollination by larger bees. The calyx base may be intrusive, the petals thick, the standard broad (and shortly clawed, with thickenings at the base of the blade) and the keel rostrate (with a stout upwardly directed beak).

The unspecialized type of flower predominates in *Aspalathus*, *Lebeckia* and *Wiborgia* and the flowers of *Rafnia* with a rostrate keel are mostly specialized, with a transition to the unspecialized type (Polhill, 1976). In *Rafnia*, two basic types of flower structure are distinguished here, namely flowers with a rostrate keel (Figure 4.3, 1–17), belonging to section *Rafnia*, and those with an obtuse or truncate to emarginate keel (Figure 4.3, 18–28), of section *Colobotropis* (see Chapter 7). Polhill (1976) does not refer to the type of flower with a truncate or emarginate keel.

The flowers in *Rafnia* with a rostrate keel have thin petals, sculptured wing petals and a keel which is generally not strongly beaked. In some species, the flower has a more strongly developed keel, often accompanied by basal callosities on the broad standard petal, e.g. *R. amplexicaulis*. The flowers of *R. diffusa* (Figure 4.3, 18) and *R. spicata* (Figure 4.3, 19) are a transition from a rostrate to a truncate keeled type of flower. These flowers are thinly textured, the standard is sometimes folded in slightly along the lower edges, the wings are not always sculptured (*R. spicata*) and the keel may be beaked or obtuse.

The flowers with a truncate or emarginate keel, which may be considered more specialized than the strongly rostrate flower referred to by Polhill (1976), do not seem to occur in related genera and may be considered unique to *Rafnia*. These flowers are generally smaller and more firmly constructed than those with a rostrate keel. The calyx usually has a broad lateral sinus and tends to form a trifid lower lip. The petals are thickly textured and the claws often rigid and calloused. The standard petal is folded in along the edges, and often reflexed far back from the other petals at anthesis. The oblong wings invariably lack petal sculpturing and have a broad central fold. The keel petals are variable in shape, but basically truncate or emarginate with a distinct lateral pocket (spur) on the basal central part which fits into the fold of the wing. These features play a role in the pollination mechanism observed in these flowers.

The papilionoid flower is suitably adapted for pollination by bees (Polhill, 1976; Stirton, 1981), and the whole flower is a structural-functional unit, participating in the pollination mechanism. Field observations showed that the two types of flowers in *Rafnia* have different pollination mechanisms.

In the flowers with a rostrate keel, the bee uses the wings as a landing platform, taking hold of the pockets and petal sculpturing (Figure 4.5a). The standard is pressed back and pollen from the anthers within the keel comes into contact with the abdomen of the bee (Figure 4.5b). In the flowers with a truncate keel, the bee uses the standard petal instead of the wings as a landing platform. The standard is borne upright, often reflexed away from the other petals, and is strengthened by the folded edges and thicker texture. The keel faces upwards, and while the bee's head strikes the keel apex, pollen from within the keel comes into contact with the head or dorsal surface of the thorax of the bee. It was observed that these types of flowers in *Rafnia* are pollinated by Xylocopid bees which have hairy thoraces, convenient for the pollen to cling to, whereas ordinary

Apis have smooth thoraces, hence the pollen must cling to the legs or abdomen. The truncate or emarginate keeled type of flower therefore seems to be adapted for a different pollination mechanism.

Figure 4.5 A bee pollinating the rostrate keeled flower of *R. racemosa* subsp. *racemosa*: **a**, the bee takes hold of the petal sculpturing and pockets on the wings, which are the landng platform; **b**, the standard petal is pressed back and pollen from within the keel comes into contact with the abdomen of the bee.

In their pollination study, Gess & Gess (1994) found that the Cape Crotalarieae attract an assemblage of potential bee-pollinators which is consistent with the general pattern previously presented for the Papilionoideae. The potential bee-pollinators belong only to the families Megachilidae and Anthophoridae and mainly only to the two subfamilies Megachilinae and Xylocopinae. In the study, the most dependable visitors were the Masarinae, and the Eumeninae seemed to be unimportant as pollinators except possibly of *R. amplexicaulis*.

Flower morphology presented taxonomically useful characters at the sectional, species and subspecies levels. The basic type of flower, whether having a rostrate or truncate keel, is useful for dividing the species into sections and combinations of flower characters are useful for the identification of numerous species and subspecies.

4.2.1 Bract and bracteoles

The homologies of bracts and bracteoles and the significance of their presence have not been thoroughly studied in legumes (Tucker, 1987a). Bracts are generally simple in the Crotalarieae, or rarely trifoliolate in some species of *Aspalathus* (Dahlgren, 1963a). Bracts are usually situated at the base of the pedicel, or rarely above the base (Polhill, 1976; Van Wyk, 1991a).

In *Rafnia*, bracts are invariably present, simple and situated at the base of the pedicel. Variation in bract and bracteole structure is given in Figure 4.6. The bracts are commonly narrowly-triangular or subulate, but may be broader as in *R. angulata* subsp. *angulata* (Figure 4.6, 3d) or rarely very large and leaf-like, as in *R. alata* (Figure 4.6, 12). Bracts are mostly subglabrous, with hairs towards the apex. Bract length ranges from ± 0.4 mm in *R. diffusa*, *R. spicata* (Figure 4.6, 21) and some forms of *R. capensis* subsp. *capensis* to 5 mm in the Swartberg and Bredasdorp forms of *R. alata*.

Bracteoles are not always present in legumes (Tucker, 1987a), but absence at flowering does not mean that bracteoles were not present during earlier stages of flower development. In the Crotalarieae, bracteoles are usually present and generally small, but may also be minute or lacking (Polhill, 1976).

In *Rafnia*, two small, linear to triangular simple bracteoles, which resemble the bracts, are generally borne on the pedicel, higher up on either side above the bract. In *R. triflora*, however, the bract and bracteoles seem to occur at the same level at the base of the pedicel. The bracteoles may be strongly reduced (minute) or even absent (as in the

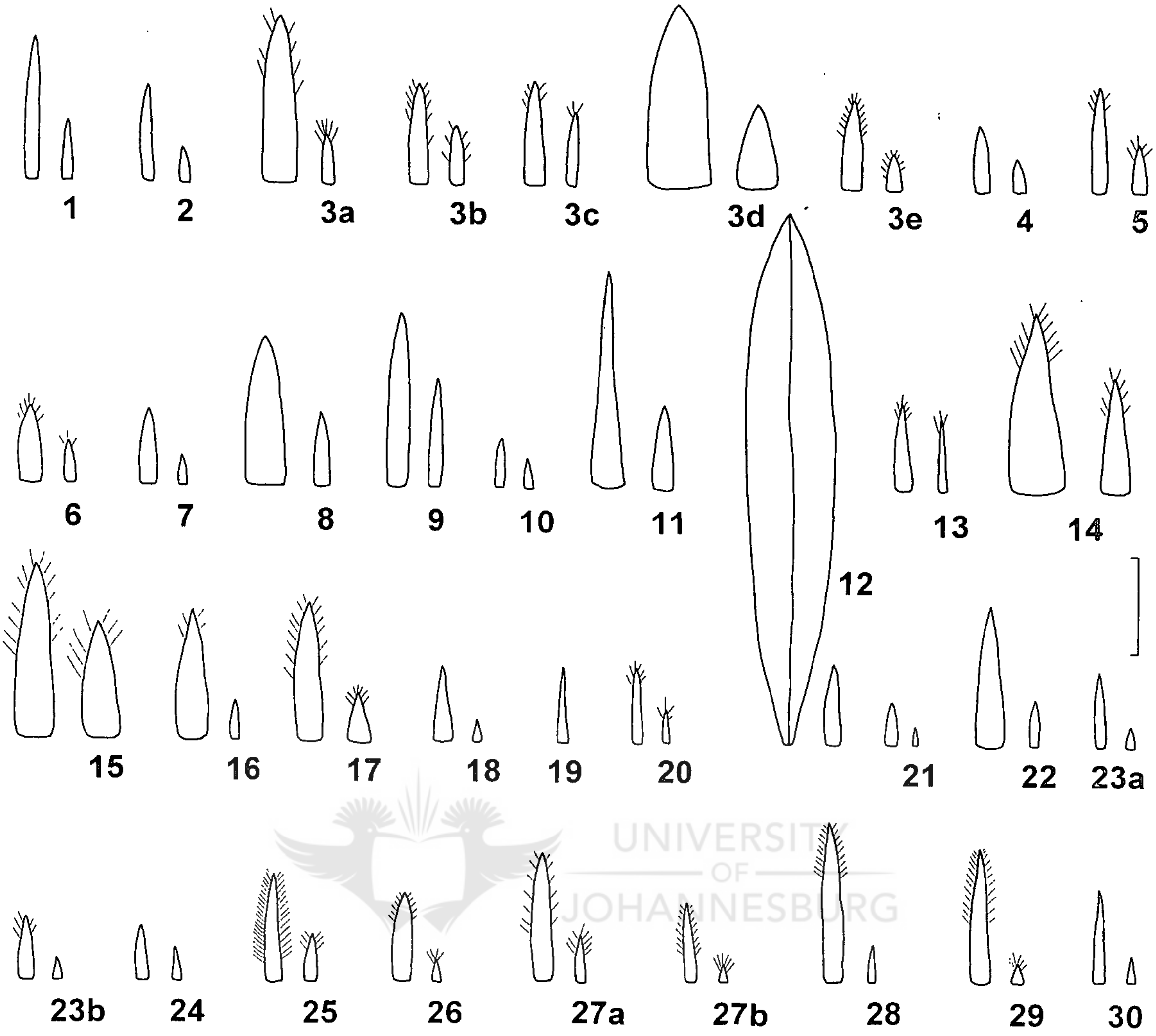


Figure 4.6 Variation in bracts (left) and bracteoles (right) in *Rafnia*, showing differences in relative sizes and shapes. 1–19 = section *Rafnia*; 20–30 = section *Colobotropis* (bracteoles often minute): **1,** *R. racemosa* subsp. *racemosa* (*Van Wyk 2156*); **2,** *R. racemosa* subsp. *pumila* (*Esterhuysen 33444*); **3,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Esterhuysen 22143*); **b,** Form 1 (*Van Wyk 3679*); **c,** Form 2 (*Compton 12669*); **d,** Form 5 (*Campbell & Van Wyk 138*); **e,** Form 9 (*Schutte & Vlok 762*); **4,** *R. angulata* subsp. *thunbergii* (*Van Wyk 2908*); **5,** *R. angulata* subsp. *humilis* (*Leighton 1474*); **6,** *R. angulata* subsp. *ericifolia* (*Esterhuysen 28056*); **7,** *R. angulata* subsp. *montana* (*Andreae 1245*); **8,** *R. crispa* (*Stirton 8439*); **9,** *R. lancea* (*Walters 203*); **10,** *R. rostrata* subsp. *rostrata* (*Barker 2358*); **11,** *R. rostrata* subsp. *pauciflora* (*Bean & Viviers 1991*); **12,** *R. alata* Form 1 (*Campbell et al. 154*)—bract large, leaf-like; **13,** *R. crassifolia* (*Vlok & Schutte 258*); **14,** *R. elliptica* (*Van Wyk & C.M. van Wyk 1066*); **15,** *R. triflora* Form 1 (*Ellis 45*); **16,** *R. ovata* (*Compton 18813*); **17,** *R. inaequalis* (*Campbell & Van Wyk 119*); **18,** *R. acuminata* Form 1 (*Campbell & De Castro 97*); **19,** *R. amplexicaulis* (*Walters 1869*)—bracteoles absent; **20,** *R. diffusa* Form 4 (*Taylor 11098*); **21,** *R. spicata* (*Oliver 9042*); **22,** *R. schlechteriana* (*Esterhuysen 13421*); **23,** *R. capensis* subsp. *capensis*: **a,** Form 1b (*Vlok & Schutte 406*); **b,** Form 5 (*Campbell et al. 131*); **24,** *R. capensis* subsp. *carinata* (*Van Wyk 2304*); **25,** *R. capensis* subsp. *calycina* (*Compton 22963*); **26,** *R. capensis* subsp. *dichotoma* Form 2 (*Van Wyk 2999*); **27,** *R. capensis* subsp. *ovata*: **a,** Form 3b (*Walters 1429*); **b,** Form 5 (*Esterhuysen 34389*); **28,** *R. capensis* subsp. *elsieae* (*Esterhuysen 14858*); **29,** *R. capensis* subsp. *pedicellata* (*Compton 20442*); **30,** *R. globosa* (*Campbell & Van Wyk 125*). Scale = 1 mm.

Outeniqua form of *R. alata* and *R. amplexicaulis*) and also often have hairs towards the apex.

The bracteoles are often minute in taxa of section *Colobotropis* (Figure 4.6, 20–30), in which case they may be visible only as a tuft of hair or a small triangular tooth on the middle part of the glabrous pedicel. Similarly, the bracteoles of the Podalyrieae (and Liparieae) are usually strongly reduced or absent (Van Wyk & Schutte, 1995).

Bracteole length varies from 0.1 mm in *R. capensis* subsp. *capensis* to 1.4 mm in *R. triflora*. Larger flowers tend to have longer bracteoles, but not necessarily the longest bracts, and bracts are always longer than bracteoles. The lengths of the bract and bracteole were useful in the phenetic analysis.

The presence or absence of bracts and bracteoles has limited taxonomic value in *Rafnia*, compared with *Cyclopia* for example, where bracts are crucially important for identifying most of the species (Schutte, 1997). Bracts and bracteoles have some value in identifying certain species of *Rafnia*, however, such as *R. alata* with its very large, leaf-like bracts and many taxa of section *Colobotropis* in which bracteoles may be minute or practically absent.

4.2.2 Calyx

The calyx is an important taxonomic character in the Papilionoideae and has been used as one of the main criteria for the subdivision of the Genisteae *sensu lato* into four separate tribes (Polhill, 1976). The most common and presumably least specialized type of calyx in the Papilionoideae has the upper lobes often somewhat expanded and the upper sinus shallowest.

The calyces of the Crotalarieae may be "lebeckioid", with a subequally lobed calyx, or "lotononoid", in which the calyces have relatively shallow lateral sinuses (higher fusion of the upper and lateral lobes on either side) and a narrow lower lobe (Polhill, 1976). The three lower lobes may be partially fused to form a trifid lip and the resulting bilabiate calyx is characteristic of the Genisteae *sensu stricto.* Genera with a bilabiate calyx previously included in the Crotalarieae (e.g. *Dichilus* and *Melolobium* Eckl. & Zeyh.) were transferred to the Genisteae *sensu stricto* by Van Wyk & Schutte (1995). True Crotalarieae do not have a distinctly bilabiate calyx, but sometimes there is a tendency towards the development of a trifid lower lip. However, it only occurs sporadically and is not as well developed as in the Genisteae *sensu stricto.* In the Crotalarieae, the upper sinus may be deeper than the other sinuses and is very rarely shallower.

In a cladistic analysis of the Crotalarieae (Van Wyk & Schutte, 1995), calyx characters useful at the generic level included the absence of a trifid lower lip (lower calyx lobes not fused higher up to form a trifid lip), the presence of a lotononoid calyx (lateral lobes fused higher up to form a pair on either side) and the presence of very small calyx lobes.

The calyx is an important character in *Rafnia* and is useful at the sectional, generic, specific and subspecific levels. Calyx morphology is variable in *Rafnia* and the range of variation is shown in Figure 4.7. *Rafnia* plants were previously considered to be totally glabrous, but in this study it was found that hairs occur on the inner surfaces of the calyces in all the species. This is a useful synapomorphy for the genus. The calyces in *Rafnia* are lebeckioid, with the exception of the calyx of *R. lancea* (Figure 4.7, 9) which is lotononoid. The calyx of *R. crispa* (Figure 4.7, 8) is similar to that of *R. lancea*.

The calyx is commonly subequally lobed and the carinal lobe is usually distinctly narrower than the other lobes. The carinal lobe is very narrow in *R. elliptica* (Figure 4.7, 14), *R. triflora* (Figure 4.7, 15b) and *R. capensis* subsp. *calycina* (Figure 4.7, 25) and almost hair-like in *R. vlokii* (Figure 4.7, 11) and *R. inaequalis* (Figure 4.7, 17). Twenty seven phenetic characters (see Table 6.1) and 10 cladistic characters (see Table 7.1) were obtained from calyx structure and those characters that were useful in both the phenetic and cladistic analyses are discussed below.

When *Aspalathus* or *Lebeckia* are taken as outgroup, the plesiomorphic type of calyx appears to be that of *R. racemosa* subsp. *racemosa* (Figure 4.7, 1), in which the lobes are subequal and about as long as the tube.

The calyx may be about as long as, shorter than or much shorter than that part of the corolla exceeding it. The calyx is very long and about as long as that part of the corolla exceeding it in *R. vlokii* (see Figure 4.3, 9), *R. alata* (see Figure 4.3, 10), *R. crassifolia* (see Figure 4.3, 11), *R. inaequalis* (see Figure 4.3, 15) and *R. capensis* subsp. *calycina* (see Figure 4.3, 23). The calyx is much shorter than that part of the corolla exceeding it in *R. diffusa* (see Figure 4.3, 18), for example. The relatively long calyx is considered apomorphic.

Another useful character is the ratio between length of calyx lobes and length of calyx tube. There may be a short tube and long lobes, e.g. *R. vlokii* (Figure 4.7, 11) and *R. crassifolia* (Figure 4.7, 13), or a long tube and short lobes, e.g. *R. angulata* subsp. *thunbergii* (Figure 4.7, 4) and *R. diffusa* (Figure 4.7, 20c). The lobes are more often about as long as the tube, e.g *R. capensis* subsp. *pedicellata* (Figure 4.7, 29).

The calyx lobes are generally triangular or acute to ovate-acuminate. The upper lobes

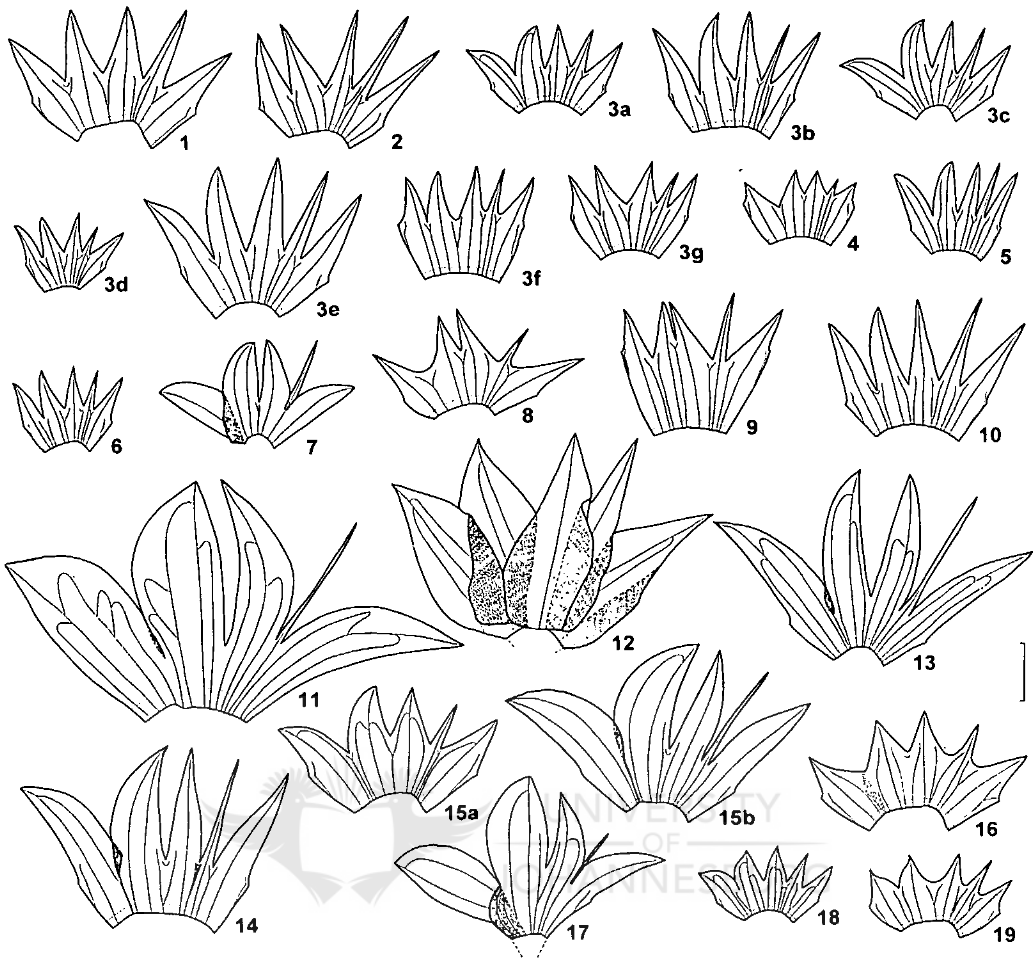


Figure 4.7 Variation in the calyces of *Rafnia*, showing differences in size and shape. 1–19 = section *Rafnia*; 20–30 = section *Colobotropis* (overleaf). Calyces are shown opened out with the two upper lobes to the left and the three lower lobes to the right: **1,** *R. racemosa* subsp. *racemosa* (*Wurts 1641*)—lobes subequal, ± as long as tube; **2,** *R. racemosa* subsp. *pumila* (*Esterhuysen 33444*)—lobes longer than tube; **3,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Van Wyk s.n.*); **b,** Form 1 (*Van Wyk 3679*)—lower lobe shortest, upper sinus deepest; **c,** Form 1 (*Snijman 44*)—upper lobes broader than lateral lobes, upper sinus deepest; **d,** Form 1 (*Barker 10333*); **e,** Form 5 (*Stirton 11195*); **f,** Form 8 (*Purcell 334*); **g,** Form 9 (*Schutte & Vlok 762*); **4,** *R. angulata* subsp. *thunbergii* (*Campbell et al. 130*)—lobes shorter than tube; **5,** *R. angulata* subsp. *humilis* (*Salter 2875*); **6,** *R. angulata* subsp. *ericifolia* (*Esterhuysen 28056*); **7,** *R. angulata* subsp. *montana* (*Andreae 1245*)—upper lobes broad, falcate, wing-like extension between upper lobes, carinal lobe longest; **8,** *R. crispa* (*Stirton 8439*); **9,** *R. lancea* (*Esterhuysen 11936*)—calyx lotononoid, upper and lateral lobes fused higher up, lateral sinus shallowest; **10,** *R. rostrata* subsp. *rostrata* (*Campbell & Van Wyk 145*); **11,** *R. vlokii* (*Vlok 534*)—upper lobes broad, falcate, lower lobe hair-like, shortest; **12,** *R. alata* Form 1 (*Campbell et al. 154*)—five large wing-like extensions between lobes; **13,** *R. crassifolia* (*Walters 595*); **14,** *R. elliptica* (*Van Wyk & C.M. van Wyk 1066*); **15,** *R. triflora*: **a,** Form 1 (*Ellis 45*); **b,** Form 2 (*Burgers 1342*)—upper lobes much larger and broader than in Form 1; **16,** *R. ovata* (*Compton 18813*); **17,** *R. inaequalis* (*Campbell & Van Wyk 119*)—upper lobes broadly falcate, lower lobe hair-like and shortest; **18,** *R. acuminata* Form 1 (*Barker 4164*)—upper lobes falcate; **19,** *R. amplexicaulis* (*Walters 1869*). Scale = 5 mm.

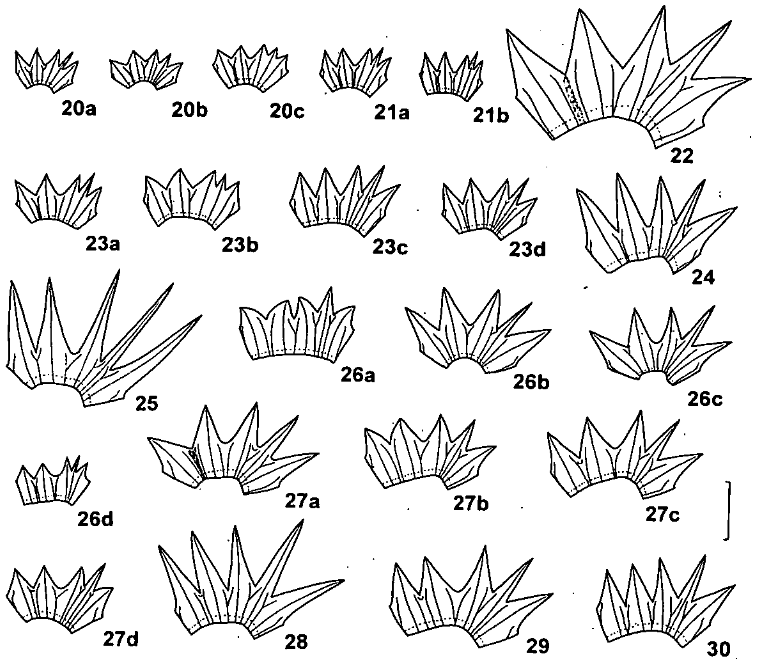


Figure 4.7 Continued: **20,** *R. diffusa*: **a,** Form 1 (*Barker 9776*); **b,** Form 2 (*Stokoe s.n. sub SAM 61409*)—lobes shorter than in Form 1, broadly triangular; **c,** Form 3 (*Pillans 8726*)—lobes broad, shorter than tube; **21,** *R. spicata*: **a,** (*Campbell & Van Wyk 141*); **b,** (*Campbell & Van Wyk 142*)—trifid lower lip; **22,** *R. schlechteriana* (*Goldblatt s.n. sub NBG 97432*); **23,** *R. capensis* subsp. *capensis*: **a,** Form 2 (*Campbell et al. 151*); **b,** Form 3 (*Stokoe s.n. sub SAM 61412*); **c,** Form 4 (*Compton 13800*); **d,** Form 6 (*Lewis 5707*); **24,** *R. capensis* subsp. *carinata* (*Stirton 9182*); **25,** *R. capensis* subsp. *calycina* (*Maguire 1178*)—lobes much longer than tube; **26,** *R. capensis* subsp. *dichotoma*: **a,** Form 2 (*Campbell 98*); **b,** Form 3 (*Lewis 5699*); **c,** Form 4 (*Van der Merwe 190*); **d,** Form 5 (*Esterhuysen 15960*); **27,** *R. capensis* subsp. *ovata*: **a,** Form 2 (*Barker 8121*); **b,** Form 3b (*Walters 1429*); **c,** Form 3c (*Barker 4165*); **d,** Form 4 (*Taylor 4295*); **28,** *R. capensis* subsp. *elsieae* (*Esterhuysen 14858*)—carinal lobe longer than other lobes; **29,** *R. capensis* subsp. *pedicellata* (*Campbell & De Castro 85*); **30,** *R. globosa* (*Le Maitre 262*). Scale = 5 mm.

may be falcate (asymmetrical) or non-falcate (symmetrical). The lobes are distinctly falcate in e.g. *R. angulata* subsp. *montana* (Figure 4.7, 7), *R. vlokii* (Figure 4.7, 11) and *R. inaequalis* (Figure 4.7, 17) and are slightly falcate in e.g. *R. rostrata* subsp. *rostrata* (Figure 4.7, 10), *R. alata* (Figure 4.7, 12) and *R. crassifolia* (Figure 4.7, 13). The lobes of most of the remaining taxa are non-falcate.

The upper calyx lobes may be similar to or much broader than the lateral lobes. The latter includes *R. alata* (Figure 4.7, 12), *R. elliptica* (Figure 4.7, 14), *R. triflora* (Figure 4.7, 15a & b), *R. inaequalis* (Figure 4.7, 17) and *R. acuminata* (Figure 4.7, 18). Broad upper lobes (Figure 4.8) are considered apomorphic and this character was useful in the cladistic analysis. A character useful as a synapomorphy for *R. vlokii* and *R. alata* is the broad lateral calyx lobe, where the mean value is more than 4.5 mm.

The upper sinus is usually as deep as the other sinuses, or at least the lateral sinuses, but it may be slightly shallower than the other sinuses only in *R. lancea* (Figure 4.7, 9), or deeper, in at least some individuals, in *R. angulata* subsp. *angulata* (Figure 4.7, 3b, d & g), *R. rostrata* subsp. *rostrata*, *R. elliptica* and rarely in *R. racemosa* subsp. *racemosa* and *R. globosa*. The upper sinus is much deeper than the lateral sinuses in *R. triflora* and *R. ovata* and this character proved to be a useful synapomorphy.

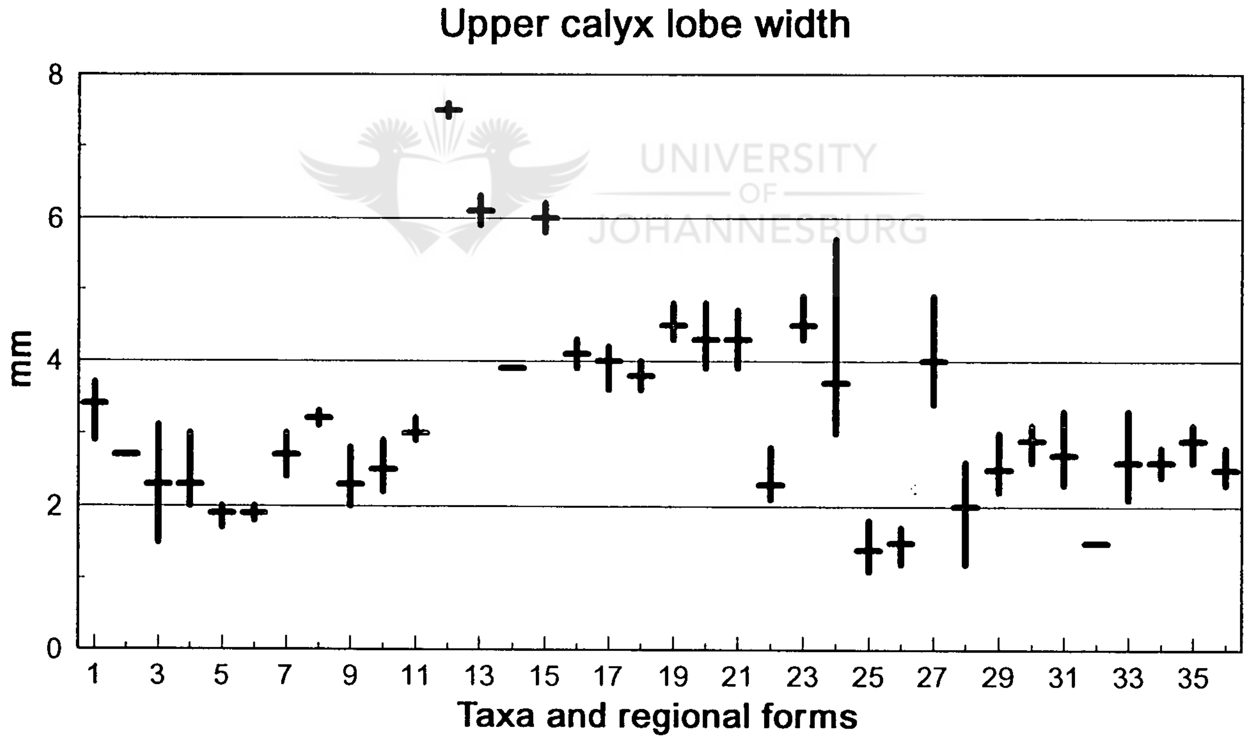


Figure 4.8 Range and mean values for upper calyx lobe width of taxa and regional forms of *Rafnia*. Upper calyx lobes are broad (mean equal to or more than 3.5 mm) in *R. racemosa* subsp. *racemosa* (1), *R. crispa* (8), *R. rostrata* subsp. *pauciflora* (11), *R. vlokii* (12), *R. alata* Form 1 (13) and Form 3 (15), *R. crassifolia* (16), *R. elliptica* (17), *R. triflora* Form 1 (18) and Form 2 (19), *R. ovata* (20), *R. inaequalis* (21), *R. acuminata* Form 2 (23), *R. amplexicaulis* (24) and *R. schlechteriana* (27). (Taxa and regional forms are numbered as in Table 2.2.)

In some species, the lower sinuses are shallower than the lateral ones, so that the calyx may be considered to have a trifid lower lip (Figure 4.7, 20–30). The presence of this trifid lip is a useful synapomorphy for section *Colobotropis* (see Chapter 7). The trifid lip is most pronounced in *R. diffusa* (Figure 4.7, 20a–c), *R. spicata* (Figure 4.7, 21a & b), *R. capensis* subsp. *capensis* (Figure 4.7, 23a–d) and *R. capensis* subsp. *ovata* (Figure 4.7, 27a–d) and is less well developed in *R. schlechteriana* (Figure 4.7, 22) and *R. globosa* (Figure 4.7, 30), for example.

The carinal calyx lobe may be shorter than, more or less as long as, or longer than the other lobes. The carinal lobe is often longer than the other lobes where a trifid lower lip is present and the lower sinuses are then shallower than the other sinuses, for example *R. diffusa* (Figure 4.7, 20a–c), *R. spicata* (Figure 4.7, 21a & b) and *R. capensis* subsp. *capensis* (Figure 4.7, 23a & c).

This rarely occurs where the lower lobes do not form a trifid lip, e.g. *R. angulata* subsp. *montana* (Figure 4.7, 7) and *R. rostrata* subsp. *rostrata* (Figure 4.7, 10). Cladistic analyses showed that this is a convergent occurrence in distantly related species. The carinal lobe is rarely shorter than the other lobes, e.g. *R. angulata* subsp. *angulata* (Figure 4.7, 3d) (in which it may also be more or less as long as the others), *R. angulata* subsp. *thunbergii* (Figure 4.7, 4), *R. triflora* (Figure 4.7, 15a) and *R. inaequalis* (Figure 4.7, 17). This character often occurs simultaneously with an upper calyx sinus that is deeper than the lateral sinuses.

The calyx tube may have a thickening, ridge or wing-like extension on the tube between the upper lobes. Thickenings occur on the tubes of *R. vlokii*, *R. crassifolia*, *R. elliptica* (Figure 4.7, 14), *R. triflora* and *R. ovata*. A ridge-like extension may be present in *R. angulata* subsp. *humilis*, *R. rostrata* subsp. *rostrata*, *R. acuminata*, *R. schlechteriana*

(Figure 4.7, 22) and *R. capensis* subsp. *pedicellata*. In *R. angulata* subsp. *montana* (Figure 4.7, 7) and *R. inaequalis* (Figure 4.7, 17), the extension is wing-like and wing development is taken to its extreme in *R. alata* (Figure 4.7, 12), which has five distinct wings occurring below each of the sinuses. This character is an autapomorphy for *R. alata*.

In terms of calyx variation, the Piquetberg is particularly interesting because the calyces of several species found on the Piquetberg differ from the normal calyces of these species elsewhere. For example, in the form of *R. acuminata* that occurs on the Piquetberg (Figure 4.9, 1b), the upper lobes are much broader than the lateral lobes, and there is a ridge-like thickening between the upper lobes. The form of the calyx in *R. amplexicaulis* also differs on the Piquetberg (Figure 4.9, 2a & b). The calyx of *R. capensis* subsp. *calycina* (basically the Piquetberg form of *R. capensis* subsp. *dichotoma*) has long, narrow, reflexed lobes (Figure 4.9, 3b), whilst *R. capensis* subsp. *dichotoma* (Figure 4.9, 3a) has shorter, broader lobes. The calyx of *R. inaequalis*, which is endemic to the Piquetberg (Figure 4.9, 4) has an unusual shape, with large, falcate upper lobes, a wing-like extension on the tube and a hair-like lower lobe.

Similarly, the calyx can be used to distinguish between the regional forms of other taxa. For example, the calyx lobes of the typical form of *R. triflora* (Figure 4.7, 15a) are more or less triangular and about as long as the tube, while in the Caledon form of *R. triflora* (Figure 4.7, 15b), the upper calyx lobes are much broader than the lateral lobes and the lobes are longer than the tube.

Unique calyx characters useful for identifying certain species and subspecies include the lotononoid calyx of *R. lancea* (Figure 4.7, 9), the large calyx of *R. vlokii* (Figure 4.7, 11), which completely envelopes the flower bud so that it looks like a leaf (this similarly occurs in *R. angulata* subsp. *montana*), the extreme zygomorphy of the calyx of

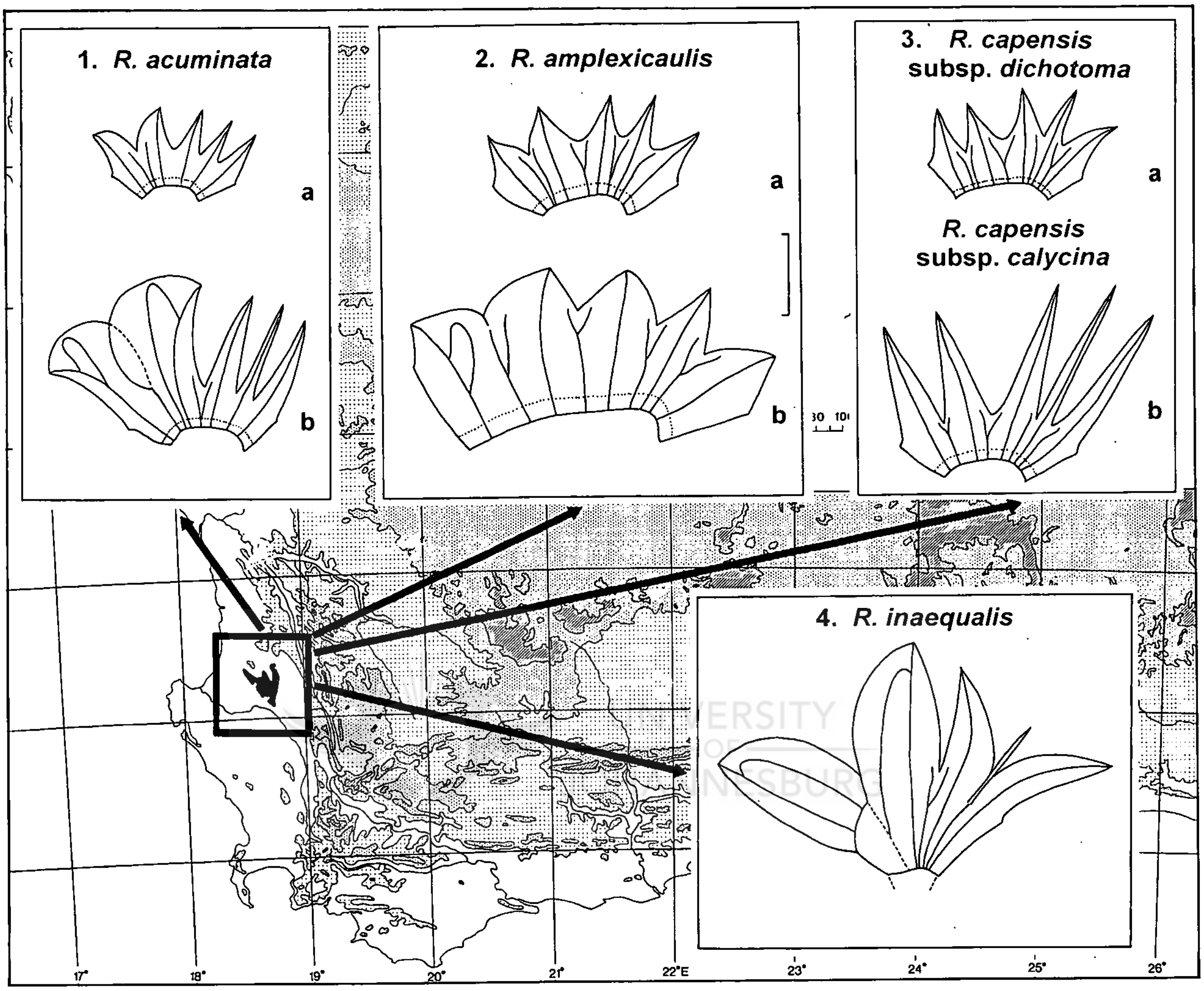


Figure 4.9 Differences in calyx morphology between forms of species on the Piquetberg as opposed to forms elsewhere (typical forms): **1,** *R. acuminata*: **a,** typical form; **b,** Northern form (Piquetberg); **2,** *R. amplexicaulis*: **a,** typical form; **b,** Piquetberg form; **3a,** *R. capensis* subsp. *dichotoma*; **b,** *R. capensis* subsp. *calycina* (Piquetberg form of *R. capensis* subsp. *dichotoma*); **4,** *R. inaequalis*—Piquetberg endemic species.

R. inaequalis (Figure 4.7, 17), the long, thin, greatly reflexed lobes of *R. capensis* subsp. *calycina* (Figure 4.7, 25) and the lobes which curl backwards after senescence of the flowers in *R. globosa* (see Figure 3.3). Unusual calyx characters are particularly useful for distinguishing some of the subspecies and rare species in *Rafnia*.

Calyx morphology is taxonomically important in *Rafnia* and useful at the generic level in that the hairs inside the calyx provide a synapomorphy for the genus. At sectional level, the trifid lower lip of the calyx is a useful synapomorphy for section *Colobotropis* and at species and subspecies levels, the calyx is useful for identifying individual taxa. The calyx is even useful for identifying certain regional forms within species.

4.2.3 Standard petal

Corolla morphology is an important taxonomic character in *Rafnia*, being useful at the species and subspecies levels. A number of corolla characters were used in the cladistic and phenetic analyses. Standard petal characters used in the phenetic analysis are listed in Table 6.1.

Variation in the standard petals in *Rafnia* is shown in Figure 4.10. The standards range in size from 6 mm long and wide in *R. spicata* (Figure 4.10, 22) to 19 mm long and 20 mm wide in *R. ovata* (Figure 4.10, 17). The standard may be ovate, e.g. *R. angulata* subsp. *angulata* (Figure 4.10, 3f), boadly ovate, e.g. *R. inaequalis* (Figure 4.10, 18), elliptic, e.g. *R. rostrata* subsp. *pauciflora* (Figure 4.10, 11), broadly elliptic, e.g. *R. amplexicaulis* (Figure 4.10, 20) or round, e.g. *R. angulata* subsp. *angulata* (Figure 4.10, 3a) and *R. diffusa* (Figure 4.10, 21a).

The standard in *Rafnia* is generally longer than the calyx, e.g. *R. angulata* subsp. *thunbergii*, *R. crispa*, *R. ovata*, *R. amplexicaulis* and *R. diffusa*, but it may also be as long as or shorter than the calyx. The standard is shorter than the calyx in e.g. *R. vlokii*, *R. alata*, *R. inaequalis*, *R. capensis* subsp. *calycina* and *R. capensis* subsp. *elsieae.* The standard is usually longer than the keel petals, or is less often about as long as or shorter than the keel.

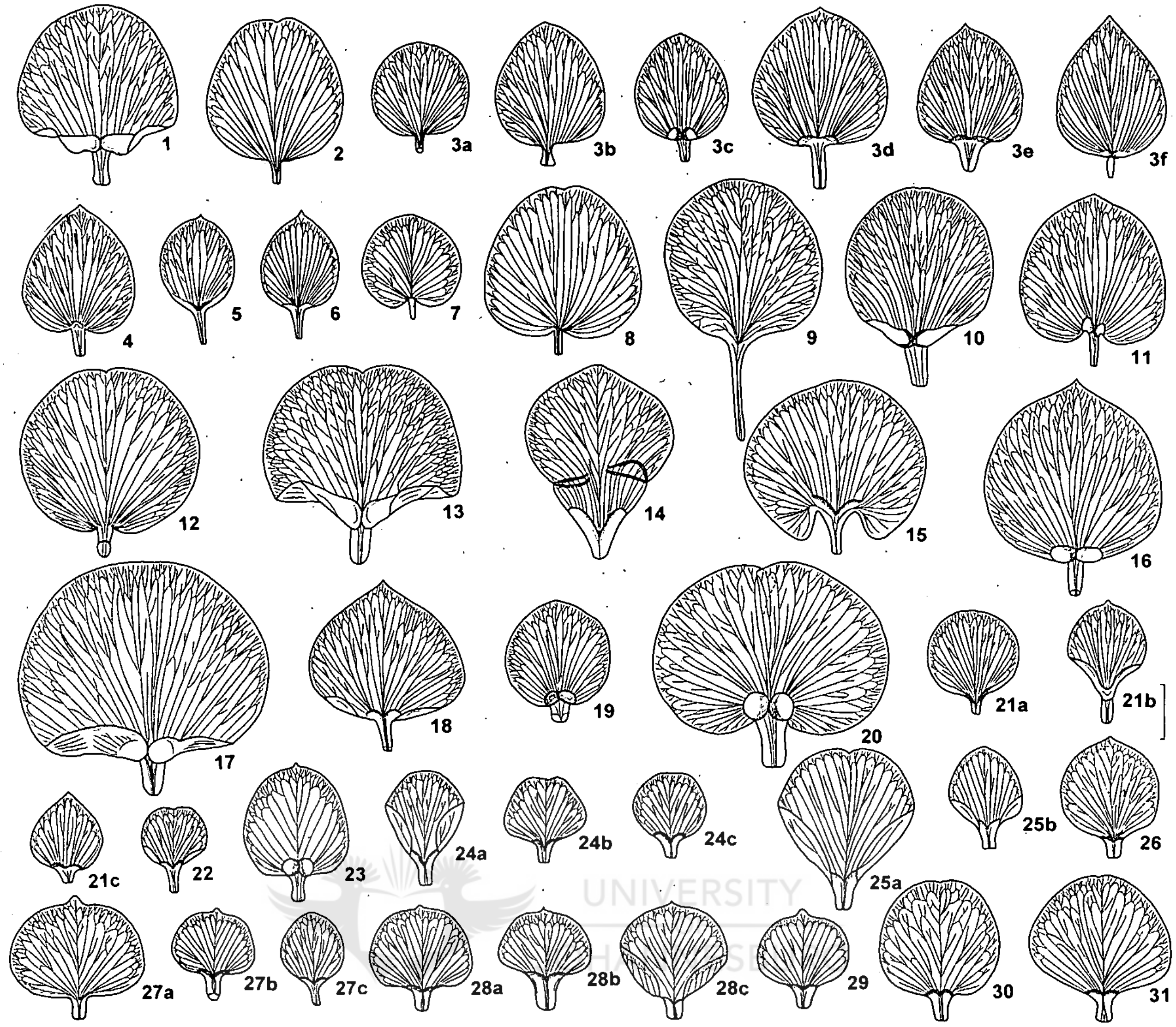


Figure 4.10 Variation in standard petals in *Rafnia*, showing differences in size and shape. 1–20 = section *Rafnia*; 21–31 = section *Colobotropis*: **1,** *R. racemosa* subsp. *racemosa* (*Campbell et al. 155*)—basal callosities; **2,** *R. racemosa* subsp. *pumila* (*Esterhuysen 33444*); **3,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Van Wyk s.n.*); **b,** Form 1 (*Van Wyk 3679*); **c,** Form 1 (*Snijman 44*); **d,** Form 1 (*Compton 18728*); **e,** Form 6 (*Campbell & Van Wyk 132*)—small apical cusp; **f,** Form 9 (*Schutte & Vlok 762*)—apex acuminate; **4,** *R. angulata* subsp. *thunbergii* (*Van Wyk 2908*); **5,** *R. angulata* subsp. *humilis* (*Leighton 1474*); **6,** *R. angulata* subsp. *ericifolia* (*Barker 8862*); **7,** *R. angulata* subsp. *montana* (*Andreae 1245*); **8,** *R. crispa* (*Stirton 8439*); **9,** *R. lancea* (*Johnson 481*)—long claw; **10,** *R. rostrata* subsp. *rostrata* (*Campbell & Van Wyk 145*); **11,** *R. rostrata* subsp. *pauciflora* (*Esterhuysen 28833*); **12,** *R. vlokii* (*Vlok 534*); **13,** *R. alata* Form 1 (*Campbell et al. 154*)—basal callosities; **14,** *R. crassifolia* (*Campbell & Van Wyk 150*)—subpanduriform shape; **15,** *R. elliptica* (*Vlok & Schutte 352*); **16,** *R. triflora* Form 1 (*Campbell & Van Wyk 118*); **17,** *R. ovata* (*Campbell & Van Wyk 128*); **18,** *R. inaequalis* (*Campbell & Van Wyk 119*); **19,** *R. acuminata* Form 1 (*Campbell & De Castro 97*); **20,** *R. amplexicaulis* (*Campbell & Van Wyk 120*); **21,** *R. diffusa*: **a,** Form 2 (*Stokoe s.n. sub SAM 61409*)—round; **b,** Form 3 (*Campbell & Van Wyk 140*); **c,** Form 5 (*Maguire 1151*); **22,** *R. spicata* (*Campbell & Van Wyk 141*); **23,** *R. schlechteriana* (*Campbell & De Castro s.n.*); **24,** *R. capensis* subsp. *capensis*: **a,** Form 4 (*Campbell et al. 151*); **b,** Form 4 (*Barker 3260*); **c,** Form 5 (*Campbell et al. 131*); **25,** *R. capensis* subsp. *carinata*: **a,** (*Campbell & Van Wyk 126*); **b,** (*Kruger KR956*); **26,** *R. capensis* subsp. *calycina* (*Esterhuysen 35798*); **27,** *R. capensis* subsp. *dichotoma*: **a,** Form 1 (*Esterhuysen 17867*); **b,** Form 2 (*Van Wyk 2999*); **c,** Form 5 (*Esterhuysen 15960*); **28,** *R. capensis* subsp. *ovata*: **a,** Form 3a (*Forsyth 377*); **b,** Form 4 (*Campbell & Van Wyk 147*); **c,** Form 4 (*Compton 20169*); **29,** *R. capensis* subsp. *elsieae* (*Esterhuysen 14858*); **30,** *R. capensis* subsp. *pedicellata* (*Campbell & De Castro 85*); **31,** *R. globosa* (*Pillans 9081*). Scale = 5 mm.

In *Rafnia*, the standard apex may be acuminate, rounded, retuse or folded to make an almost closed pocket (apical cusp), which also occurs in some species of *Aspalathus* (Dahlgren, 1963a). There is usually a small apical cusp in e.g. *R. angulata* subsp. *angulata* (Figure 4.10, 3d & e) and a larger, more distinct cusp in e.g. *R. capensis* subsp. *dichotoma* (Figure 4.10, 27a & b), *R. capensis* subsp. *ovata* (Figure 4.10, 28a–c) and *R. capensis* subsp. *elsieae* (Figure 4.10, 29).

Some of the larger, broader standards have basal callosities or ridges near the attachment of the claw, which are often disc-shaped. These occur in *R. racemosa* subsp. *racemosa* (Figure 4.10, 1), *R. rostrata* subsp. *rostrata* (Figure 4.10, 10), *R. alata* (Figure 4.10, 13), *R. triflora* (Figure 4.10, 16), *R. ovata* (Figure 4.10, 17) and *R. amplexicaulis* (Figure 4.10, 20). Basal callosities also occur in a group of *Aspalathus* species (Dahlgren, 1963a).

The lower half or lower two thirds of the edges of the standard blade are folded inwards to varying degrees in taxa of section *Colobotropis*. This character was used in the cladistic analysis. The folded standard is strongly correlated with a truncate or emarginate keel and a distinct lack of petal sculpturing on the wings. This forms part of the pollination syndrome of the flowers with truncate or emarginate keels (see Chapter 4.2). This feature is shown in *R. capensis* subsp. *capensis* (Figure 4.10, 24a), *R. capensis* subsp. *carinata* (Figure 4.10, 25a) and *R. capensis* subsp. *ovata* (Figure 4.10, 28c).

Figure 4.11 shows a comparison between the normal, flat standard as is found in *R. angulata* subsp. *angulata* (Figure 4.11a), representative of taxa of section *Rafnia* and that which is folded in along the edges, as in *R. schlechteriana* (Figure 4.11b),

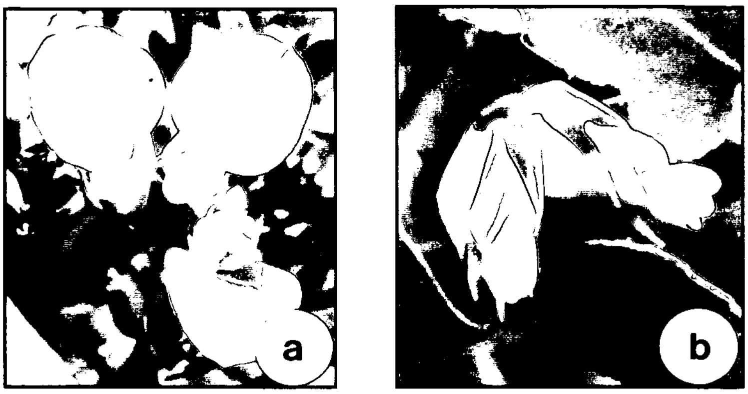


Figure 4.11 The flowers of two species of *Rafnia*, showing the difference between a flat standard petal and one which is folded in along the edges: **a,** *R. angulata* subsp. *angulata*—standard flat; **b,** *R. schlechteriana*—standard folded in along the edges.

representing taxa of section *Colobotropis*. In *Aspalathus*, the margins of the standard blade are often more or less incurved, especially in small-flowered species with rigid, subcarnose petals (Dahlgren, 1963a).

A feature which is very characteristic for *Wiborgia* (Dahlgren, 1975) and some species of *Lebeckia* (Van Wyk & Schutte, 1989) is the strong basal reflexion of the standard blade. When the flower reaches anthesis, the blade curves backwards against the claw at a very acute angle or is even closely pressed against it. In *Rafnia*, reflexion is not as marked as in *Wiborgia*, but in many species of section *Colobotropis*, especially *R. capensis*, the standard petals do tend to be reflexed at anthesis (see *R. capensis* subsp. *dichotoma* in Figure 4.3, 24a).

The claw is generally well developed, and may be rather short, broad and somewhat calloused, e.g. *R. capensis* subsp. *ovata* (Figure 4.10, 28a–c), or longer, narrower and softer-textured, as in *R. angulata* subsp. *angulata* (Figure 4.10, 3d). The claw is invariably shorter than the blade, except in *R. lancea* (Figure 4.10, 9), in which it is about as long as the blade. The claw may sometimes be arched, in which case it is at an angle of 90° to the blade.

The standard petal has taxonomic value in *Rafnia* in that it is useful for distinguishing between sections and for identifying certain species.

4.2.4 Wing petals

With regard to the papilionoid flower as a functional unit, Stirton (1981) investigated the relationship between wing petals (landing stages) and pollinators. He emphasized that the wing petal is not a character on its own, but is rather an important part of a functional-structural unit. The same is true for the other components of the corolla.

Variation in wing petals in *Rafnia* is represented in Figure 4.12. The wings in *Rafnia* are clawed, generally elongate, oblong or ovate to obovate, or even obliquely triangular, as in *R. angulata* subsp. *humilis* (Figure 4.12, 5). The distal part may be round and extended, e.g. *R. crispa* (Figure 4.12, 8) and *R. alata* (Figure 4.12, 13c), or the wing may be compressed and round, as in *R. capensis* subsp. *capensis* (Figure 4.12, 24a). The upper basal margin usually forms a rounded basal lobe or auricle whereas the lower margin merges gradually into the claw or may be slightly lobed.

The wings vary in size from 6 mm long and 2 mm wide in *R. spicata* (Figure 4.12, 22) and *R. capensis* subsp. *capensis* (Figure 4.12, 24a–c) to 18 mm long and 10 mm wide in *R. ovata* (Figure 4.12, 17). Size and shape of the wing petals are variable and do not appear to have diagnostic value at the generic level, but have some value in identifying species and subspecies.

The wing claw is usually shorter than the wing blade, and may be very long in *R. lancea* (Figure 4.12, 9) or very short, as in *R. acuminata* (Figure 4.12, 19b) and *R. diffusa* (Figure 4.12, 21a–c). The claw may be rather narrow and thinly textured (in most taxa

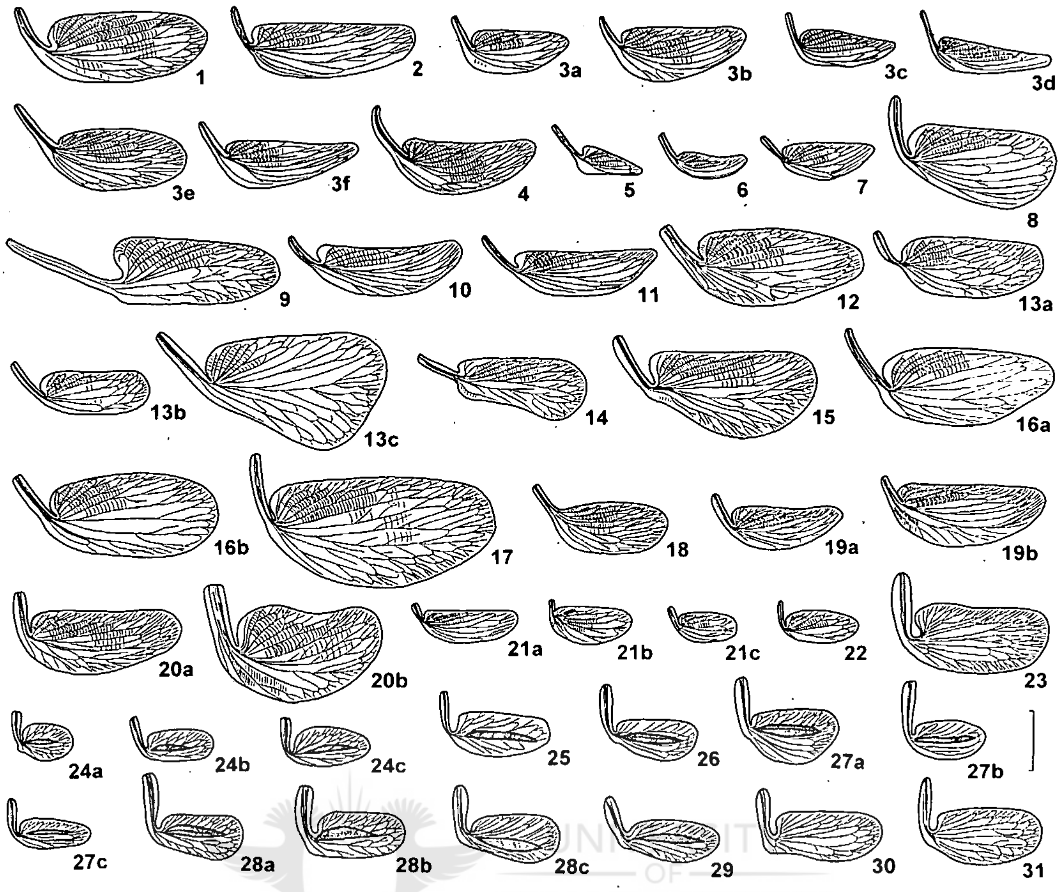


Figure 4.12 Variation in wing petals in *Rafnia*, showing differences in size and shape. 1–20 = section *Rafnia*; 21–31 = section *Colobotropis*: **1,** *R. racemosa* subsp. *racemosa* (*Campbell et al. 155*); **2,** *R. racemosa* subsp. *pumila* (*Esterhuysen 33444*); **3,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Esterhuysen 22143*); **b,** Form 1 (*Van Wyk 3679*); **c,** Form 1 (*Snijman 44*); **d,** Form 6 (*Campbell & Van Wyk 132*); **e,** Form 8 (*Purcell 334*); **f,** Form 9 (*Schutte & Vlok 762*); **4,** *R. angulata* subsp. *thunbergii* (*Walters 147*)—up to 12 rows of sculpturing extending to upper central part; **5,** *R. angulata* subsp. *humilis* (*Guthrie 188*); **6,** *R. angulata* subsp. *ericifolia* (*Esterhuysen 28056*); **7,** *R. angulata* subsp. *montana* (*Andreae 1245*); **8,** *R. crispa* (*Stirton 8439*); **9,** *R. lancea* (*Johnson 481*)—claw long; **10,** *R. rostrata* subsp. *rostrata* (*Campbell & Van Wyk 145*); **11,** *R. rostrata* subsp. *pauciflora* (*Esterhuysen 28833*); **12,** *R. vlokii* (*Vlok 534*); **13,** *R. alata*: **a,** Form 1 (*Campbell et al. 154*); **b,** Form 2 (*Vlok 736*); **c,** Form 3 (*Burgers 1404*); **14,** *R. crassifolia* (*Vlok & Schutte 258*)—distal part expanded and rounded; **15,** *R. elliptica* (*Campbell & Van Wyk 158*); **16,** *R. triflora*: **a,** Form 1 (*Purcell 259*); **b,** Form 2 (*Burgers 1342*); **17,** *R. ovata* (*Campbell & Van Wyk 128*); **18,** *R. inaequalis* (*Campbell & Van Wyk 119*); **19,** *R. acuminata*: **a,** Form 1 (*Campbell & De Castro 97*); **b,** Form 2 (*Maguire 1154*); **20,** *R. amplexicaulis*: **a,** (*Walters 1869*); **b,** (*Campbell & Van Wyk 120*); **21,** *R. diffusa*: **a,** Form 1 (*Compton 20815*); **b,** Form 1 (*Van Wyk 2881*); **c,** Form 5 (*Maguire 1151*); **22,** *R. spicata* (*Campbell & Van Wyk 127*); **23,** *R. schlechteriana* (*Campbell & Van Wyk 117*)—oblong wing; **24,** *R. capensis* subsp. *capensis*: **a,** Form 1a (*Lewis 5413*)—very small, rounded; all following wings have distinct central folds: **b,** Form 3 (*Wurts 547*); **c,** Form 6 (*Lewis 5707*); **25,** *R. capensis* subsp. *carinata* (*Taylor 11917*); **26,** *R. capensis* subsp. *calycina* (*Maguire 1178*); **27,** *R. capensis* subsp. *dichotoma*: **a,** Form 1 (*Esterhuysen 17867*); **b,** Form 2 (*Walters 2359*); **c,** Form 5 (*Esterhuysen 15960*); **28,** *R. capensis* subsp. *ovata*: **a,** Form 2 (*Bond 623*); **b,** Form 3a (*Forsyth 377*); **c,** Form 4 (*Burman 1016*); **29,** *R. capensis* subsp. *elsieae* (*Esterhuysen 8308*); **30,** *R. capensis* subsp. *pedicellata* (*Walters 1135*); **31,** *R. globosa* (*Pillans 9081*). Scale = 5 mm.

with rostrate keels) or broad and thickly textured, as in many taxa with truncate keels, e.g. *R. schlechteriana* (Figure 4.12, 23) and *R. capensis* subsp. *ovata* (Figure 4.12, 28a–c).

The wings in *Rafnia* are totally glabrous, as are those in many species of *Aspalathus* (Dahlgren, 1963a), but the upper and/or lower basal margins may be minutely ciliated in a number of taxa, especially *R. lancea*, *R. alata*, *R. elliptica*, *R. triflora*, *R. inaequalis*, *R. acuminata* and *R. amplexicaulis.*

The presence of wing sculpturing, which serves as a foothold for insect pollinators, is a prominent feature of the Papilionoideae (Stirton, 1981). Lunate sculpturing is most common in the Crotalarieae, and occurs in *Rafnia* but may also be absent.

Wing petal sculpturing is useful at the sectional, species and subspecies levels in *Rafnia*. Wing sculpturing is invariably present in all taxa of section *Rafnia* (Figure 4.12, 1–20) and also in *R. diffusa* (Figure 4.12, 21a–c). It may be present or absent in *R. spicata* and is invariably absent in the remaining taxa of section *Colobotropis.* This character was polarized for inclusion in the cladistic analysis (see Table 7.1). According to Stirton (1981), there is a general trend towards a reduction in sculpturing as flowers become more specialized, and this may also apply to *Rafnia*, since the specialized flowers with truncate keels completely lack petal sculpturing.

The rows of petal sculpturing in *Rafnia* are usually situated on the upper basal and sometimes upper central parts of the wings [terminology according to Stirton (1981)], and this is generally also the case in *Aspalathus* (Dahlgren, 1963a; Stirton, 1981). The number of rows of petal sculpturing (in taxa where it is present) ranges from two in *R.*

spicata to 12 in *R. angulata* subsp. *thunbergii* (Figure 4.12, 4). However, five to seven rows are most common in the genus. This character was useful in the phenetic analysis (see Table 6.1).

In species lacking sculpturing, the whole petal, rather than the epidermis only, has become convoluted or pocketed. These pockets serve as thrusting pads for use by pollinating insects (Stirton, 1981). In *Rafnia*, the wings of taxa of section *Rafnia* are usually broadly pocketed to fit the keel, which is also broadly pocketed. The wings of taxa of section *Colobotropis* have a more pronounced central fold which usually extends from the basal to the distal part of the wing blade (Figure 4.12, 24–31). These folds in the wing blade often have the effect of keeping the wings and keel more firmly together (Dahlgren, 1963a).

In *Rafnia*, the wings are usually slightly longer than the keel, but may also be shorter than or about as long as the keel. This character is not particularly taxonomically useful in *Rafnia*, compared with related genera such as *Lebeckia* and *Wiborgia*, in which the wings are usually markedly shorter than the keel, while in *Polhillia* Stirton of the Genisteae *sensu stricto* (Van Wyk, 1991a) for instance, the wings are longer than or at least as long as the keel (Van Wyk & Schutte, 1989).

4.2.5 Keel petals

Keel shape is taxonomically important in *Rafnia* and provided some useful characters for the phenetic and cladistic analyses (see Tables 6.1 & 7.1). These characters will be discussed below.

In *Rafnia*, keel morphology is rather variable and the variation is shown in Figure 4.13.

There are two basic keel shapes, namely rostrate or beaked (Figure 4.13, 1–20) and truncate (including obtuse and emarginate shapes) (Figure 4.13, 21–31). These shapes form the basis of the division of *Rafnia* into two sections, since the two monophyletic groups on the cladogram (see Figure 7.1) are distinguished by keel shape. Section *Rafnia* contains taxa with rostrate keels and section *Colobotropis* has taxa with obtuse or truncate to emarginate keels.

In *Rafnia*, rostrate keels are generally lunate, and the beaked apex is often upcurved to varying degrees. The apex may be long, strongly beaked and upcurved, e.g. *R. crispa* (Figure 4.13, 8) and *R. amplexicaulis* (Figure 4.13, 20a & b), or shortly beaked and not upcurved, e.g. *R. angulata* subsp. *angulata* (Figure 4.13, 3a) and *R. inaequalis* (Figure 4.13, 18).

It seems that *R. diffusa* (Figure 4.13, 21a–d) and *R. spicata* (Figure 4.13, 22a–d) have keel shapes that are transitional between the rostrate and truncate types. The keel shape is very variable in these species and may be obtuse, as in *R. diffusa* (Figure 4.13, 21a) and *R. spicata* (Figure 4.13, 22c).

The keel is slightly lobed below the apex in *R. capensis* subsp. *carinata* (Figure 4.13, 25) and *R. globosa* (Figure 4.13, 31) and is thus neither truly rostrate nor truncate. Truncate keels are oblong and usually have a large lobe below the apex, and the size of the lobe (whether large or small) was a useful character in the cladistic and phenetic analyses.

The keel may be emarginate, as in *R. capensis* subsp. *elsieae* (Figure 4.13, 29), in which there is an indentation between the apex and the lobe below. A rather unusual keel shape is that of the Malmesbury form of *R. diffusa* (Figure 4.13, 21d), in which the

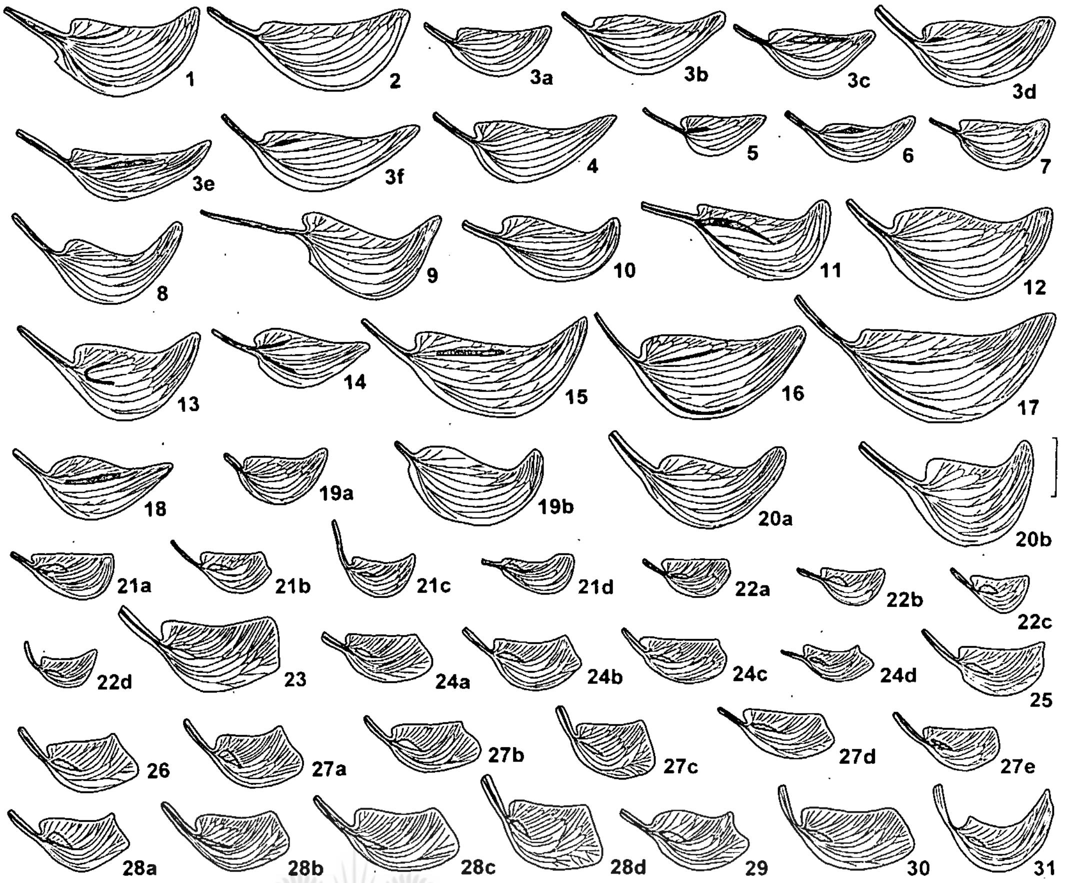


Figure 4.13 Variation in keel petals in *Rafnia*, showing differences in size and shape. 1–20 = section *Rafnia* (larger, rostrate keels with broad, lateral pockets); 21–31 = section *Colobotropis* (smaller, truncate keels with callous, lateral pockets): **1,** *R. racemosa* subsp. *racemosa* (*Campbell et al. 155*); **2,** *R. racemosa* subsp. *pumila* (*Esterhuysen 33444*); **3,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Esterhuysen 22143*); **b,** Form 1 (*Van Wyk 3679*); **c,** Form 1 (*Compton 10078*); **d,** Form 5 (*Rycroft 1810*); **e,** Form 8 (*Purcell 334*); **f,** Form 9 (*Schutte & Vlok 762*); **4,** *R. angulata* subsp. *thunbergii* (*Campbell et al. 130*); **5,** *R. angulata* subsp. *humilis* (*Salter 2875*); **6,** *R. angulata* subsp. *ericifolia* (*Barker 8862*); **7,** *R. angulata* subsp. *montana* (*Andreae 1245*); **8,** *R. crispa* (*Stirton 8439*)—strongly beaked, upcurved; **9,** *R. lancea* (*Johnson 481*)—long claw; **10,** *R. rostrata* subsp. *rostrata* (*Esterhuysen 3727*); **11,** *R. rostrata* subsp. *pauciflora* (*Thompson 2211*); **12,** *R. vlokii* (*Vlok 534*); **13,** *R. alata* Form 2 (*Burgers 1404*); **14,** *R. crassifolia* (*Vlok & Schutte 258*); **15,** *R. elliptica* (*Campbell & Van Wyk 157*); **16,** *R. triflora* Form 1 (*Campbell & Van Wyk 118*); **17,** *R. ovata* (*Campbell & Van Wyk 128*)—shortly rostrate, not upcurved; **18,** *R. inaequalis* (*Campbell & Van Wyk 119*); **19,** *R. acuminata*: **a,** Form 1 (*Bayer 3360*); **b,** Form 2 (*Maguire 1154*)—short claw; **20,** *R. amplexicaulis*: **a,** (*Salter 2760*); **b,** (*Campbell & Van Wyk 120*); **21,** *R. diffusa*: **a,** Form 1 (*Compton 20815*); **b,** Form 2 (*Grobbelaar 1128*); **c,** Form 3 (*Stokoe s.n. sub SAM 55790*); **d,** Form 6 (*Stirton & Zantovska 11412*); **22,** *R. spicata*: **a,** (*Campbell & Van Wyk 142*); **b,** (*Campbell & Van Wyk 127*); **c,** (*Campbell & Van Wyk 141*); **d,** (*Van Wyk 2308*); **23,** *R. schlechteriana* (*Goldblatt s.n. sub NBG 97432*); **24,** *R. capensis* subsp. *capensis*: **a,** Form 1b (*Matthews 1110*); **b,** Form 3 (*Stokoe s.n. sub SAM 61412*); **c,** Form 5 (*Campbell et al. 131*); **d,** Form 5 (*Campbell & Van Wyk 104*); **25,** *R. capensis* subsp. *carinata* (*C.M. van Wyk 2549*)—slight lobe below apex; **26,** *R. capensis* subsp. *calycina* (*Campbell & Van Wyk 121*); **27,** *R. capensis* subsp. *dichotoma*: **a,** Form 1 (*Esterhuysen 17867*); **b,** Form 2 (*Van Wyk 2999*); **c,** Form 2 (*Compton 12969*); **d,** Form 3 (*Lewis 5699*); **e,** Form 5 (*Esterhuysen 15960*); **28,** *R. capensis* subsp. *ovata*: **a,** Form 2 (*Campbell & Van Wyk 37*); **b,** Form 3a (*Forsyth 377*); **c,** Form 3b (*Haynes 686*); **d,** Form 4 (*Campbell & Van Wyk 147*); **29,** *R. capensis* subsp. *elsieae* (*Esterhuysen 14858*)—apex emarginate; **30,** *R. capensis* subsp. *pedicellata* (*Walters 1935*); **31,** *R. globosa* (*Salter 7565*). Scale = 5 mm.

keel is upcurved with a slightly extended, square-shaped apex. This keel shape is found in some species of *Aspalathus* (Dahlgren, 1963a).

Polhill (1976, 1981a) described keel shape in the Crotalarieae as obtuse, pointed or beaked, with no reference to the truncate or emarginate keel found in *Rafnia*. The latter type appears to be unique to *Rafnia* and is not found to the same extent in related genera. In *Aspalathus patens* Garab. ex Dahlg., there is an extra lobe below the convex upper-apical margin, but Dahlgren (1963a) considered this a sporadic peculiarity developed at a relatively late stage.

The upper margin usually has a lobe or auricle at the upper basal part where it joins the claw, and the lower basal part gradually merges with the claw or there may be a slight lobe or protrusion, e.g. *R. racemosa* subsp. *racemosa* (Figure 4.13, 1) and *R. crassifolia* (Figure 4.13, 14).

Certain quantitative characters not used in the cladistic analysis provided additional support for the arrangement of taxa on the cladogram, since phenetic trends compared favourably with phylogenetic trends. For example, keel length showed discontinuities according to groupings within the cladogram (see Figure 7.1), suggesting convergence within those groups (Figure 4.14). Rostrate keels (section *Rafnia*) are generally large (Figure 4.14, 1–24) and truncate keels (section *Colobotropis*), smaller (Figure 4.14, 25–36). Keel size in *Rafnia* varies from 5 mm long and 3 mm wide in *R. spicata* (Figure 4.13, 22a–d) to 16 mm long and 8 mm wide in *R. ovata* (Figure 4.13, 17).

The keel in *Rafnia* is clawed and the claw is mostly shorter than the blade. The keel claw is particularly long in relation to the blade in *R. lancea* (Figure 4.13, 9) and the

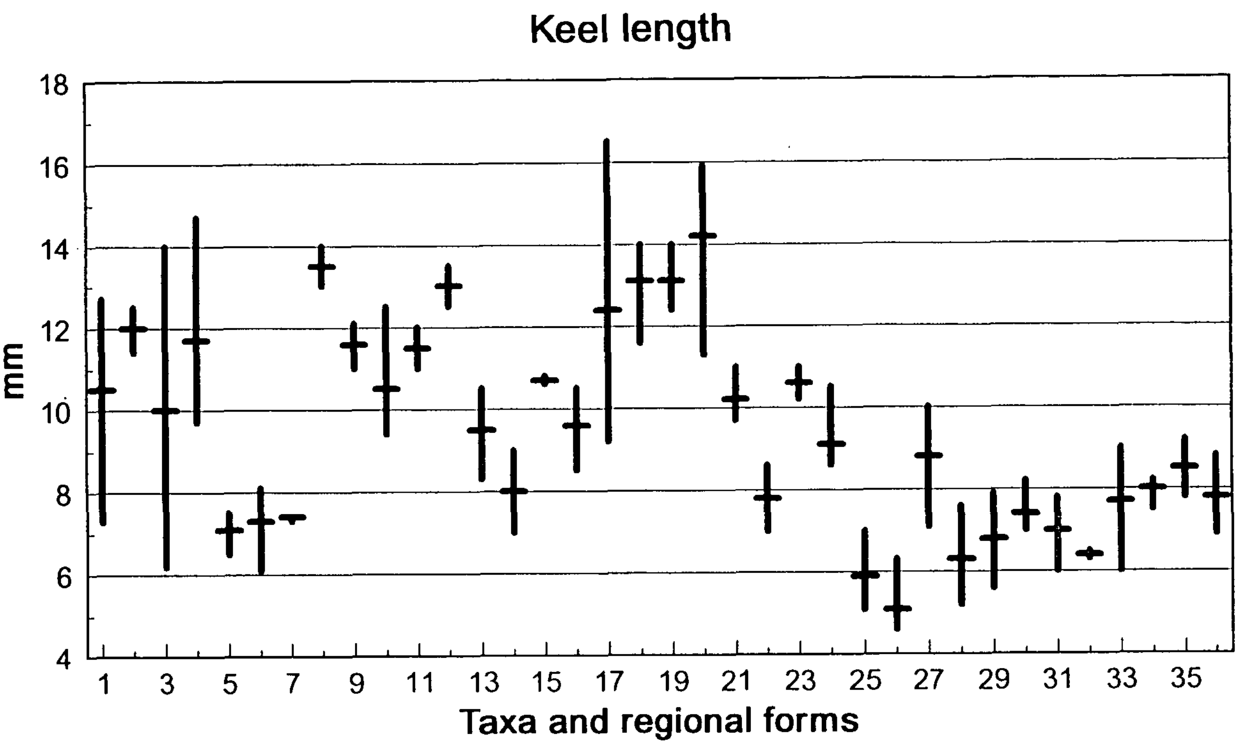


Figure 4.14 Range and mean values for keel length of taxa and regional forms of *Rafnia*. Section *Rafnia* is represented by 1–24 and section *Colobotropis* by 25–36. The discontinuties are not marked between the two sections, but the general phylogenetic trends are apparent, and correspond to the trends on the cladogram (see Figure 7.1). The rostrate keels are generally larger and truncate keels, smaller. The largest keel is that of *R. ovata* (20) and the smallest, that of *R. spicata* (26). (Taxa and regional forms are numbered as in Table 2.2.)

Citrusdal form of *R. diffusa* (Figure 4.13, 21c). The claw may be very short in relation to the blade in *R. acuminata* (Figure 4.13, 19a & b) and often in *R. diffusa* (Figure 4.13, 21a & d) and *R. capensis* subsp. *capensis* (Figure 4.13, 24a & d).

Like the wings, the keel blades are totally glabrous, except for the presence of minute cilia on the upper and/or lower basal margins. All the keels seem to be ciliate to a certain extent, while only some wing petals are ciliate. In *Aspalathus*, the keels are often entirely glabrous, or may be pubescent or papillose (Dahlgren, 1963a).

All the taxa of section *Colobotropis* (Figure 4.13, 21–31) have a distinct, callous auriculate pocket on the central basal part of the keel. This was a useful character in both phenetic and cladistic analyses. There is no such pocket on the rostrate keels, but most of the surface of the blade forms a large, broad pocket, e.g. *R. racemosa* subsp. *racemosa* (Figure 4.13, 1) and *R. rostrata* subsp. *pauciflora* (Figure 4.13, 11). The prominent basal bulges are also often lacking in *Aspalathus* when the keel is rostrate (Dahlgren, 1963a).

In *Rafnia*, keel shape is useful at the sectional and species levels, but is generally too variable to be of practical use at the subspecies level. The presence or absence of a lobe below the apex has certain value in distinguishing taxa within section *Colobotropis* and the presence of a distinct callous pocket on the keel is useful at sectional level.

4.2.6 Stamens

The staminal arrangement was one of the criteria used by Polhill (1976) to divide the Genisteae *sensu lato* into four tribes. The Crotalarieae is characterized by filaments united into a staminal sheath which is open on the upper side, unlike the closed tube of the Genisteae *sensu stricto* (Dahlgren, 1963a; Polhill, 1976, 1981a; Van Wyk, 1991a). The free parts of the filaments are usually relatively short, and the vexillary filament rarely consistently free (Polhill, 1976), but the separation or not of the vexillary filament is not particularly important in this group.

In the Crotalarieae, the anthers are generally dimorphic, with four to five longer, basifixed anthers alternating with five to six shorter or less often subequal, dorsifixed ones, with the carinal anther often intermediate (Polhill, 1976, 1981a). These features are considered plesiomorphic in the Crotalarieae (Van Wyk & Schutte, 1995). The differentiation of large and small anthers is most marked in the species with strongly beaked keels, but is overall too gradual to be of much systematic value (Polhill, 1976).

Although the staminal fusion and shape and attachment of the anthers are taxonomically useful at different levels (Polhill, 1976; Van Wyk & Schutte, 1995) and generally rather well correlated with other features (Polhill, 1976), they are perhaps more variable than previously recognized (Van Wyk & Schutte, 1995).

Ten staminal characters were included in the phenetic analysis (see Table 6.1). These characters did not show marked discontinuities, so they could not be polarized for use in the cladistic analysis. The length of the basifixed anthers, however, showed discontinuities similar to those in keel length (see Chapter 4.2.5) and reflected the phylogenetic trends in the genus.

Staminal structure in *Rafnia* (Figure 4.15) is similar to that in the Crotalarieae. The 10 stamens are fused into a sheath (usually for about two thirds of the length of the filaments) which is open on the upper side. The staminal sheath is more or less oblong or rectangular in shape, but in *R. crassifolia* (Figure 4.15, 7) and *R. inaequalis* (Figure 4.15, 11), the sheath is elliptic. The sheath may be straight and relatively thinly textured, or widened towards the base and thicker-textured. The latter occurs in most taxa of section *Colobotropis* (Figure 4.15, 16–22), excluding *R. diffusa* (Figure 4.15, 14a & b) and *R. spciata* (Figure 4.15, 15). *R. capensis* subsp. *capensis* (Figure 4.15, 17a & b) may have straight or widened sheaths. This character was useful in the phenetic and cladistic analyses and is a useful synapomorphy for *R. schlechteriana*, *R. capensis* and *R. globosa*.

Priestleya DC. and *Liparia* L. of the Podalyrieae often have the free parts of the filaments as long as or even longer than the joined part (Polhill, 1976). Similarly, in *Rafnia* the free

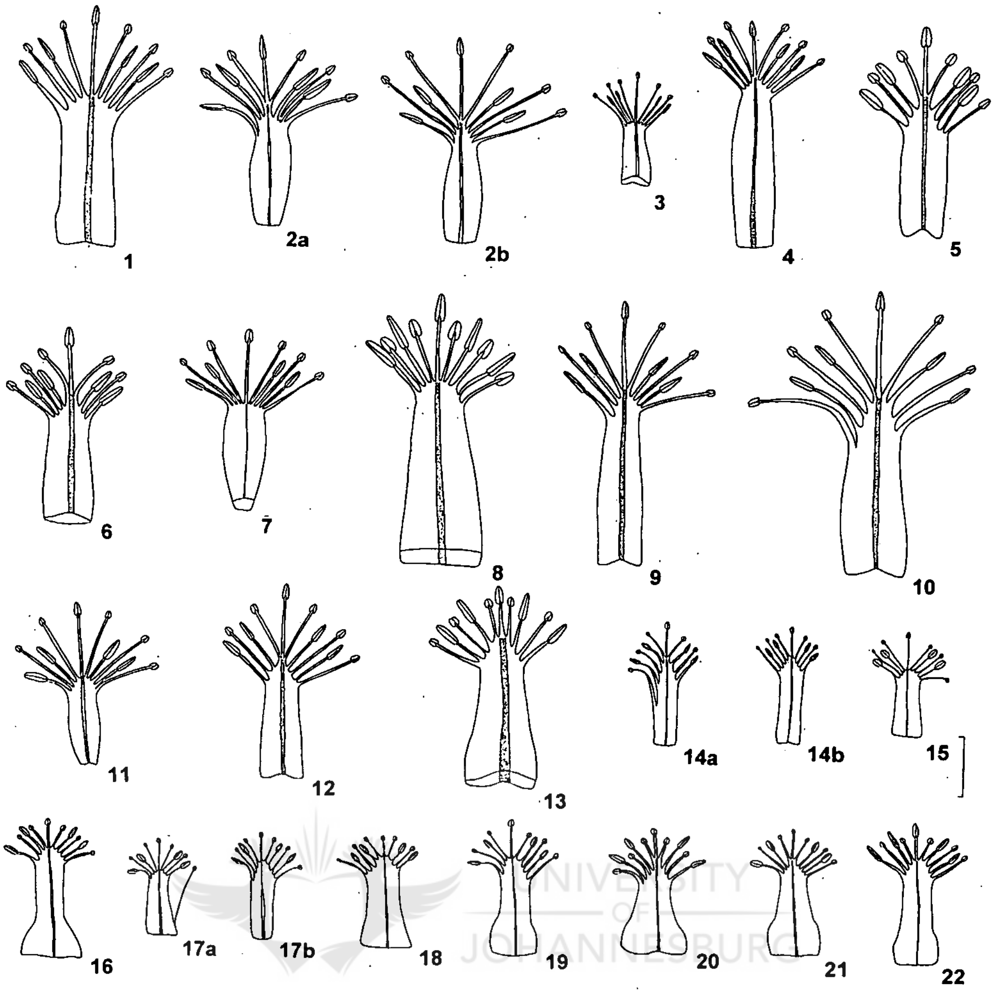


Figure 4.15 Variation in stamens in *Rafnia*, showing differences between shapes of the staminal sheath, lengths of free parts of the filaments and differences in anther dimorphism. 1–13 = section *Rafnia* (staminal sheaths mostly straight); 14–22 = section *Colobotropis* (staminal sheaths mostly widened towards the base; free parts of filaments short). Four large, basifixed anthers alternate with five smaller, dorsifixed ones and the carinal anther is intermediate in size and shape: **1,** *R. racemosa* subsp. *racemosa* (*Wurts 1641*); **2,** *R. angulata* subsp. *angulata*: **a,** Form 5 (*Rycroft 1810*); **b,** Form 9 (*Schutte & Vlok 762*)—free parts of filaments very long; **3,** *R. angulata* subsp. *humilis* (*Young s.n. sub TM 27329*); **4,** *R. lancea* (*Esterhuysen 11936*); **5,** *R. rostrata* subsp. *rostrata* (*Campbell & Van Wyk 145*); **6,** *R. alata* Form 1 (*Campbell et al. 154*); **7,** *R. crassifolia* (*Campbell & Van Wyk 150*); **8,** *R. elliptica* (*Campbell & Van Wyk 157*); **9,** *R. triflora* Form 1 (*Purcell 259*); **10,** *R. ovata* (*Barker 9568*); **11,** *R. inaequalis* (*Campbell & Van Wyk 119*); **12,** *R. acuminata* Form 2 (*Maguire 1154*); **13,** *R. amplexicaulis* (*Van Wyk s.n.*)—free parts of filaments short; **14,** *R. diffusa*: **a,** Form 1 (*Compton 20815*)—stamens diadelphous; **b,** Form 4 (*Taylor 11098*); **15,** *R. spicata* (*Taylor 11627*); **16,** *R. schlechteriana* (*Esterhuysen 13421*); **17,** *R. capensis* subsp. *capensis*: **a,** Form 5 (*Campbell & Van Wyk 104*)—stamens diadelphous; **b,** Form 6 (*Schutte & Vlok 563*); **18,** *R. capensis* subsp. *carinata* (*Kruger KR956*); **19,** *R. capensis* subsp. *calycina* (*Esterhuysen 35798*); **20,** *R. capensis* subsp. *ovata* Form 3a (*Forsyth 377*); **21,** *R. capensis* subsp. *pedicellata* (*Compton 20442*); **22,** *R. globosa* (*Campbell & Van Wyk 125*). Scale = 5 mm.

parts of the filaments may be rather long (usually more than half as long as the fused part of the staminal sheath), e.g. *R. angulata* subsp. *angulata* (Figure 4.15, 2a & b), *R. ovata* (Figure 4.15, 10), *R. inaequalis* (Figure 4.15, 11), and *R. acuminata* (Figure 4.15, 12). The longer free parts of the filaments are usually correlated with a strongly beaked keel and a greater degree of anther dimorphism.

The free parts of the filaments may be rather short (less than half as long as the fused part of the staminal sheath) in *R. lancea* (Figure 4.15, 4), *R. amplexicaulis* (Figure 4.15, 13) and the taxa of section *Colobotropis* (Figure 4.15, 14–22). Shorter free parts of the filaments are usually correlated with a truncate or emarginate keel and a lesser degree of anther dimorphism. This character was useful in the phenetic and cladistic analyses and supported the grouping of taxa in section *Colobotropis*. Since this character occurs independently in both sections, and is not correlated with the other characters in the same way, it may be considered a convergence in the two sections.

The stamens are almost always monadelphous in *Rafnia*, but may rarely and sporadically be diadelphous. In *R. diffusa* (Figure 4.15, 14a), the vexillary filament, bearing a dorsifixed anther, is inserted about half way into the staminal sheath, and in *R. capensis* subsp. *capensis* (Figure 4.15, 17a), the filament is inserted only at its base. Diadelphy has also been observed in *R. angulata* subsp. *thunbergii* and *R. capensis* subsp. *dichotoma*.

Variation in anther structure is shown in Figure 4.16. The anthers in *Rafnia* are almost always distinctly dimorphic, with four long, oblong to linear basifixed anthers alternating with five (or six) short, ovate dorsifixed ones (Figure 4.15). Anther connectives are usually always clearly visible. The degree of dimorphism is more marked in the anthers of taxa with strongly beaked keels. The basifixed anthers are always at least twice as

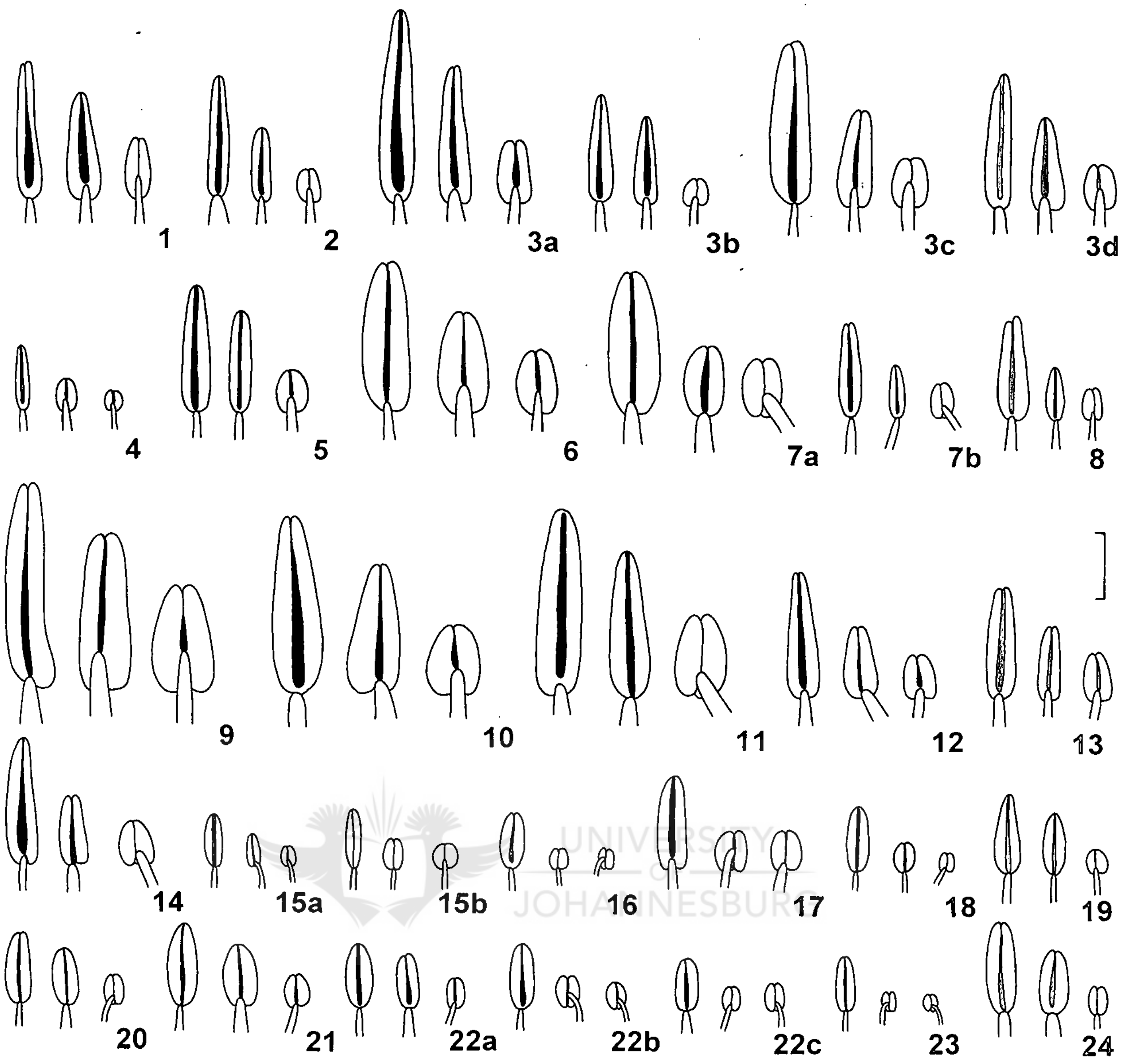


Figure 4.16 Variation in anther structure in *Rafnia*, showing differences in size and degree of dimorphism. 1–14 = section *Rafnia*; 15–24 = section *Colobotropis*. Basifixed anthers are always at least twice as long as dorsifixed anthers: **1,** *R. racemosa* subsp. *racemosa* (*Wurts 1641*)—carinal anther resembles basifixed anthers; **2,** *R. angulata* subsp. *thunbergii* (*Thorne s.n sub NBG 14263*); **3,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Van Wyk 3679*); **b,** Form 1 (*Bean & Viviers 1977*); **c,** Form 6 (*Campbell & Van Wyk 132*); **d,** Form 9 (*Schutte & Vlok 762*); **4,** *R. angulata* subsp. *humilis* (*Young s.n. sub TM 27329*); **5,** *R. lancea* (*Esterhuysen 11936*); **6,** *R. rostrata* subsp. *rostrata* (*Campbell & Van Wyk 145*); **7,** *R. alata*: **a,** Form 1 (*Campbell et al. 154*); **b,** Form 3 (*Vlok 736*); **8,** *R. crassifolia* (*Walters 595*)—basifixed anthers five times as long as dorsifixed anthers; **9,** *R. elliptica* (*Campbell & Van Wyk 157*); **10,** *R. triflora* (*Campbell & Van Wyk 118*); **11,** *R. ovata* (*Campbell & Van Wyk 128*); **12,** *R. inaequalis* (*Campbell & Van Wyk 119*); **13,** *R. acuminata* Form 2 (*Maguire 1154*); **14,** *R. amplexicaulis* (*Walters 1869*); **15,** *R. diffusa*: **a,** Form 1 (*Compton 20815*); **b,** Form 2 (*Grobbelaar 1128*); **16,** *R. spicata* (*Taylor 11627*); **17,** *R. schlechteriana* (*Campbell & Van Wyk 117*)—carinal anther identical to dorsifixed anthers; **18,** *R. capensis* subsp. *capensis* (*Campbell et al. 131*)—carinal anther resembles dorsifixed anthers; **19,** *R. capensis* subsp. *carinata* (*Compton 24283*); **20,** *R. capensis* subsp. *calycina* (*Campbell & Van Wyk 121*); **21,** *R. capensis* subsp. *dichotoma* Form 2 (*Campbell 98*); **22,** *R. capensis* subsp. *ovata*: **a,** Form 1 (*Barker 9201*); **b,** Form 2 (*C.M. van Wyk 2554*); **c,** Form 2 (*Esterhuysen 6155*); **23,** *R. capensis* subsp. *pedicellata* (*Compton 20442*)—carinal anther identical to dorsifixed anthers; **24,** *R. globosa* (*Campbell & Van Wyk 125*). Scale = 1 mm.

long as the dorsifixed ones, and in *R. crassifolia*, they may be up to five times as long as the dorsifixed ones.

The carinal anther is usually intermediate in size and shape, and may closely resemble the larger anthers, e.g. *R. angulata* subsp. *angulata* (Figure 4.16, 3a) and *R. lancea* (Figure 4.16, 5), or the smaller anther, e.g. *R. alata* (Figure 4.16, 7a) and *R. capensis* subsp. *capensis* (Figure 4.16, 18), or it may be intermediate between the two. The carinal anther may be identical to the smaller anther in some taxa of section *Colobotropis*, e.g. *R. spicata* (Figure 4.16, 16), *R. schlechteriana* (Figure 4.16, 17) and *R. capensis* subsp. *pedicellata* (Figure 4.16, 23).

Stamen and anther characters have some value at the sectional and species levels in *Rafnia*. The shape of the staminal sheath, length of the free parrts of the filaments, degree of anther dimorphism and intermediacy of the carinal anther are useful at sectional level.

4.2.7 Pollen

According to Guinet (1981), the most common type of pollen in the Papilionoideae is the tricolporate tectate-reticulate single grain. There is a 'complete' exine with a well-developed tectum, a columellar layer and a nexine which is about as thick as the underlying endexine. The aperture has a small circular or lalongate thinning of the endexine (Ferguson & Skvarla, 1981).

Pollen grains of the Papilionoideae are rather uniform in size, with the average about 50 µm (Ferguson & Skvarla, 1981). The shape varies from prolate or spheroidal to oblate and triangular to flattened in some specialized pollen types.

Pollen morphology is mostly uniform in the Crotalarieae, and variation is mainly in the structure of the apertures (Ferguson & Skvarla, 1981). The pollen of the Crotalarieae is generally tricolporate, or sometimes appearing tricolpate, with variation from a lalongate endoaperture to a well-developed colpus membrane (Polhill, 1981a).

Pollen is similarly uniform in *Rafnia*, with only slight differences in size and surface reticulation. The pollen is tricolporate (Figure 4.17a & b) and the colpi are rather narrow and immersed, extending to the poles, and the colpus membrane is psilate. The pollen grains are spheroidal to prolate-spheroidal, with a reticulate to almost microreticulate surface sculpture (Figure 4.17c). The grains are small, isopolar and radially symmetrical

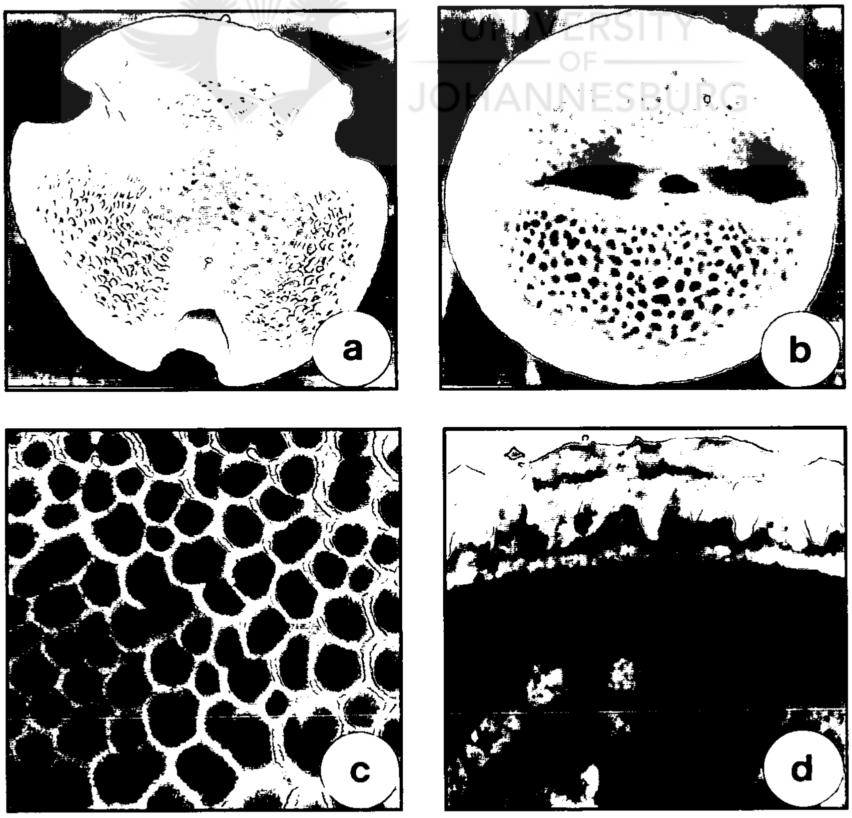


Figure 4.17 SEM (a–c) and TEM (d) photographs showing typical pollen of *Rafnia*: **a**, *R. schlechteriana* (*Van Wyk 3228*)—polar view, with tricolporate apertures; **b–d**, *R. amplexicaulis* (*Van Wyk* 2440)—**b**, equatorial view with colporus visible; **c**, reticulate surface sculpture; **d**, section of a pollen grain wall.

and the tectal surface surrounding the apertures is more or less psilate.

The wall of the pollen grain shows a well-developed tectum (Figure 4.17d), with a columellar layer and the nexine thicker than the underlying endexine. The pollen showed no significant discontinuities useful for distinguishing among the taxa.

4.2.8 Pistil

There is a lack of distinct discontinuities in pistil characters in the Crotalarieae and related tribes (Polhill, 1976; Van Wyk & Schutte, 1995). Significant divergence occurs only in the most specialized and reduced flowers (Polhill, 1976). The ovary may be sessile to long-stipitate, with two to many ovules. The stipitate gynoecium base is a useful generic apomorphy in the Crotalarieae (Van Wyk & Schutte, 1995). The usually upcurved style which is also tapering (Polhill, 1976), is considered plesiomorphic in the Crotalarieae at generic level (Van Wyk & Schutte, 1995). In the apomorphic condition, the style is straight or downcurved. The style is glabrous or with one to two lines of hairs as in *Crotalaria* (Polhill, 1981a; Van Wyk & Schutte, 1995).

The stigma in the Crotalarieae is terminal (Polhill, 1976) and small, but may sometimes appear to be more capitate than it really is because it is covered with pollen in mature flowers. The surface is papillose to fibrillose, with the peripheral elements tending to be longer. The style-tip is often incurved, with the stigma terminal, but stigma and style characters may be misleading because the style-tip may be incurved to various degrees (Polhill, 1976).

Pistil structure in *Rafnia* (Figure 4.18) is similar to that in *Aspalathus* (Dahlgren, 1963a), but the variation is greater in *Aspalathus*. The pistil in *Rafnia* may be short-stipitate as

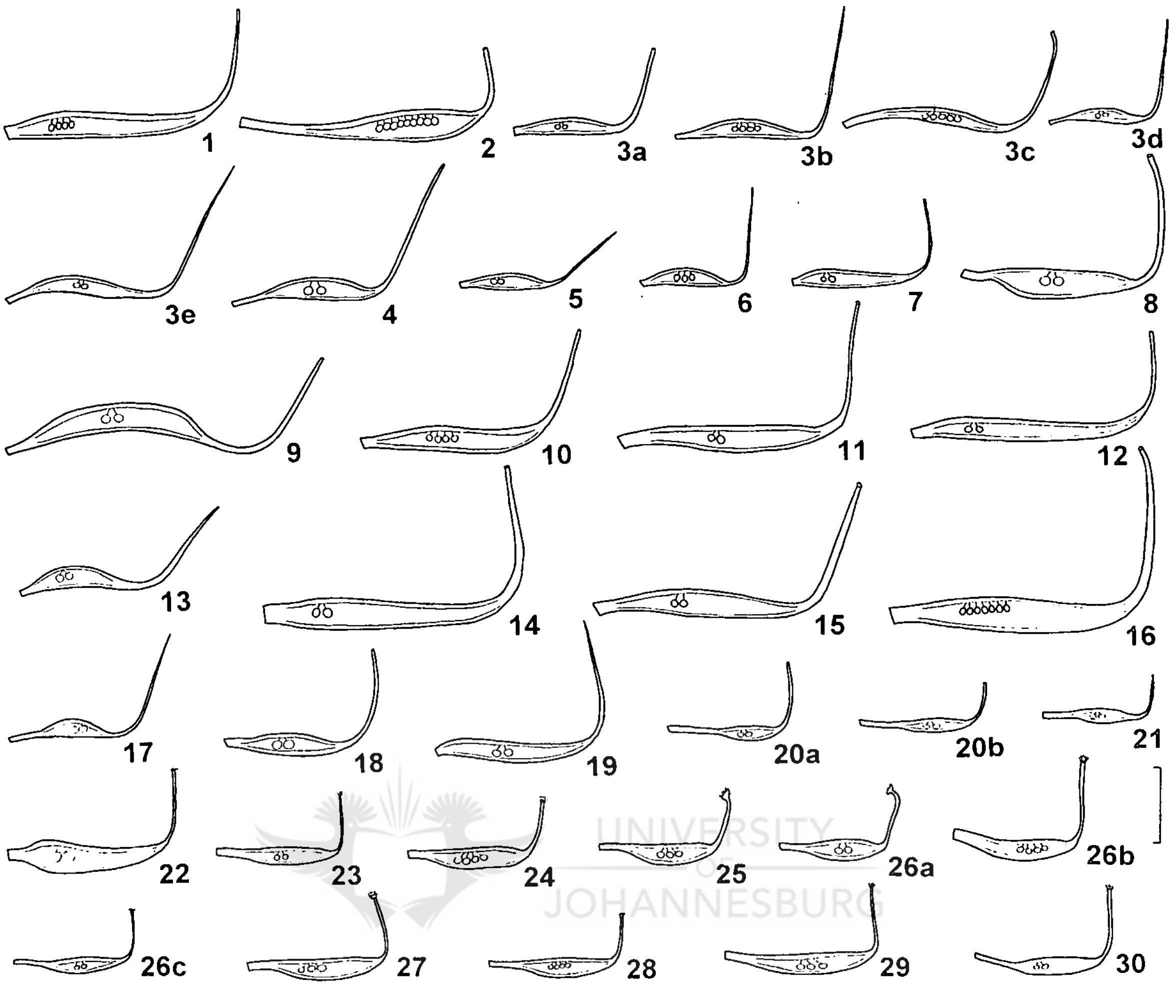


Figure 4.18 Variation in pistils in *Rafnia*, showing variation in size, stipe length, number of ovules, style curvature and stigma structure. 1–19 = section *Rafnia*; 20–30 = section *Colobotropis*. There are usually two to four ovules per ovary in *Rafnia*: **1,** *R. racemosa* subsp. *racemosa* (*Van Wyk 2156*); **2,** *R. racemosa* subsp. *pumila* (*Esterhuysen 33444*)—nine ovules; **3,** *R. angulata* subsp. *angulata*: **a,** Form 1 (*Esterhuysen 22143*); **b,** Form 1 (*Van Wyk 3679*); **c,** Form 1 (*Campbell & Van Wyk146*); **d,** Form 5 (*Van Wyk 2689*); **e,** Form 9 (*Schutte & Vlok 762*); **4,** *R. angulata* subsp. *thunbergii* (*Campbell et al. 130*); **5,** *R. angulata* subsp. *humilis* (*Salter 2875*); **6,** *R. angulata* subsp. *ericifolia* (*Barker 8862*)—style tapering, slender, sharply upcurved; **7,** *R. angulata* subsp. *montana* (*Andreae 1245*); **8,** *R. crispa* (*Stirton 8439*); **9,** *R. lancea* (*Johnson 481*)—style gradually upcurved; **10,** *R. rostrata* subsp. *rostrata* (*Campbell & Van Wyk 145*); **11,** *R. vlokii* (*Vlok 534*); **12,** *R. alata* Form 1 (*Campbell et al. 154*); **13,** *R. crassifolia* (*Vlok & Schutte 258*); **14,** *R. elliptica* (*Campbell & Van Wyk 157*)—stigma small and glabrous; **15,** *R. triflora* Form 1 (*Ellis 45*); **16,** *R. ovata* (*Barker 9568*); **17,** *R. inaequalis* (*Compton 23005*); **18,** *R. acuminata* Form 1 (*Campbell & De Castro 97*); **19,** *R. amplexicaulis* (*Walters 1869*); **20,** *R. diffusa*: **a,** Form 3 (*Stokoe s.n. sub SAM 55790*)—stipe long; **b,** Form 4 (*Goldblatt 3081*); **21,** *R. spicata* (*Campbell & Van Wyk 142*); **22,** *R. schlechteriana* (*Compton 22961*); **23,** *R. capensis* subsp. *capensis* Form 3 (*Taylor 7181*); **24,** *R. capensis* subsp. *carinata* (*Taylor 11917*); **25,** *R. capensis* subsp. *calycina* (*Campbell & Van Wyk 121*)—style shorter than ovary, stigma capitate and fibrillose; **26,** *R. capensis* subsp. *dichotoma*: **a,** Form 1 (*Esterhuysen 17867*)—style shorter than ovary **b,** Form 2 (*Stokoe s.n. sub SAM 7819*); **c,** Form 5 (*Esterhuysen 15960*); **27,** *R. capensis* subsp. *ovata* Form 4 (*Campbell & Van Wyk 147*); **28,** *R. capensis* subsp. *elsieae* (*Esterhuysen 28730*); **29,** *R. capensis* subsp. *pedicellata* (*Walters 1935*); **30,** *R. globosa* (*Campbell & Van Wyk 125*). Scale = 5 mm.

in *R. angulata* subsp. *ericifolia* (Figure 4.18, 6), *R. alata* (Figure 4.18, 12) and *R. ovata* (Figure 4.18, 16), or less often long-stipitate, e.g. *R. angulata* subsp. *thunbergii* (Figure 4.18, 4), *R. inaequalis* (Figure 4.18, 17) and *R. diffusa* (Figure 4.18, 20a). The stipe is always shorter than the ovary.

Ovule number in *Rafnia* is variable. Ovaries may contain many ovules, with up to nine ovules per ovary in *R. racemosa* subsp. *pumila* (Figure 4.18, 2) and up to seven ovules per ovary in *R. ovata* (Figure 4.18, 16). However, most taxa have two to four ovules per ovary, as in *Aspalathus* (Van Wyk & Schutte, 1995).

The glabrous, generally slender, tapering style is upcurved, either sharply, as in *R. angulata* subsp. *ericifolia* (Figure 4.18, 6) or more gently as in *R. lancea* (Figure 4.18, 9). The style tip is sometimes slightly incurved, e.g. *R. capensis* subsp. *calycina* (Figure 4.18, 25) and *R. capensis* subsp. *dichotoma* (Figure 4.18, 26a). The style may be longer than the ovary, especially in the Hermanus form of *R. angulata* subsp. *angulata* (Figure 4.18, 3e), more or less as long as the ovary, e.g. the Cedarberg form (Figure 4.18, 3a), or shorter than the ovary, especially in taxa of section *Colobotropis* (Figure 4.18, 20–30). A long style is generally correlated with strongly rostrate flowers and a short style with truncate keeled flowers or flowers with shortly beaked apices.

Stigma characters were useful in the cladistic analysis (see Table 7.1). The stigma is terminal and may be small (in most taxa) or less often capitate (in taxa of section Colobotropis). The small stigma is usually glabrous, and the capitate stigma, fibrillose, e.g. *R. capensis* subsp. *calycina* (Figure 4.18, 25). The fibrilllose stigma is covered with small papillae, the peripheral elements of which may be developed as hairs (Dahlgren, 1963a). The stigma is fibrillose in all taxa of section *Colobotropis* and therefore a useful synapomorphy for this section.

Since there are few major discontinuities among the pistils of the genus, these characters seem to be of limited taxonomic value at species level, but have some value at sectional level in the relative length of the style to the ovary and size and pubescence of the stigma.

4.3 Pods

Legume pods are very variable (Polhill, 1976; Pate, 1989). Pod characters are not particularly useful at the tribal and generic levels because of the variation and lack of distinct discontinuities, which often lead to artificial segregation of natural groups (Polhill, 1976; Van Wyk & Schutte, 1989, 1995).

Van Wyk & Schutte (1995) included some pod characters in their generic analysis of the Crotalarieae, but infrageneric variation complicated polarity decisions. Useful pod characters included the asymmetrically convex shape of the upper suture and that at least the upper suture is winged (in some species). The shape of the upper suture was one of the two synapomorphies which grouped *Aspalathus* and *Rafnia* as sister genera on the cladogram; the other was the absence of a petiole.

Pod characters such as wing development and number of seeds are useful for distinguishing *Wiborgia* from the similar species of *Lebeckia* (Dahlgren, 1975; Polhill, 1976; Van Wyk & Schutte, 1989, 1995). *Lebeckia* seems to have the most diverse pod morphology (Van Wyk & Schutte, 1989) and *Rafnia* and *Lebeckia* contain most of the diversity of types of the more derived genera (Polhill, 1976). The basic pod shape in *Crotalaria* is stipitate and oblong-clavate like some species of *Rafnia* and *Lebeckia*,

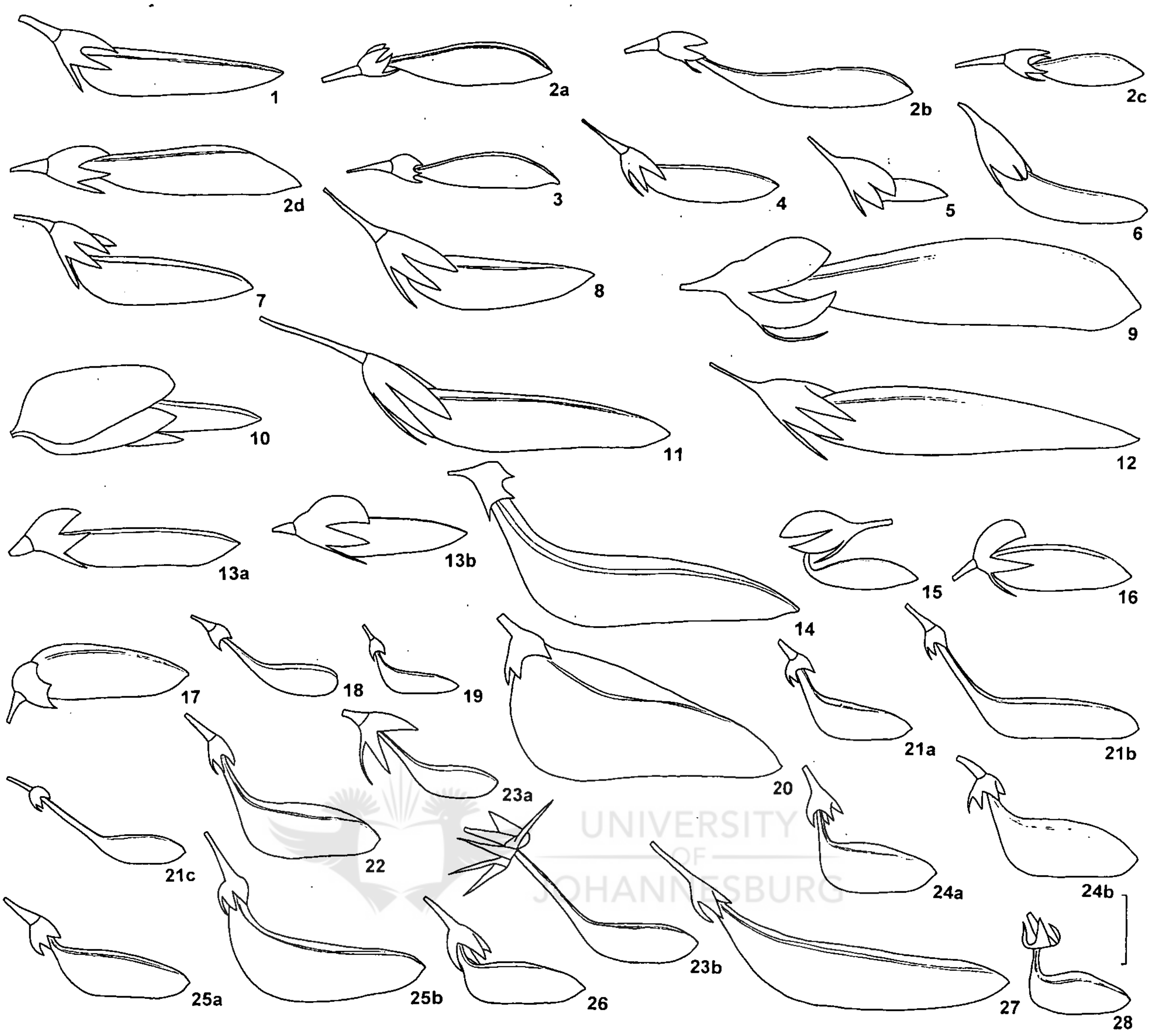


Figure 4.19 Variation in pods of *Rafnia*, showing range in size, shape and stipe length and the winged upper suture. 1–17 = section *Rafnia*; 18–28 = section *Colobotropis* (upper margin asymmetrically convex; pods stipitate): **1**, *R. racemosa* subsp. *racemosa* (*Levyns 2098*)—obliquely lanceolate; **2**, *R. angulata* subsp. *angulata*: **a**, Form 1 (*Esterhuysen 22143*); **b**, Form 1 (*Campbell & Van Wyk 146*); **c**, Form 2 (*Esterhuysen 7134*); **d**, Form 5 (*Campbell & Van Wyk 159*); **3**, *R. angulata* subsp. *thunbergii* (*Campbell et al. 130*); **4**, *R. angulata* subsp. *ericifolia* (*Barker 8862*); **5**, *R. angulata* subsp. *montana* (*Van Wyk & Schutte 3323*); **6**, *R. lancea* (*Acocks 24519*); **7**, *R. rostrata* subsp. *rostrata* (*Campbell & Van Wyk 145*); **8**, *R. rostrata* subsp. *pauciflora* (*Esterhuysen 28833*); **9**, *R. vlokii* (*Van Wyk 3172*); **10**, *R. alata* Form 2 (*Vlok 1713*); **11**, *R. crassifolia* (*Leighton 868*); **12**, *R. elliptica* (*Campbell & Van Wyk 157*); **13**, *R. triflora*: **a**, Form 1 (*Henderson 1403*); **b**, Form 2 (*Willemse 19*); **4**, *R. ovata* (*Campbell & Van Wyk 122*); **15**, *R. inaequalis* (*Campbell & Van Wyk 119*)—pod stipitate; **16**, *R. acuminata* Form 2 (*Esterhuysen 17909*); **17**, *R. amplexicaulis* (*Isaac s.n. sub BOL 32555*); **18**, *R. diffusa* Form 3 (*Campbell & Van Wyk 140*); **19**, *R. spicata* (*Campbell & Van Wyk 141*); **20**, *R. schlechteriana* (*Esterhuysen 17875*); **21**, *R. capensis* subsp. *capensis*: **a**, Form 1b (*Oliver & Fellingham 9142*); **b**, Form 4 (*Campbell & Van Wyk 151*); **c**, Form 5 (*Walters 1337*); **22**, *R. capensis* subsp. *carinata* (*Van Wyk 2304*); **23**, *R. capensis* subsp. *calycina*: **a**, (*Campbell & Van Wyk 121*); **b**, (*Maguire 1178*)—long-stipitate; **24**, *R. capensis* subsp. *dichotoma*: **a**, Form 1 (*Taylor 11483*); **b**, Form 4 (*Van Wyk 2798*); **25**, *R. capensis* subsp. *ovata*: **a**, Form 3a (*Van der Merwe 838*); **b**, Form 4 (*De Vos 460*); **26**, *R. capensis* subsp. *elsieae* (*Esterhuysen 28730*); **27**, *R. capensis* subsp. *pedicellata* (*Walters 287*); **28**, *R. globosa* (*Levyns 2197*). Scale = 10 mm.

from which cylindrical, ellipsoid, ovoid and nearly globular forms are derived (Polhill, 1976). In the Crotalarieae, the pods are flat or inflated, sometimes impressed between the seeds, one to many seeded and dehiscent or indehiscent (Polhill, 1976, 1981a).

The pods of *Rafnia* (Figure 4.19) may be sessile or stipitate. Sessile pods occur in e.g. *R. racemosa* subsp. *racemosa* (Figure 4.19, 1), *R. lancea* (Figure 4.19, 6) and *R. crassifolia* (Figure 4.19, 11).Stipitate pods occur in *R. inaequalis* (Figure 4.19, 15), and taxa of section *Colobotropis* (Figure 4.19, 18–28), with the exception of *R. schlechteriana*, which is sessile (Figure 4.19, 20). Stipitate pods are usually smaller than sessile pods. The stipe may be long or short and is usually shorter than the pod, as in *R. globosa* (Figure 4.19, 28), or more or less as long as the pod, e.g. *R. capensis* subsp. *capensis* (Figure 4.19, 21c) and *R. capensis* subsp. *calycina* (Figure 4.19, 23b). The stipe of the latter subspecies is the longest in the genus and some forms of *R. capensis* subsp. *ovata* have the shortest stipes. The broad-leaf Malmesbury form of *R. angulata* subsp. *angulata* is rarely stipitate (Figure 4.19, 2b), but this stipe is non-homologous with the stipe found elsewhere in the genus. The presence of a stipe is a useful synapomorphy for section *Colobotropis*, with the exception of *R. schlechteriana* in which it is a reversal (see Figure 7.1). This character is apparently convergent in *R. inaequalis*.

The pods of *Rafnia* are compressed to slightly inflated. The smallest pods are those of *R. diffusa* (Figure 4.19, 18) and *R. spicata* (Figure 4.19, 19), which are 10 mm long and 3 mm wide, and the largest, those of *R. vlokii* (Figure 4.19, 9), which are up to 53 mm long and 13 mm wide. The colour of the ripe pods varies from pale yellowish-brown (e.g. *R. inaequalis* and sometimes *R. diffusa*), to greyish-brown, dark grey, dark brown or black (e.g. *R. triflora*). The surface is usually smooth, but may be prominently veined, as in *R.*

elliptica.

The pods in *Rafnia* are obliquely lanceolate to oblanceolate or narrowly to broadly oblong. The pods may be broadest proximally and tapering, e.g. *R. crassifolia* (Figure 4.19, 11) and *R. elliptica* (Figure 4.19, 12), or nearly oblong and broadened distally, e.g. *R. vlokii* (Figure 4.19, 9). The pods of most subspecies of *R. angulata* are narrow proximally and broadened distally, with the upper margin asymmetrically convex and the lower margin more or less straight (Figure 4.19, 2 & 3). The pods of *R. schlechteriana* (Figure 4.19, 20) are obliquely subtriangular, and broadest in the genus (up to 18 mm wide). The pods of *R. amplexicaulis* (Figure 4.19, 17) have the upper margin proximally convex as opposed to the lower margin usually being proximally convex.

The ratio of pod length:pod width (mean value equal to or more than six) was useful for grouping *R. alata*, *R. elliptica* and *R. triflora* in the cladistic analysis (see Figure 7.1). Morphometrical pod characters were omitted from the phenetic analysis since there were missing data for six taxa.

The upper suture is often developed into a narrow or rather broad wing. The upper suture is narrowly winged (1–2 mm wide) in *R. racemosa* subsp. *racemosa* (Figure 4.19, 1), *R. rostrata* subsp. *rostrata* (Figure 4.19, 7), *R. rostrata* subsp. *pauciflora* (Figure 4.19, 8), *R. vlokii* (Figure 4.19, 9) and most taxa of section *Colobotropis* (Figure 4.19, 18–28). The upper suture is broadly winged in *R. ovata* (Figure 4.19, 14) and *R. schlechteriana* (Figure 4.19, 20), in which the wing may be up to 5 mm wide.

The pods are one to four-seeded in *Rafnia* and Polhill (1976) observed that the seeds are on long funicles (which is characteristic of some Crotalarieae). The pods are one-seeded in *Aspalathus* (Van Wyk & Schutte, 1995). In *Rafnia*, the pods are dehiscent and usually open while on the plant. The toughly textured but rather thin valves separate or twist on dehiscence (Polhill, 1976) and the walls become more or less curved and spiralled, as in *Aspalathus* (Dahlgren, 1963a). The pod walls often remain on the plant for a long time after the seeds have been released.

Pod morphology is rather useful for identifying some species in *Rafnia*, since the pods of many taxa have distinct shapes. However, in the *R. angulata* and *R. capensis* species complexes, pod shape is variable and there are many intermediate shapes, so that this character has limited value below species level.

4.4 Seeds

Seed and embryo characters have been used to distinguish the Papilionoideae from the Mimosoideae and Caesalpinioideae (Gunn, 1981a; Manning & Van Staden, 1987). Papilionoid seeds have been investigated by Corner (1951), Isely (1955), Kopooshian & Isely (1966), Polhill (1976, 1981a), Gunn (1981a, b), Lersten (1982) and Manning & Van Staden (1985, 1987).

The seeds of the Crotalarieae are very variable in size, shape and colour (Polhill, 1976). Seed shape varies from almost circular to oblong-ovate or oblong-elliptic. When the radicular lobe is pronounced, as in the more derived genera, shapes may be oblique-cordiform and oblique-reniform or less often reniform or discoidal (Polhill, 1976, 1981a).

The hilum in the Crotalarieae is small and in a definite sinus (Polhill, 1976). A feature which is limited to the Crotalarieae and Podalyrieae (and Liparieae) (Schutte, 1998) is the punctate micropyle, which is completely enclosed by funicular remains and forms part of the hilum (Gunn, 1981a; Manning & Van Staden, 1987). The lens of the Crotalarieae is small, but varies with the shape of the seed (Polhill, 1976).

There are few distinct discontinuities in seed characters among the genera of the Crotalarieae (Polhill, 1976). However, seed characters that were useful in the generic analysis of the Crotalarieae (Van Wyk & Schutte, 1995) include the often rugose or tuberculate seed surface and orange testa with a white hilar area.

Seed characters investigated in *Rafnia* include size, colour, shape, hilum, lens and features of the testa (texture and cell patterns). Seed variation in *Rafnia* is represented in Figures 4.20 & 4.21.

The seeds of *Rafnia* range from 2 mm long in *R. diffusa* (Figure 4.20, row 2), to 6 mm long in *R. amplexicaulis* (Figure 4.20, row 1) and from 1 mm wide in *R. diffusa* to 4.7 mm wide in *R. schlechteriana* (Figures 4.20, row 3 & 4.21, row 8). These values are similar to those of related genera, for example, the seeds of *Aspalathus* are 3.2–3.8 mm long and those in *Lebeckia*, 2.5–3.6 mm long (Polhill, 1976). Seed size does not present any significant discontinuities among the species of *Rafnia*, but it may have limited value in identifying the seeds of certain species.

Seed colour is very variable in *Rafnia*. Colour ranges from greyish-white or pale yellow, through various shades of brown, to black. The seeds of *R. acuminata* are pale greyish-white or yellowish (Figure 4.20, row 1), those of *R. diffusa* (Figure 4.20, row 2) are pale yellow and one population (Piquetberg) of *R. angulata* subsp. *angulata* (Figure 4.21, row 5) has pale pink seeds. The seeds may be reddish-brown in *R. angulata*

Figure 4.20 Variation in seed morphology in 19 taxa of *Rafnia*, showing range in seed size, shape and colour. Seeds are arranged in rows (top row = row 1) and given from left to right in each row: **Row 1:** *R. racemosa* subsp. *racemosa* (*Vlok 35*); *R. ovata* (*Campbell & Van Wyk 122*); *R. triflora* (*Campbell & Van Wyk 118*); *R. crassifolia* (*Schlechter 7303*); *R. acuminata* (*Van Wyk 2994*); *R. amplexicaulis* (*Campbell & Van Wyk 105*); *R. inaequalis* (*Campbell & Van Wyk 119*); **Row 2:** *R. elliptica* (*Vlok s.n.*); *R. alata* (*Vlok s.n.*); *R. vlokii* (*Van Wyk 3172*); *R. angulata* subsp. *thunbergii* (*Compton 10371*); *R. angulata* subsp. *angulata* (*Campbell & Van Wyk 139*); *R. diffusa* (*Campbell & Van Wyk 124*); **Row 3:** *R. capensis* subsp. *ovata* (*Campbell & Van Wyk 159*); *R. capensis* subsp. *capensis* (*Vlok & Schutte 406*); *R. capensis* subsp. *calycina* (*Campbell & Van Wyk 121*); *R. capensis* subsp. *dichotoma* (*Van Wyk 2798*); *R. globosa* (*Campbell & Van Wyk 125*); *R. schlechteriana* (*Campbell & Van Wyk 117*). Scale bars = mm.

subsp. *thunbergii* (Figure 4.20, row 2) and *R. capensis* subsp. *ovata* (Figure 4.20, row 3), dark brown, or various shades of mottled or streaked browns as in *R. schlechteriana* (Figures 4.20, row 3 & 4.21, row 8) and *R. globosa* (Figures 4.20, row 3 & 4.21, row 7). The seeds may have a mottled greyish or black appearance, as in *R. racemosa* subsp. *racemosa* (Figures 4.20, row 1 & 4.21, row 1), *R. angulata* subsp. *angulata* (Figures 4.20, row 2 & 4.21, row 5), *R. elliptica* (Figure 4.20, row 2) and *R. triflora* (Figures 4.20, row 1 & 4.21, row 2).

The hilar region may be the same colour as the rest of the testa, e.g. *R. globosa* (Figures 4.20, row 3 & 4.21, row 7), or the testa may be pale or dark brown to black in the hilar region, e.g. *R. alata* (Figures 4.20, row 2 & 4.21, row 4) and *R. capensis* subsp. *ovata* (Figure 4.20, row 3). There may be a distinct dark ring around the hilum in *R. angulata* subsp. *angulata* (Figures 4.20, row 2 & 4.21, row 5) and *R. elliptica* (Figure

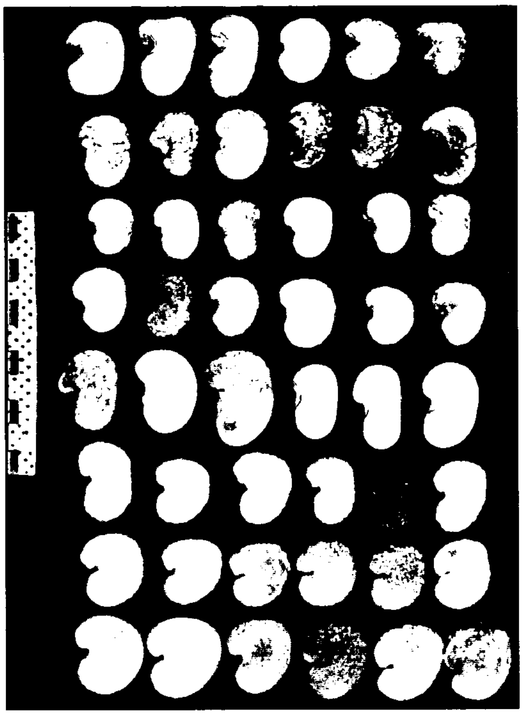


Figure 4.21 Variation among seeds within different species (in rows 1, 2 and 5, two different populations are represented—the number after the voucher name and locality represents the number of seeds taken from the same population). The species of each row are given from left to right: **Row 1:** *R. racemosa* subsp. *racemosa* (*Vlok 35*, Swartberg x 3); (*Van Wyk 2971*, Swartberg x 3); **Row 2:** *R. triflora* (*Campbell & Van Wyk 118*, Piquetberg x 3); (*Van Wyk 3010*, Smithswinkelbaai x 3); **Row 3:** *R. inaequalis* (*Campbell & Van Wyk 119*, Piquetberg x 6); **Row 4:** *R. alata* (*Vlok s.n.*, Swartberg x 6); **Row 5:** *R. angulata* subsp. *angulata* (*Campbell & Van Wyk 138*, Mamre x 3); (*Campbell & Van Wyk 35*, Piquetberg x 3); **Row 6:** *R. capensis* subsp. *calycina* (*Campbell & Van Wyk 121*, Piquetberg x 6); **Row 7:** *R. globosa* (*Campbell & Van Wyk 125*, Algeria x 6); **Row 8:** *R. schlechteriana* (*Campbell & Van Wyk 117*, Piquetberg x 6). Scale bars = mm.

4.20, row 2) or a distinct pale ring in *R. diffusa* (Figure 4.20, row 2).

The seeds of taxa of section *Rafnia* are mostly similar to those of *Aspalathus*, in which they are narrowly oblong to obliquely oblong-reniform, e.g. *R. angulata* subsp. *angulata* (Figures 4.20, row 2 & 4.21, row 5). The seeds of taxa of section *Colobotropis* may be broadly oblong to oblique-cordiform, e.g. *R. schlechteriana* (Figures 4.20, row 3 & 4.21, row 8), reniform or discoidal or oblong-cordiform, as in *R. capensis* subsp. *ovata* (Figure 4.20, row 3), almost subtriangular, as in *R. capensis* subsp. *dichotoma* (Figure 4.20, row 3) or suborbicular, e.g. *R. globosa* (Figures 4.20, row 3 & 4.21, row 7).

The prominence of the incurved radicular and micropylar lobes varies in *Rafnia*, giving rise to shallow or deep sinuses. *R. triflora* (Figures 4.20, row 1 & 4.21, row 2) and *R. inaequalis* (Figures 4.20, row 1 & 4.21, row 3) have shallow sinuses, while those of *R. schlechteriana* (Figures 4.20, row 3 & 4.21, row 8) and *R. globosa* (Figures 4.20, row 3 & 4.21, row 7) have deep, apparently gaping sinuses, in which the small elliptic to round exarillate hilum is sunken. A deep seed sinus is a useful synapomorphy for the species *R. schlechteriana*, *R. capensis* and *R. globosa* of section *Colobotropis* (see Chapter 7.1). In most taxa, the testa is slightly swollen around the hilum, except in *R. angulata* subsp. *angulata*, and there is a large, distinct swollen ring around the hilum in *R. vlokii* (Figure 4.20, row 2), which distinguishes it from the remaining taxa.

The lens in *Rafnia* is generally slightly protrusive, oblong to elliptic in shape and usually a pale to dark brown colour, which differs from the colour of the testa. The zone immediately surrounding the lens may be paler than the lens and the rest of the testa.

There are two characters of the seed testa that should not be confused, each of which will be discussed separately below. Firstly, the texture of the testa surface may be smooth or covered with protuberances (Figure 4.22). The pattern of protuberances formed by several cells that are raised above the general surface of the seed give the testa a tuberculate appearance. The texture is smooth, i.e. without protuberances in *R. racemosa* subsp. *racemosa*, *R. angulata* subsp. *angulata*, *R. angulata* subsp. *thunbergii*, *R. elliptica*, *R. triflora* (Figure 4.22a), *R. inaequalis* and *R. acuminata*. The texture may be slightly tuberculate in *R. alata*, *R. ovata*, *R. amplexicaulis*, *R. spicata*, and *R. capensis* subsp. *dichotoma* and is distinctly tuberculate in *R. diffusa* (Figure 4.22b), *R. schlechteriana*, *R. capensis* subsp. *capensis*, *R. capensis* subsp. *calycina*, *R. capensis* subsp. *ovata* and *R. globosa*. *R. vlokii* is unique in having a longitudinally striate seed surface.

Secondly, the testa cell pattern (Figure 4.23) is a pattern formed by the cell walls of individual cells of the testa, and it can only be observed using scanning electron microscopy. The Papilionoideae has a particularly wide range of testa cell patterns (Manning & Van Staden, 1987). The supposedly plesiomorphic rugose pattern is widespread throughout the family and the only pattern common to all three subfamilies of the Fabaceae (Manning & Van Staden, 1987).

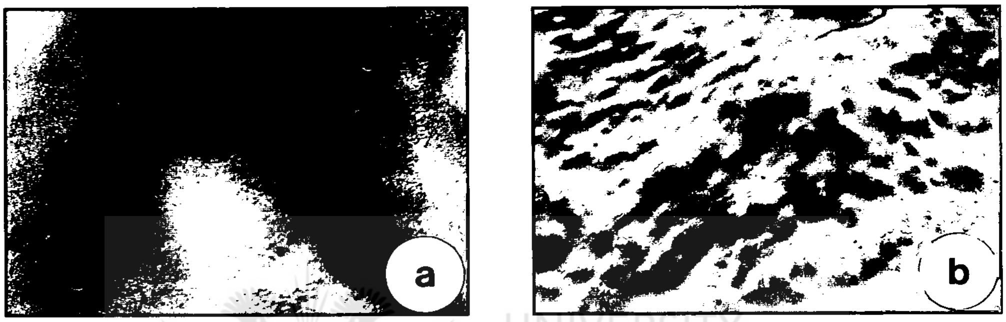


Figure 4.22 Variation in the texture of the testa surface in *Rafnia*: **a,** *R. triflora*—smooth surface; **b,** *R. diffusa*—distinctly tuberculate surface.

The closely related tribes Podalyrieae (and Liparieae) and Crotalarieae share a predominantly multi-reticulate pattern. Lersten (1981) and Manning & Van Staden (1987) assigned limited value to testa cell patterns in assessing broader phylogenetic trends, even though they are significant within and between adjacent tribes.

Richardson & Cross (1991) studied the testa cell patterns of the seeds of 18 species of *Rafnia*. These patterns revealed interesting differences that were used to construct a key for the identification of species. Richardson & Cross (1991) used the nine categories of testa cell patterns proposed by Lersten (1981), but these were found to be difficult to interpret as the different types seem to merge, with no distinct discontinuities between them. There are, however, basically two types of testa cell patterns in *Rafnia*, namely reticulate and foveolate patterns. This character was found to have limited taxonomic value as a species diagnostic character in *Rafnia*.

Table 4.1 gives a comparison between the testa cell patterns described by Richardson & Cross (1991) and the results obtained in this study. The multi-reticulate testa cell pattern is most common in *Rafnia*. Taxa in which it occurs include for example *R. angulata* subsp. *angulata* (Figure 4.23, 2), *R. inaequalis* (Figure 4.23, 9) and *R. capensis* subsp. *calycina* (Figure 4.23, 11). This pattern is defined by Richardson & Cross (1991) as the presence of primary plus secondary ridges. The simple-reticulate pattern which is less common, is defined as a meshwork of ridges enclosing single cells (Richardson & Cross, 1991).

The patterns broadly follow phylogenetic trends in the genus and the strongest evidence for this is that all taxa of section *Colobotropis* (except *R. schlechteriana*) have multi-reticulate patterns. However, this pattern is also found sporadically in taxa of section *Rafnia*. The multi-reticulate cell patterns are mostly thin-walled. The remaining taxa mostly have a foveolate testa cell pattern, which is defined as single cell ends isolated by grooves (simple-foveolate) or a unit of several cells surrounded by grooves (multi-foveolate) (Richardson & Cross, 1991), e.g. *R. elliptica* (Figure 4.23, 7) and *R. triflora* (Figure 4.23, 8).

R. vlokii (Figure 4.23, 4) appears to have a foveolate pattern, but the general effect is that the surface appears to have longitudinal striations formed by the testa cells. The foveolate pattern of *R. racemosa* subsp. *racemosa* (Figure 4.23, 1) seems to merge with a papillose pattern, defined by Richardson & Cross (1991) as consisting of single protruding epidermal cells. *R. schlechteriana* seems to have a pattern that is either rugulate, defined as irregularly roughened by Richardson & Cross (1991), or reticulate.

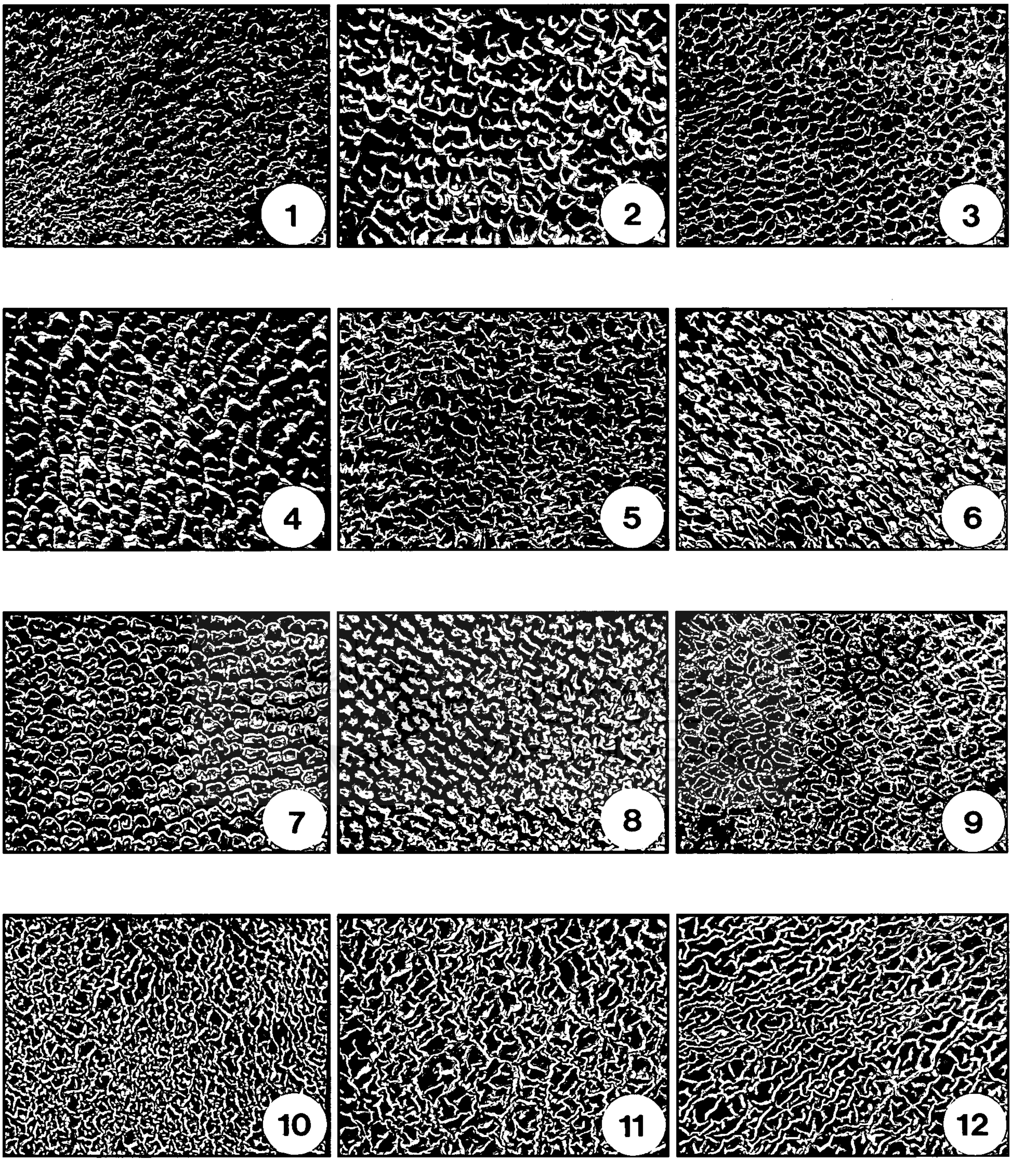


Figure 4.23 SEM photographs showing the variation in testa cell patterns in *Rafnia*: **1,** *R. racemosa* subsp. *racemosa* (*Vlok 35*)—foveolate-papillose; **2,** *R. angulata* subsp. *angulata* (*Campbell & Van Wyk 139*)—multi-reticulate; **3,** *R. angulata* subsp. *thunbergii* (*Compton 10371*)—multi-reticulate; **4,** *R. vlokii* (*Van Wyk 3172*)—foveolate, striate; **5,** *R. alata* (*Vlok s.n.*)—multi-reticulate; **6,** *R. crassifolia* (*Wolley-Dod s.n. sub BOL 42925*)—foveolate; **7,** *R. elliptica* (*Oliver 9363*)—foveolate; **8,** *R. triflora* (*Van Wyk 3010*)—foveolate; **9,** *R. inaequalis* (*Campbell & Van Wyk 119*)—simple reticulate; **10,** *R. capensis* subsp. *capensis* (*Van Wyk 2972*)—multi-reticulate; **11,** *R. capensis* subsp. *calycina* (*Campbell & Van Wyk 121*)—multi-reticulate; **12,** *R. capensis* subsp. *ovata* (*Campbell & Van Wyk 159*)—multi-reticulate.

Table 4.1 Comparison of testa cell patterns for taxa examined by Richardson & Cross (1991) and findings from the current study.

Taxon	**Richardson & Cross (1991)**	**Current study**
R. racemosa subsp. *racemosa*	Simple rugulate	Foveolate-papillose
R. angulata subsp. *angulata*	Simple rugulate	Multi-reticulate, thick walls
R. angulata subsp. *thunbergii*	Rectangular compressed rugulate	Multi-reticulate, thick walls
R. angulata subsp. *ericifolia*	Densely involute	*
R. lancea	Simple rugulate	*
R. vlokii	Confluent-continuous tuberculate	Foveolate
R. alata	Simple rugulate	Multi-reticulate, thick walls
R. crassifolia	Papillose, no central depressions on papillae	Foveolate
R. elliptica	Foveolate pattern of cells composed of central depressions with raised circular borders	Foveolate
R. triflora	Lophate pattern composed of short ridges and irregular sides	Foveolate
R. ovata	Simple rugulate	Simple reticulate, thin walls
R. inaequalis	*	Simple reticulate, thick walls
R. acuminata	*	Simple reticulate, thick walls
R. amplexicaulis	*	Multi-reticulate, thick walls
R. diffusa	Multi-reticulate, thin walls	Multi-reticulate, thin walls
R. spicata	*	Multi-reticulate, thin walls
R. schlechteriana	Simple reticulate, thick walls	Rugulate/reticulate
R. capensis subsp. *capensis*	Simple-reticulate, thin walls	Multi-reticulate, thin walls
R. capensis subsp. *calycina*	*	Multi-reticulate, thin walls
R. capensis subsp. *dichotoma*	Striate-rugulate	Multi-reticulate, thin walls
R. capensis subsp. *ovata*	Simple-reticulate, thick walls	Multi-reticulate, thin walls
R. globosa	*	Multi-reticulate, thick walls

*Not studied. Taxa for which seeds were not studied include *R. racemosa* subsp. *pumila*, *R. angulata* subsp. *humilis*, *R. angulata* subsp. *montana*, *R. crispa*, *R. rostrata* subsp. *rostrata*, *R. rostrata* subsp. *pauciflora*, *R. capensis* subsp. *carinata*, *R. capensis* subsp. *elsieae* and *R. capensis* subsp. *pedicellata*.

Seed characters have limited taxonomic value in *Rafnia*, since there is much uncertainty in the interpretation of these characters, especially testa cell patterns. Seed texture revealed interesting differences among the species, but no taxonomically useful discontinuities. Broad phylogenetic trends can be traced in the seed characters, however. The seeds of taxa of section *Rafnia* are generally oblong, often with a distinct ring around the hilum and a smooth surface, and those of section *Colobotropis* are generally broader with extended lobes, a deeper sinus, without a distinct ring around the hilum, with a tuberculate surface and a multi-reticulate testa cell pattern.

CHAPTER 5

OTHER EVIDENCE

5.1 Introduction

In addition to morphological characters, other forms of evidence were researched in order to find new characters that would improve the understanding of relationships among the taxa of *Rafnia*. The complex geographical patterns were studied and distributions for all taxa are plotted (for species maps see Chapter 9). Ecological factors, including habitat and substrate conditions, are not discussed here but are briefly summarized in the species treatments in Chapter 9. Information regarding flowering and fruiting phenology, as well as chromosome cytology and alkaloids, is presented below. The results of flavonoid and enzyme surveys are also presented below. These methods proved feasible for *Rafnia*, but the scope of this study did not permit full further investigation of these characters.

5.2 Distribution and geographical patterns

The Crotalarieae is mainly restricted to Africa with most of the diversity centred in southern Africa (Van Wyk, 1991a). *Rafnia* forms part of a temperate element of the Crotalarieae and is distributed in the Western and Eastern Cape Provinces and southern KwaZulu-Natal (between 31° and 35° S and 18° and 30° E). *Rafnia* extends from Nieuwoudtville and Vanrhynsdorp in the north-western part of the Western Cape Province down through the south-western and southern parts of the fynbos region, eastwards to Grahamstown and further up into Pondoland, in the southern parts of KwaZulu-Natal. The approximate geographical distribution of *Rafnia* is given in Figure 5.1.

Rafnia has a similar distribution to *Aspalathus* (Figure 5.1), with the species of both genera concentrated in the mountains of the south-western part of the Western Cape Province. *Rafnia* has a more limited distribution than *Aspalathus*, but with similar centres of diversity.

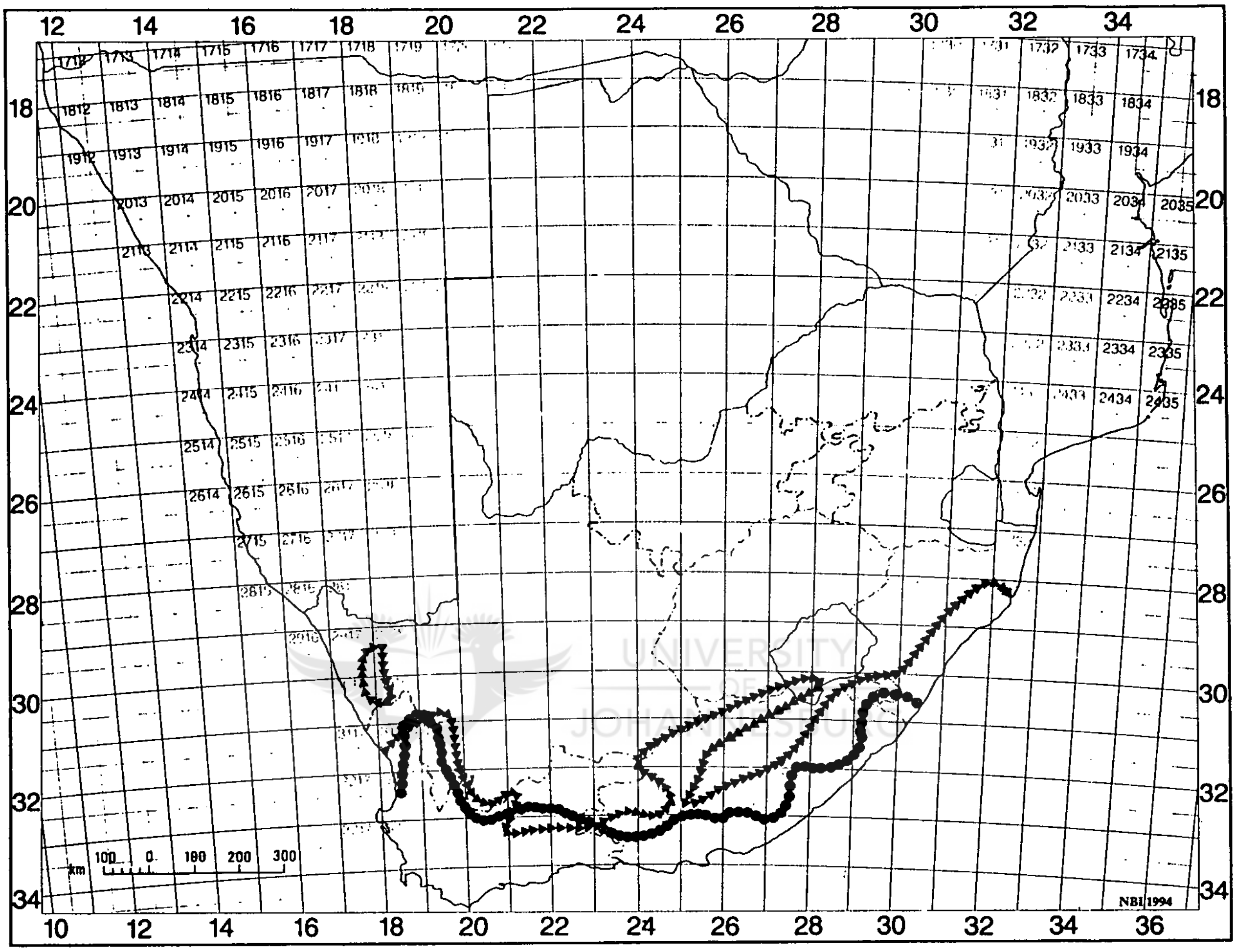


Figure 5.1 The approximate geographical distributions of *Rafnia* (line composed of circles) and *Aspalathus* (line composed of triangles).

The main centres of species diversity in *Rafnia* appear to be the Cedarberg, Piquetberg, Worcester and Stellenbosch districts, and numerous species also occur on the Cape Peninsula and Swartberg (Figure 5.2). The highest concentration of species (11 species) occurs on the Piquetberg, including species from section *Rafnia* and section *Colobotropis*. *R. inaequalis* is endemic to the Piquetberg and *R. capensis* subsp. *calycina* occurs only on the Piquetberg and Olifantsrivier mountains. *Aspalathus* also shows diversity on the Piquetberg, with approximately 35 species occurring there, four of which are endemic (Dahlgren, 1963b).

Rafnia is characterized by complex geographical patterns which are similar to those of *Aspalathus* (Dahlgren, 1963b). There is exceptional geographical variation in *Rafnia*, particularly in the widespread species. Many Cape plants are similarly variable. The species often have characteristic appearances at specific localities, so that it is possible to distinguish regional forms within the species (see Table 2.1). Some forms are so distinct that the rank of subspecies seems appropriate.

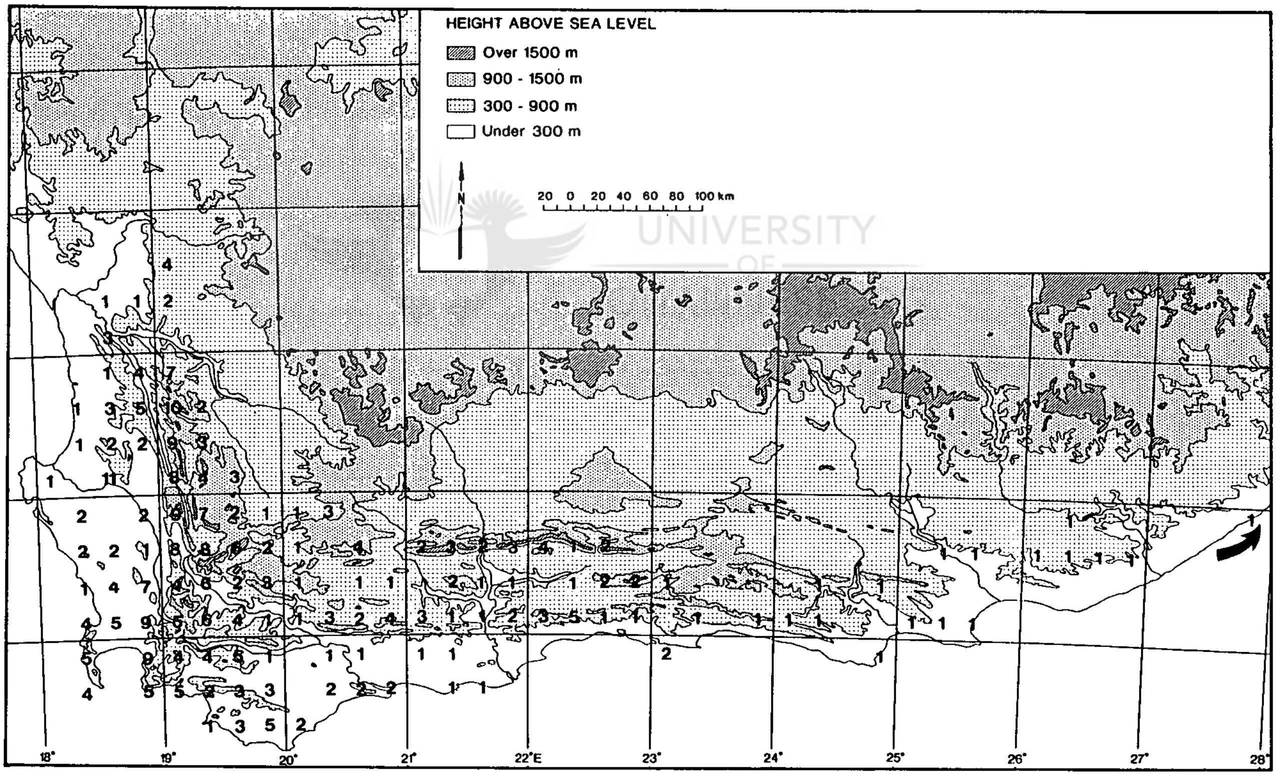


Figure 5.2 Concentrations of species within the distribution area of *Rafnia*—the number of species present within each quarter degree square is shown. The arrow indicates that one species continues into KwaZulu-Natal.

Some of the less variable species may have distinct forms at certain localities. For example, on the Piquetberg, *R. acuminata* differs in calyx structure, and this may be considered a regional form (see Chapter 4.2.2). In the Caledon/Bredasdorp area, *R.*

triflora grows on limestone and differs in habit and calyx structure from the typical form of *R. triflora*, so that this is also a distinct regional form. *R. alata* and *R. diffusa* have characteristic forms in different localities, but these are not considered worthy of taxonomic recognition. The regional forms may be so characteristic that the geographical origin (sometimes even the exact locality) of a specimen can be told from its appearance. This is true for other Cape genera of the Fabaceae.

R. angulata is a widely distributed and extremely variable species. The extreme regional forms, which are local endemics, i.e. having restricted distributions, are morphologically sufficiently distinct to be recognized as subspecies. Figure 5.3 shows the distribution of the subspecies and some extreme regional forms of *R. angulata*.

There are many regional variants even within *R. angulata* subsp. *angulata.* These forms are not always clearly distinguishable since they often merge into each other, and there is every conceivable intermediate form. It is difficult to believe that all the forms belong to the same taxon, but when the full variation is taken into account, they are seen to be regional forms of one variable taxon. If certain intermediate forms or populations are removed, the remaining secondary populations may be morphologically distinguishable.

In *R. capensis*, there is even more variation than in *R. angulata*. The regional variants here are closely connected with and merge into others, so that they are hardly distinguishable by any discontinuity. It is almost impossible to determine where one subspecies begins and another ends, particularly in *R. capensis* subsp. *capensis*, *R. capensis* subsp. *dichotoma* and *R. capensis* subsp. *ovata*, which are widely distributed and may be divided into numerous regional forms as in the case of *R. angulata* subsp. *angulata*. The remaining subspecies of *R. capensis* are local endemics, namely *R.*

capensis subsp. *carinata*, *R. capensis* subsp. *calycina*, *R. capensis* subsp. *pedicellata* and *R. capensis* subsp. *elsieae*. Figure 5.4 shows the distribution of the subspecies of *R. capensis*.

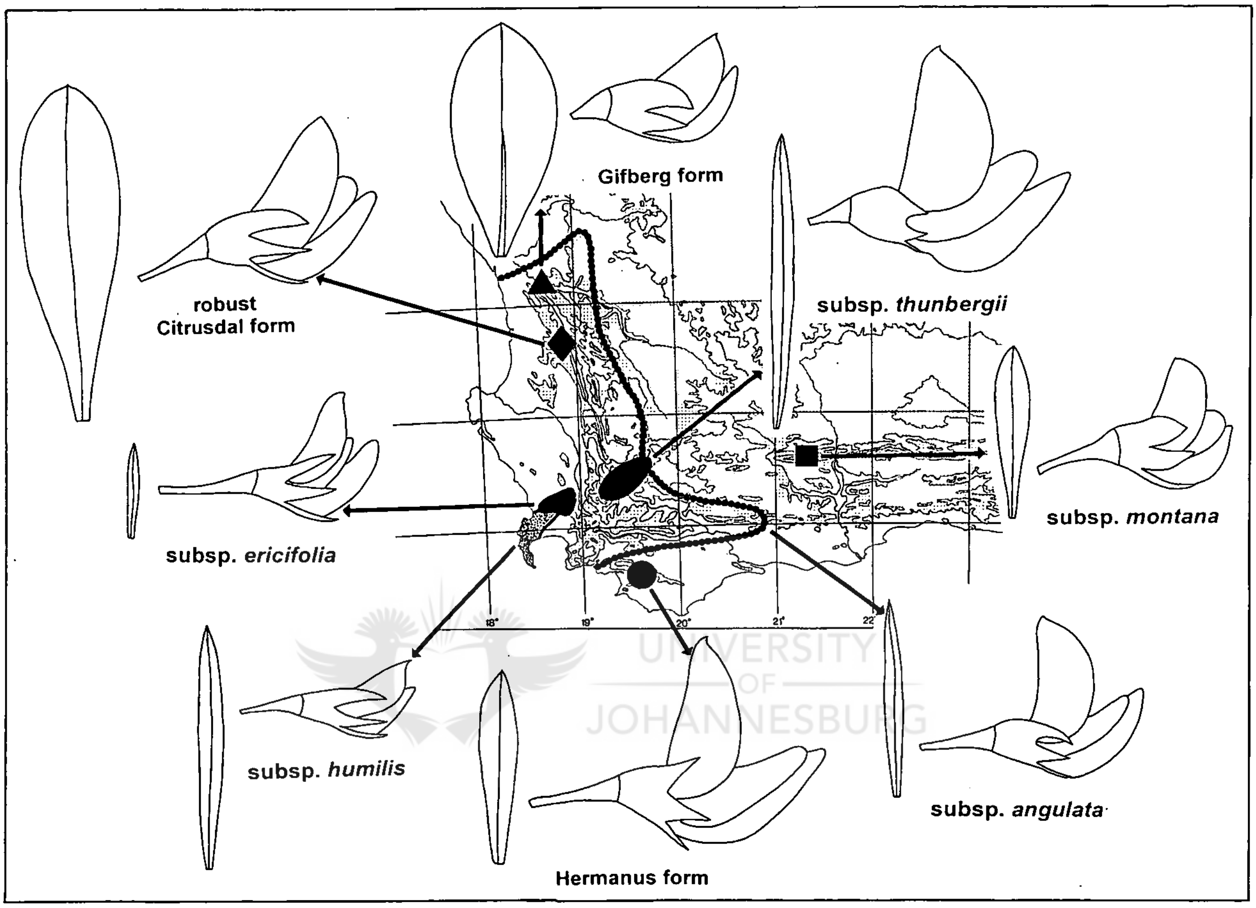


Figure 5.3 Distribution of subspecies and some extreme regional forms of *R. angulata*.

It seems that *R. capensis* subsp. *ovata* inhabits the more northern centres and is gradually replaced in the south from the Peninsula eastwards by *R. capensis* subsp. *capensis*. The distribution of *R. capensis* subsp. *dichotoma* seems to be intermediate between these two (Figure 5.4). *R. capensis* subsp. *capensis* starts in Ceres with forms very similar to (and almost indistinguishable from) *R. spicata* and becomes somewhat broad-leaved in the vicinity of the Peninsula. Further east, the subspecies consists of very large shrubs occasionally with very small, narrow leaves. *R. capensis* subsp. *ovata* ranges from small, woody, cuneate-shaped leaf forms in the north to broad, ovate leaf forms in the south. *R. capensis* subsp. *dichotoma* does not display the same extent of variation as *R. capensis* subsp. *ovata* and *R. capensis* subsp. *capensis*.

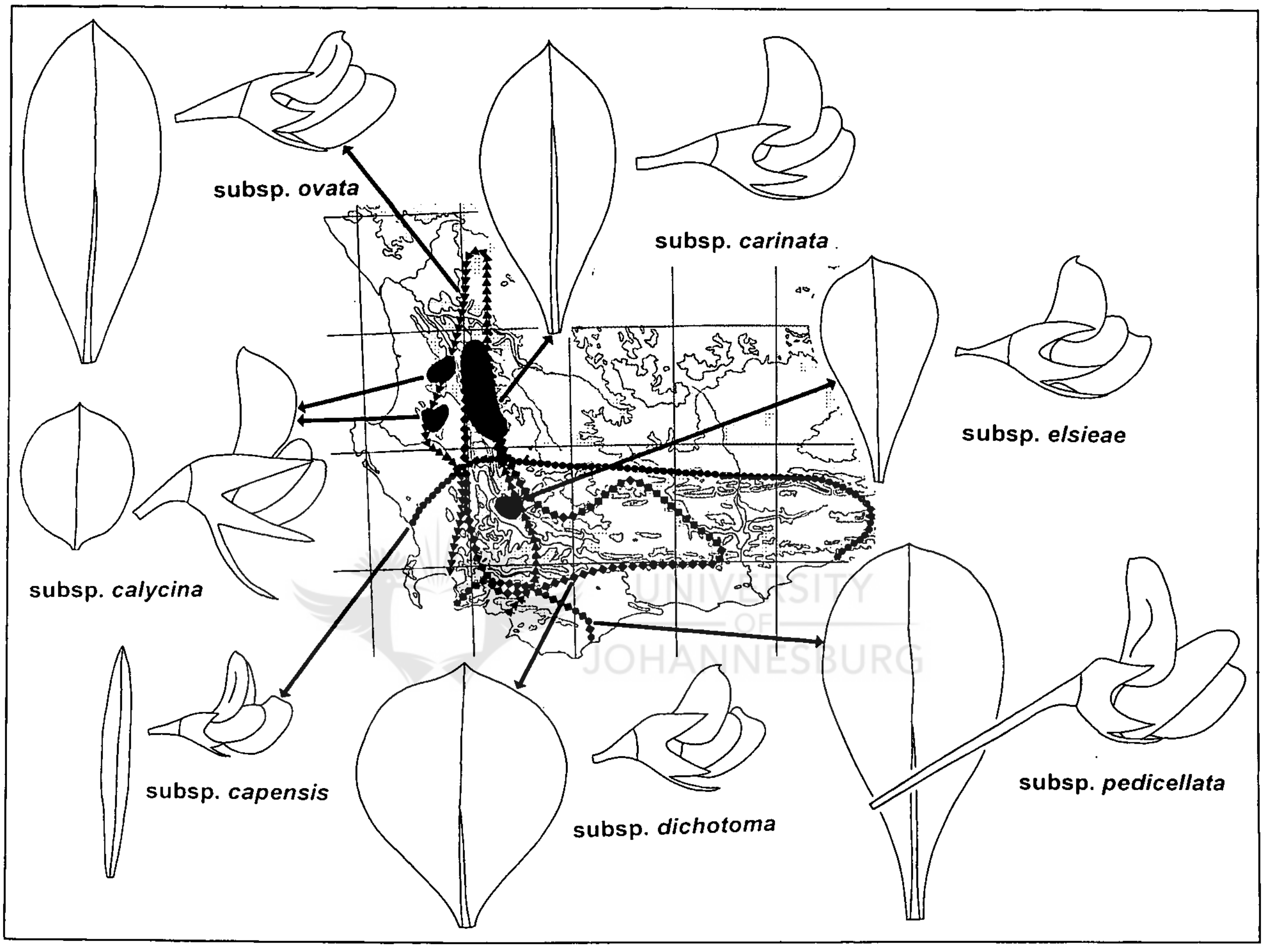


Figure 5.4 Distribution of subspecies of *R. capensis*.

The subspecies of *R. racemosa* and *R. rostrata* are easily recognizable as distinct taxa since they occupy different localities but also differ morphologically sufficiently to justify the allocation of subspecies rank.

Numerous taxa in *Rafnia* are local endemics, e.g. *R. lancea*, *R. rostrata* subsp.

pauciflora, *R. crassifolia* and *R. globosa* and some are very rare, being known only from one locality, i.e. *R. racemosa* subsp. *pumila*, *R. crispa* and *R. inaequalis.* Locality details are given in Chapter 9.

Geographical distribution patterns in *Rafnia* contribute to a better understanding of variation patterns within the variable species. It may even give clues about possible vicariance events which may have resulted in some of the major clades (see Chapter 7).

5.3 Flowering and fruiting phenology

Since the species of *Rafnia* are resprouters (see Chapter 3.2), regeneration (in spring, or particularly after fire) occurs by active growth from the underground lignotubers in the form of robust flower-bearing shoots. At such times, the species may flower profusely and there is relatively rapid production of large numbers of pods. Flowers and pods may be present simultaneously, but often shrubs with abundant ripe pods will have few or no flowers left.

The flowering and fruiting times for all the taxa of *Rafnia* are given in Table 5.1 and some of these times are represented graphically in Figure 5.5. The flowering and fruiting times differ slightly among the species of *Rafnia* and may vary within a species. Flowering and fruiting mostly occur in the spring and summer months. Peak flowering times are chiefly in October and November, e.g. in *R. racemosa* subsp. *racemosa* (Figure 5.5a), *R. triflora* (Figure 5.5d), *R. amplexicaulis* (Figure 5.5e), *R. diffusa* (Figure 5.5f) and *R. capensis* subsp. *ovata* (Figure 5.5h), while peak fruiting times are usually follow later, in December and January, e.g. *R. angulata* subsp. *angulata* (Figure 5.5b), *R. elliptica* (Figure 5.5c) and *R. capensis* subsp. *capensis* (Figure 5.5g). *R. elliptica* and *R. triflora* have peak flowering times in the spring months followed by a second peak later in

Table 5.1 The known flowering and fruiting times of the taxa of *Rafnia*.

Taxon	**Flowering (Fl) and fruiting (Fr) times**	**Peak flowering (Fl) and fruiting (Fr) times**
R. racemosa subsp. *racemosa*	Fl & Fr: All year	Fl: October Fr: January
R. racemosa subsp. *pumila**	Fl & Fr: December	
R. angulata subsp. *angulata*	Fl & Fr: ± All year	Fl & Fr: December
R. angulata subsp. *thunbergii*	Fl & Fr: October to December	Fl & Fr: November
R. angulata subsp. *humilis*	Fl: October to December	Fl: November
R. angulata subsp. *ericifolia*	Fl: November to March Fr: September to March	Fl: January & February Fr: February
R. angulata subsp. *montana**	Fl & Fr: December to February	
*R. crispa**	Fl: December	
R. lancea	Fl: September & October Fr: September to November	Fl: September Fr: October
R. rostrata subsp. *rostrata*	Fl: October to January Fr: October to March	Fl: October Fr: December
R. rostrata subsp. *pauciflora*	Fl & Fr: November to February	Fl & Fr: January
*R. vlokii**	Fl: June Fr: June to October	
R. alata	Fl & Fr: October to January	Fl: December Fr: January
R. crassifolia	Fl: October to February Fr: October to March	Fl & Fr: November
R. elliptica	Fl: September to April Fr: September to June	Fl & Fr: January
R. triflora	Fl & Fr: September to March	Fl & Fr: November
R. ovata	Fl: August to January Fr: September to January	Fl: September Fr: October
*R. inaequalis**	Fl: October to January Fr: November to January	
R. acuminata	Fl: September to February Fr: September to April	Fl & Fr: November
R. diffusa	Fl: August to January Fr: September to January	Fl: October Fr: November
R. spicata	Fl: September to January Fr: October to March	Fl: October Fr: December
R. schlechteriana	Fl: September to December Fr: September to January	Fl: October Fr: December
R. capensis subsp. *capensis*	Fl & Fr: All year	Fl: November & December Fr: December & January
R. capensis subsp. *carinata*	Fl: August to February Fr: October to February	Fl: September Fr: November to January
R. capensis subsp. *calycina*	Fl: August to February Fr: September to April	Fl: October Fr: September to April
R. capensis subsp. *dichotoma*	Fl: June to January Fr: July to January	Fl & Fr: January
R. capensis subsp. *ovata*	Fl & Fr: August to April	
R. capensis subsp. *elsieae**	Fl & Fr: November to January	Fl: November Fr: December
R. capensis subsp. *pedicellata*	Fl & Fr: September to February	Fl & Fr: October
R. globosa	Fl & Fr: September to December	Fl: September Fr: September & December

*Based on few specimens

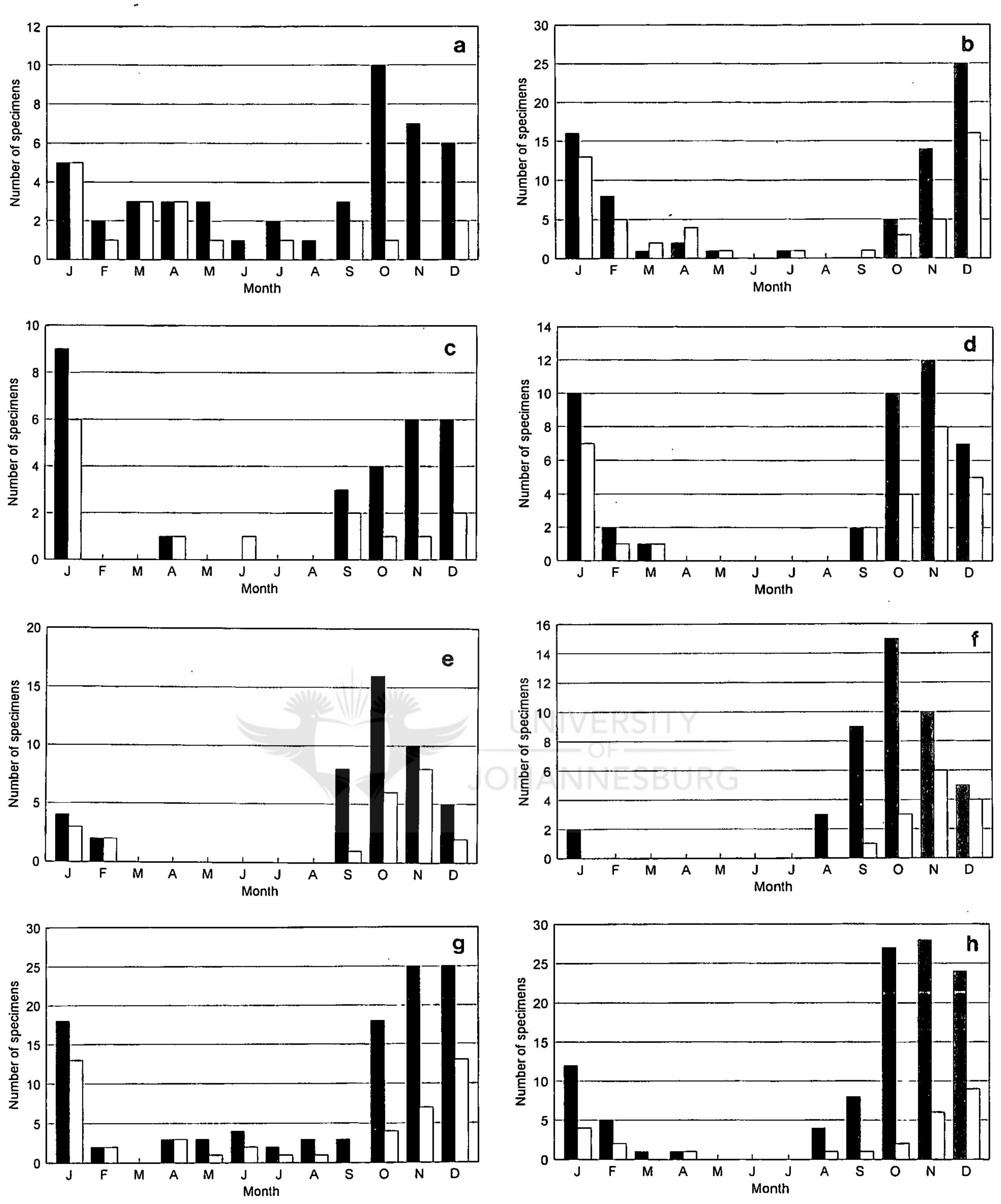


Figure 5.5 Flowering time (shaded) and fruiting time (clear) of some taxa of *Rafnia*: **a,** *R. racemosa* subsp. *racemosa*—flowering throughout the year, peak in spring; **b,** *R. angulata* subsp. *angulata*—flowering for much of the year, peak in summer; **c,** *R. elliptica* – shorter flowering period, peak in summer; **d,** *R. triflora*—peak in spring and summer; **e,** *R. amplexicaulis*—peak in spring; **f,** *R. diffusa*—peak in spring; **g,** *R. capensis* subsp. *capensis*—flowering throughout the year, peak in summer; **h,** *R. capensis* subsp. *ovata*—peak in spring and summer. For each taxon, the number of specimens flowering in each month of the year is expressed as a percentage of the total number of specimens examined for that species.

summer.

Flowering and fruiting times vary in duration (Table 5.1). Some species, especially those that are widespread, flower throughout the year, such as *R. racemosa* subsp. *racemosa*, *R. angulata* subsp. *angulata* and *R. capensis* subsp. *capensis*, with peak times being reached in the spring and summer months. *R. lancea* and *R. globosa* have short flowering times, lasting only from spring to early summer, while *R. crassifolia* and *R. elliptica* have longer flowering and fruiting times, from early spring or autumn to late summer.

R. vlokii is unusual in that its flowering time seems to begin in June and fruiting may continue until spring. *R. capensis* subsp. *dichotoma* also starts flowering in the winter months and continues flowering and fruiting until summer.

Flowering times vary according to locality and apparently also fire history and climate, so that populations of the same taxon may flower at different times. As a result, no taxonomically significant discontinuities in flowering and fruiting times could be found among the taxa of *Rafnia*.

5.4 Chromosome cytology

Polhill (1976) reported the chromosome number for the Crotalarieae to be 2n = 14, 16, 18 (28, 32, 36). Goldblatt (1981a) affirmed that the base number of x = 9 seemed likely for the Crotalarieae. Chromosome numbers in the Crotalarieae have been further discussed by Van Wyk & Schutte (1995). According to Goldblatt (1981a), chromosome numbers are valuable in revising and improving the classification of the Fabaceae and in understanding evolution in the family.

Dahlgren (1967, 1971, 1975) found that *Lebeckia*, *Wiborgia* and most species of *Aspalathus* have 2n = 18. Chromosome counts for some species of *Aspalathus* and *Rafnia elliptica* are 2n = 16 (Dahlgren, 1967), and for *Rafnia*, no chromosomes were satellited and no distinct secondary constrictions were observed. Species with numbers lower than 2n = 18 have probably evolved along several different lines (Dahlgren, 1971).

Van Wyk & Schutte (1988, 1989) and Van Wyk (1991b) reported that the most common somatic number in *Lotononis* (DC.) Eckl. & Zeyh. is 18. Other numbers found include 2n = 28 (Dahlgren 1967; Van Wyk & Schutte 1988, 1989; Van Wyk 1991b), 42, 56 and 84. This was the first report of a polyploid series in the Crotalarieae and included the highest numbers recorded in the tribe. The chromosome numbers were considered to possibly provide evidence for a more natural classification of *Lotononis*.

Goldblatt (1981a) reported that *Rafnia* and most species of *Crotalaria* have x = 8, which is the most common base number in the Fabaceae. *R. triflora* and *R. amplexicaulis* both have 2n = 16 (Goldblatt, 1981b).

5.5 Secondary metabolites

5.5.1 Alkaloids

Alkaloids of the Crotalarieae have been discussed by Van Wyk *et al.* (1988), Van Wyk & Verdoorn (1989, 1990), Van Wyk (1991a) and Van Wyk & Schutte (1995). A survey of alkaloids in the tribe showed that useful chemotaxonomic data could be obtained (Van Wyk *et al.* 1988). Quinolizidine and pyrrolizidine alkaloids are sometimes present in members of the tribe (Van Wyk & Verdoorn, 1990).

Comparisons were made of the biosynthetic routes in which the different genera specialize, based on known biochemical pathways, and four major groups could be delimited from the alkaloid patterns.

Extracts from species of *Aspalathus* and *Rafnia* contained low concentrations of several quinolizidine and piperidyl alkaloids (Van Wyk *et al.* 1988; Van Wyk & Verdoorn, 1989, 1990). Van Wyk & Verdoorn (1989) found that *Aspalathus*, *Rafnia* and *Wiborgia* contained trace quantities of sparteine, lupanine and nuttalline (∝-isolupanine in some samples). No evidence of ∝-pyridone alkaloids or pyrrolizidine alkaloids were found in any of the extracts and yield figures were extremely low.

Rafnia was found to belong to an unspecialized group without ∝-pyridone alkaloids or esters of alkaloids (Van Wyk & Verdoorn, 1990). Other members of this group include the genera *Aspalathus*, *Lebeckia*, *Wiborgia* and *Spartidium* Pomel. Since alkaloid yields in *Rafnia* are low, it was not considered to be of any practical value to explore alkaloids further in this study.

5.5.2 Flavonoids

No flavonoid data are available in the literature for *Rafnia*, hence this is the first account of flavonoids in the genus. Four morphologically distantly related species of *Rafnia* were surveyed for flavonoids. From the ultra-violet/visible spectra, the main class of compounds could be identified as isoflavone C-glycosides, which have a characteristic spectrum. A relatively complex flavonoid profile was obtained from the four species studied (Table 5.2). Table 5.2 represents the presence and quantities of different isoflavone C-glycosides that were obtained from flavonoid extractions, and the retention times of the different peaks from the flavonoid chromatograms

(Figure 5.6, 1–4).

Table 5.2 Presence of different isoflavone-C-glycosides in the leaves and petals of four species of *Rafnia*.

COMPOUNDS		***R. angulata***		***R. triflora***		***R. amplexicaulis***		***R. schlechteriana***	
No.	R_t (min)	Leaf	Petal	Leaf	Petal	Leaf	Petal	Leaf	Petal
X_1	5.8	-	T	T	+	T	-	-	-
X_2	6.5	-	T	-	+	-	-	++	+
X_3	8.1	+	T	+	T	++	T	++	+
X_4	9.5	-	-	-	-	T?	-	+	+
X_5	11.3	+++	+++	+++	+++	+++	+++	+++	+++
X_6	11.9	+	M	+	M	+	M	?	-
X_7	12.9	-	T	T	-	T	-	+	M
X_8	14.5	+	M	M	M	+	M	M	M
X_9	19.4	-	-	+	-	-	-	-	-
X_{10}	20.0	-	-	-	-	T	-	+	+
X_{11}	21.5	-	-	M?	-	T	-	-	-
X_{12}	23.3	-	-	++	T	T	-	-	-

R_t (min) = retention time, in minutes; T = trace compound (< 5 %, or not among the ten largest peaks); M = minor compound (5–15 %); + = major compound (> 15 %); ++ = present in large amounts; +++ = main compound of the profile. For compounds X_1–X_{12}, see Figure 5.6, 1–4.

The compounds with retention times of 8.1 and 11.3 minutes were present in all the extracts and appeared to be generic markers. The other compounds occurred sporadically and may be related to species differences. The compounds in the leaves were mostly similar to those in the petals and only a few compounds were generally lost after hydrolysis. Some species displayed more complex profiles than others, but there were no distinct differences among the species. The preliminary results showed that flavonoids can easily be studied and may prove to be taxonomically valuable after further investigation. It was beyond the scope of this study to explore flavonoid patterns in detail, especially since the overall pattern was found to be highly conservative and of doubtful value at species level.

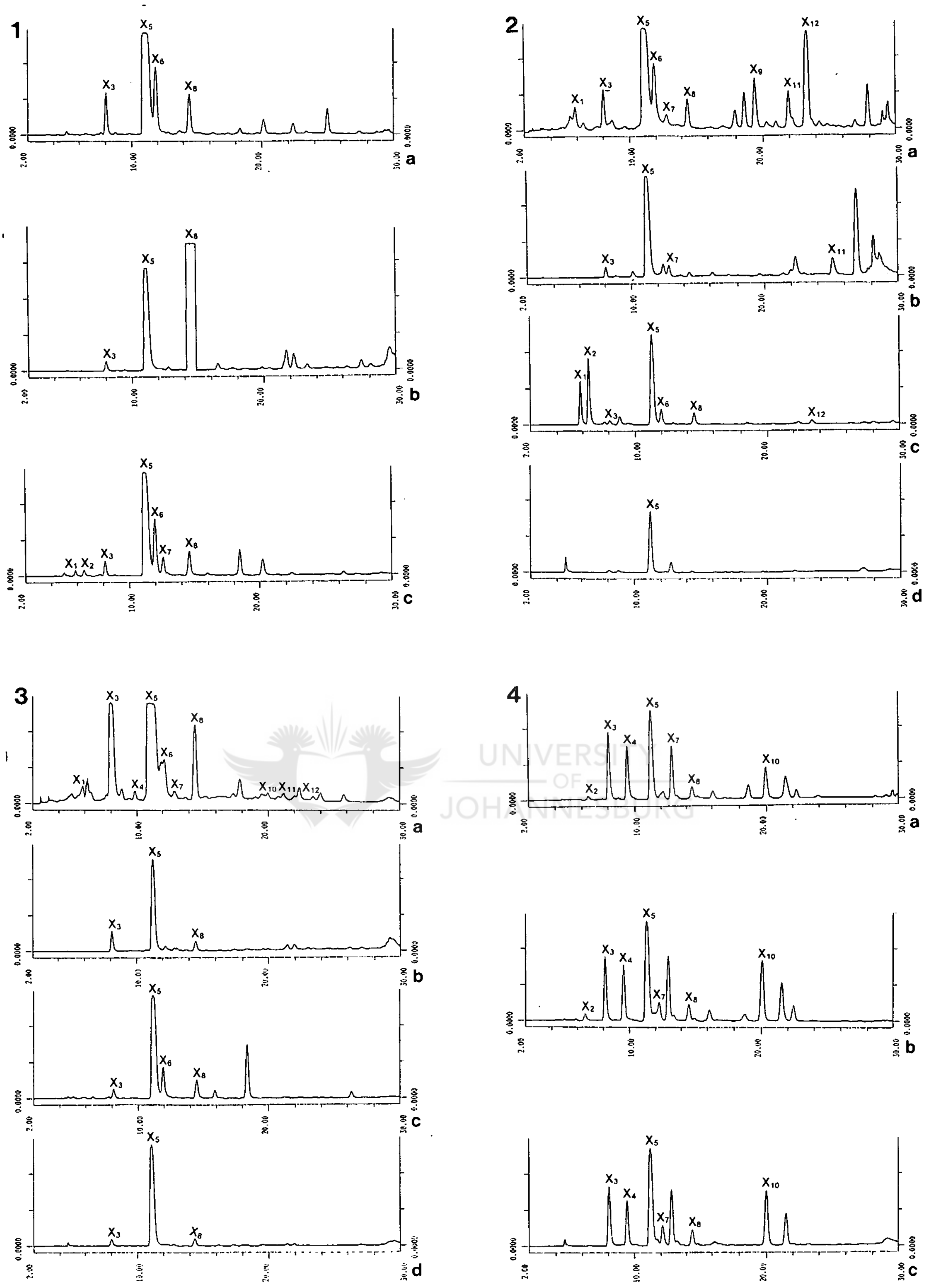


Figure 5.6 HPLC chromatograms of flavonoids in the leaves and petals of four species of *Rafnia*, showing comparisons in flavonoid patterns of crude and hydrolyzed extracts: **1,** *R. angulata* subsp. *angulata*—a, crude leaf extract, b, hydrolyzed leaf extract and c, crude petal extract; **2,** *R. triflora*—a, crude leaf extract, b, hydrolyzed leaf extract, c, crude petal extract and d, hydrolyzed petal extract; **3,** *R. amplexicaulis*—a, crude leaf extract, b, hydrolyzed leaf extract, c, crude petal extract and d, hydrolyzed petal extract; **4,** *R. schlechteriana*—a, crude leaf extract, b, crude petal extract and c, hydrolyzed petal extract.

5.6 Enzymes

A preliminary enzyme study was undertaken for *Rafnia*, the aim of which was to evaluate enzyme results and test the feasibility of using horizontal starch gel electrophoresis in species of *Rafnia*. It was considered unnecessary to determine allele frequencies and genetic distances since there was a strong possibility that the values would deviate considerably from Hardy-Weinberg proportions, due to small sample sizes.

Of the eight protein systems stained for, six produced interpretable banding patterns. There was thus a 75 % success rate with the proteins stained. Nine protein-coding loci provided interpretable results in *R. angulata* subsp. *angulata* and *R. schlechteriana*, of which four (44.44 %) displayed polymorphism (Table 5.3). Five of the nine loci (55.56 %) displayed monomorphic gel banding patterns. In addition to these loci, the following proteins were stained for: aspartate aminotransferase (E.C. 2.6.1.1) and malic enzyme (E.C. 1.1.1.38), but these proteins did not show sufficient activity or resolution to score them satisfactorily in the *Rafnia* samples. Locus abbreviations, monomorphic loci, buffers used and enzyme commission numbers are given in Table 5.3.

Alleles were monomorphic for both species on the GPI locus (Figure 5.7a). With the LAP enzyme, four loci stained, and interlocus banding occurred (Figure 5.7b). CAP-1 and CAP-2 stained for both species and were monomorphic for both, but CAP-2 showed species differences. CAP-3 was also monomorphic and occurred only in *R. schlechteriana*. The absence of this locus in *R. angulata* subsp. *angulata* indicates possible isozyme differences between the species.

The LAP locus (purple band) was monomorphic for *R. schlechteriana* (Figure 5.7b), with the exception of one alternative heterozygote, and showed allele frequency differences in *R. angulata* subsp. *angulata*. Genetic variation was obtained in LAP, but there were no considerable species differences. In the LGG enzyme, which overstained, there was a possibilty of variation, but weak resolution. A different buffer could perhaps give a better resolution.

Table 5.3 Locus abbreviations, buffer systems used and enzyme commission numbers (E.C. No.) are listed after each enzyme.

ENZYME	**LOCUS**	**BUFFER**	**E.C. No.**
Glucose-6-phosphate	GPI	RW	3.5.1.9
Cytosol aminopeptidase	CAP-1, -2, -3	MF	3.4.11.1
Leucine aminopeptidase	LAP*	MF	3.4.11.1
Peptidase substrates:			3.4.-.-.
L-leucyl-L-glycyl-L-glycine	LGG*	MF	
L-phenylalanyl-L-proline	PHP	RW	
Leucyl-tyrosine	LT*	MF	
Peroxidase	PER*	RW	1.11.1.7

*Polymorphic loci

There was variation on LT, but no species differences were apparent (Figure 5.7c). *R. schlechteriana* was monomorphic and *R. angulata* subsp. *angulata* showed allele frequency differences and hence genetic variation.

PER showed the best results, with allele frequencies differing between the two species (Figure 5.7d). The alleles were monomorphic for *R. schlechteriana*, and there was much variation in *R. angulata* subsp. *angulata*. Two loci stained on PHP (Figure 5.7e), both of which were monomorphic.

R. schlechteriana had eight monomorphic loci in total (CAP-1, -2, -3, GPI, LGG, LT, PER and PHP) and one polymorphic (LAP) locus. In *R. angulata* subsp. *angulata*, four

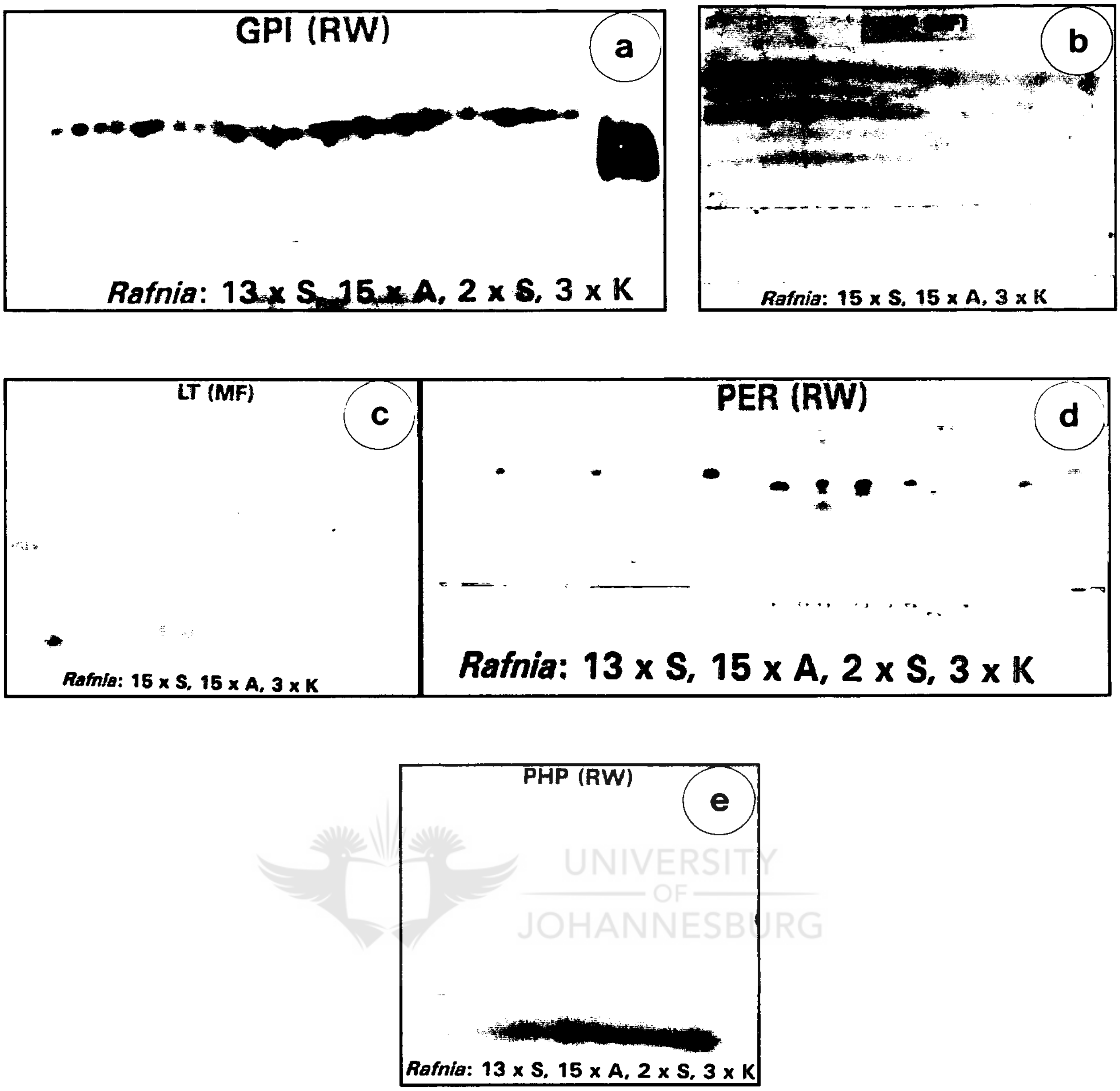


Figure 5.7 Resulting gels obtained from the enzyme electrophoresis study of species of *Rafnia*: **a,** GPI—monomorphic banding patterns for both species; **b,** LAP—three loci for *R. schlechteriana* and two for *R. angulata* subsp. *angulata*; interlocus bands and allele polymorphism in *R. angulata* subsp. *angulata*; **c,** LT—variation in *R. angulata* subsp. *angulata*; **d,** PER—species differences and polymorphism in *R. angulata* subsp. *angulata*; **e,** PHP—monomorphic for both species. The subscripts of the gels may be interpreted as follows: S—*R. schlechteriana*; A—*R. angulata* subsp. *angulata*; K—Control.

loci were monomorphic (CAP-1, -2, GPI and PHP), three showed variation (LAP, LT and PER) and one had no alleles, and this was on a locus that stained for *R. schlechteriana* (CAP-3). There were apparent species differences at two loci (CAP-2 and PER), making these potential genetic markers with which to identify the species, but in view of the obvious geographical variation in *Rafnia*, a much wider sampling would be necessary to compare species. The differences may indeed be population differences rather than species differences. *R. angulata* subsp. *angulata* showed much more variation in total than *R. schlechteriana*, which was expected, since *R. angulata* subsp. *angulata* is a far more variable and widely distributed species than *R. schlechteriana*. This is the first account of electrophoretic variants in *Rafnia* and the technique may be of value in future taxonomic studies. Sufficient sampling to account for the extreme regional variation would be a daunting task indeed.

5.7 Conclusions

The investigation of these additional forms of evidence contributed to a better understanding of relationships or indicated possible further avenues for more detailed studies, perhaps practical for investigating some of the more difficult species complexes in *Rafnia*. Geographical patterns improved the understanding of the complex relationships among the taxa and are useful for distinguishing regional forms within certain taxa. Ecological factors are also useful for identifying some species or forms of species. Flavonoid and enzyme studies showed that these characters do have taxonomic potential in *Rafnia* but that extensive sampling and comprehensive surveys would be necessary to fully evaluate these characters. In view of the large numbers of species and regional forms, the magnitude of such a task was considered to be beyond what would be expected for an M.Sc. study.

CHAPTER 6

PHENETIC ANALYSIS

The advantages and disadvantages of phenetic methods of analysis have been extensively discussed and debated. Chappill (1989) and Farris (1990) discussed the application of quantitative characters in phylogenetic analyses. Phenetic methodology has been applied relatively successfully, but not extensively in the Fabaceae. In a phenetic analysis of the genus *Dichilus*, the five groups obtained corresponded to the five species recognized in *Dichilus*, which are phenetically quite distinct (Schutte & Van Wyk, 1990). González-Andréz & Ortiz (1996) undertook a morphometric analysis of the genus *Cytisus* L. and its allies. The result showed four distinct groups within *Cytisus*, which agreed with the grouping obtained by other seed morphometry and biochemical studies, and supported the proposed generic arrangement.

Both phenetic and cladistic methods were used to explore the intricate relationships among the species of *Rafnia*. The genus was analyzed phenetically in order to quantify the similarities among species, using the package NTSYS-PC 2.01. A number of phenograms were constructed at the subspecies and species levels. A data matrix of 97 characters and 39 OTU's (including species, subspecies and forms) was constructed for the subspecies level phenogram. Fourteen fruit and seed characters, for which there were missing data, were omitted from the final phenograms.

Characters and character states included in the phenetic analysis are given in Table 6.1. A data matrix of 83 characters and 19 species (Table 6.2) was constructed for the species level phenogram, the result of which is presented below (Figure 6.1). Morphometric values for all OTU's and subspecies were included in the final measurements presented for the species. As many meaningful quantitative characters as possible, and some qualitative characters, were included in the analysis. A number of phenograms were constructed, and various coefficients of similarity applied to each. The Unweighted Pair Group Method of Analysis (UPGMA) gave a satisfactory result, presented in the form of the phenogram in Figure 6.1. The most satisfactory result was obtained using the Simple Matching Coefficient, which was most suitable for the type of data available (a mixture of qualitative and quantitative characters).

Table 6.1 Characters and character states used for the phenetic analysis.

1, Leaf arrangement on flowering branches (1 = invariably alternate; 2 = subopposite or opposite; 3 = opposite); **2,** Leaf pair below flower (1 = similar to vegetative leaves; 2 = reduced or absent); **3,** Maximum flowering branch leaf length (mm); **4,** Mean flowering branch leaf length (mm); **5,** Maximum basal leaf length (mm); **6,** Mean basal leaf length (mm); **7,** Maximum flowering branch leaf width (mm); **8,** Mean flowering branch leaf width (mm); **9,** Maximum basal leaf width (mm); **10,** Mean basal leaf width (mm); **11,** Maximum flowering branch leaf length:maximum flowering branch leaf width; **12,** Mean flowering branch leaf length:mean flowering branch leaf width; **13,** Maximum basal leaf length:maximum basal leaf width; **14,** Mean basal leaf length:mean basal leaf width; **15,** Leaf base shape (1 = cuneate or angustate; 2 = cuneate or rounded; 3 = cordate); **16,** Leaf venation (1 = non-reticulate; 2 = reticulate); **17,** Maximum inflorescence axis length (mm); **18,** Maximum number of flowers per inflorescence; **19,** Maximum flower length (mm); **20,** Mean flower length (mm); **21,** Maximum pedicel length (mm); **22,** Maximum flower length:maximum pedicel length; **23,** Maximum bract length (mm); **24,** Maximum bracteole length (mm); **25,** Maximum calyx length (mm); **26,** Mean calyx length (mm); **27,** Mean calyx length:mean corolla length; **28,** Maximum calyx lobe length (mm); **29,** Mean calyx lobe length (mm); **30,** Maximum calyx tube length (mm); **31,** Mean calyx tube length (mm); **32,** Calyx lobe length:calyx tube length; **33,** Wing-like extension on calyx tube between upper lobes (1 = no extension; 2 = ridge-like extension; 3 = wing-like extension); **34,** Maximum upper calyx lobe width (mm); **35,** Mean upper calyx lobe width (mm); **36,** Upper calyx lobes (1 = non-falcate; 2 = falcate); **37,** Maximum lateral calyx lobe width (mm); **38,** Mean lateral calyx lobe width (mm); **39,** Maximum carinal calyx lobe width (mm); **40,** Mean carinal calyx lobe width (mm); **41,** Carinal calyx lobe (1 = shorter than or as long as other lobes; 2 = longer than other lobes); **42,** Upper calyx lobe width:lateral calyx lobe width; **43,** Carinal calyx lobe width:lateral calyx lobe width; **44,** Maximum depth of upper calyx sinus (mm); **45,** Mean depth of upper calyx sinus (mm); **46,** Maximum depth of lateral calyx sinus (mm); **47,** Mean depth of lateral calyx sinus (mm); **48,** Maximum depth of lower calyx sinus (mm); **49,** Mean depth of lower calyx sinus (mm); **50,** Depth of upper calyx sinus:depth of lateral calyx sinus; **51,** Depth of lower calyx sinus:depth of lateral calyx sinus; **52,** Maximum standard length (mm); **53,** Mean standard length (mm); **54,** Standard (1 = not folded in along edges; 2 = folded in along edges); **55,** Basal callosities on standard (1 = absent; 2 = present); **56,** Maximum wing length (mm); **57,** Mean wing length (mm); **58,** Wing sculpturing (1 = invariably present; 2 = present or absent; 3 = invariably absent); **59,** Maximum number of rows of wing sculpturing; **60,** Maximum keel length (mm); **61,** Mean keel length (mm); **62,** Pocket on keel (1 = indistinct; 2 = distinct); **63,** Keel shape (1 = non-rostrate; 2 = rostrate); **64,** Keel shape (1 = not lobed below apex; 2 = slightly lobed below apex; 3 = markedly lobed below the apex); **65,** Standard length:keel length; **66,** Wing length:keel length; **67,** Standard length:calyx length; **68,** Wing length:calyx length; **69,** Keel length:calyx length; **70,** Stigma (1 = small; 2 = capitate); **71,** Stigma (1 = glabrous; 2 = fibrillose); **72,** Style (1 = shorter than ovary; 2 = as long as or longer than ovary); **73,** Maximum length of basifixed anthers (mm); **74,** Mean length of basifixed anthers (mm); **75,** Maximum length of carinal anther (mm); **76,** Mean length of carinal anther (mm); **77,** Maximum length of dorsifixed anthers (mm); **78,** Mean length of dorsifixed anthers (mm); **79,** Length of basifixed anthers:length of dorsifixed anthers; **80,** Length of basifixed anthers:length of carinal anther; **81,** Length of dorsifixed anthers:length of carinal anther; **82,** Staminal sheath (1 = even width; 2 = widened towards base); **83,** Filaments (1 = free parts more than half as long as sheath; 2 = free parts less than half as long as sheath).

The taxonomic structure (Figure 6.1) shows two definite groups in *Rafnia*. These groups correspond exactly with the two monophyletic clades of the cladogram (see Figure 7.1). The phenogram shows that the arrangement of species based on similarity agrees closely with the arrangement of species on the cladogram. The main differences between the phenogram and cladogram are in section *Rafnia*, where relationships are as yet unresolved.

The two main groups formed on the phenogram within section *Rafnia* do not correspond with the groupings on the cladogram. Smaller groups, such as those of *R. alata* and R. *acuminata* are similar on the phenogram and cladogram, but differ in order, e.g. *R. vlokii* and *R. alata* are sister taxa on the cladogram, but are phenetically separated on the phenogram. The same is true for *R. acuminata* and *R. amplexicaulis*. *R. racemosa* and *R. angulata* are separated by a relatively large phenetic distance on the phenogram, but based on a combination of other morphological characters, they are considered very closely related. *R. diffusa* and *R. spicata* are separated from the *R.*

capensis group by a large distance on the phenogram, whereas they are closely related to the *R. capensis* clade by a number of synapomorphies on the cladogram.

Table 6.2 Matrix of 19 species and 83 characters used for constructing the phenogram for *Rafnia* in Figure 6.1. (Characters and character states are given in Table 6.1.)

Species **Character number**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
R. racemosa	1	1	45	34	60	35	16	10	24	13	4.5	3.4	4.4	3.1	1	1	152	19	19	15.4
R. angulata	2	1	46	18	45	25	14	3.6	19	4.2	46	10	32	9.7	1	1	19	6	20	12.4
R. crispa	2	2	70	57	55	48	13	10	15	13	7.9	5.9	3.9	3.6	1	1	15	1	15	14.3
R. lancea	2	2	46	39	40	28	10	7	10	6	7	5.7	6.5	4.8	1	1	13	1	23.5	20.4
R. rostrata	2	1	40	24	32	23	15	9	24	8	5.3	3	11.5	4.1	1	1	5	5	19	15.1
R. vlokii	2	1	55	42	87	57	18	12	33	20	5.1	3.6	3.8	2.9	1	1	6	1	25	22.5
R. alata	2	1	51	36	54	35	19	10	32	12	5.7	3.8	6	3.7	1	1	0	1	25	18.8
R. crassifolia	2	1	44	35	55	44	13	10	17	13	4.5	3.7	5.5	3.7	1	1	0	1	20	15
R. elliptica	2	1	55	51	98	71	20	15	31	24	5.1	3.5	4.8	3.2	1	1	9	3	23	17.5
R. triflora	2	2	50	37	121	72	34	19	110	38	3.4	2.1	3.6	2.3	2	1	28	1	21	17.6
R. ovata	2	2	63	48	118	81	37	23	92	63	3.2	2.2	2.1	1.4	1	1	7	4	22	19.3
R. inaequalis	3	1	37	30	50	37	25	19	36	25	1.9	1.6	1.8	1.5	3	1	0	1	15	13.4
R. acuminata	3	1	40	24	40	30	36	21	36	25	1.5	1.2	1.6	1.2	3	2	0	1	14	11.5
R. amplexicaulis	3	1	42	30	77	51	44	33	88	53	1.3	0.9	1.3	1	3	2	0	1	17	14.2
R. diffusa	2	1	24	16	35	23	15	7	20	12	4.5	2.4	4	2.1	1	1	0	1	9	7.8
R. spicata	2	1	26	21	40	30	10	4	18	9	9	5.6	6.7	4	1	1	0	1	8	7
R. schlechteriana	3	1	45	37	76	54	34	22	60	45	2.8	1.8	1.6	1.2	2	1	0	1	16.5	13.1
R. capensis	2	1	42	21	60	25	19	10	34	13	12	2.4	4.9	4.9	2	1	68	45	14	10.2
R. globosa	3	1	33	25	44	35	18	12	26	20	3.3	2.2	2.7	1.9	1	1	0	1	14	11.4

Species **Character number**

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
R. racemosa	6.5	3.2	2.1	1.1	12	9.4	1.1	7	5.5	6	4	1.5	1	3.7	3.1	1	3.6
R. angulata	11	1.9	1.7	1.2	12.5	7.5	2.1	7.6	3.9	5.5	3.5	1.2	1	3.1	2.3	2	3
R. crispa	2	8.3	1.6	1.1	8.3	7.3	1.2	3.9	3.3	7	4.5	1	1	3.2	3.1	1	3
R. lancea	3	9.4	1.7	1	14	12	1.1	7	5.5	8	6.1	1	1	2.8	2.3	1	3
R. rostrata	8	2.3	2	0.7	13.5	11.1	2.2	8	6.8	5.5	4.1	1.7	1	3.2	2.8	2	3.3
R. vlokii	6	3.2	1.1	0.5	19.5	18.7	14.6	15	14.1	4.5	4	3.4	2	7.6	7.5	2	4.8
R. alata	8	3.8	5.1	1	22	14.9	8.5	17	10.8	8	4.5	2.7	3	6.3	5.3	2	6
R. crassifolia	17.5	1.1	0.8	0.7	18	15.7	8.6	13	10.7	5.2	4.6	2.4	2	4.3	4.1	2	3
R. elliptica	10.5	1.9	2.3	1.3	18.5	14	1.9	12.5	8.7	6	5.3	1.6	2	4.2	4	2	3.8
R. triflora	4.5	6.7	1.7	1.4	16	11.7	1.8	11	6.8	6	4.8	1.5	2	4.8	4.2	2	3.3
R. ovata	4.5	5	1.3	0.6	11	8.4	0.7	5	3.5	6	4.7	0.8	2	4.8	4.3	1	3.9
R. inaequalis	9	1.6	1.5	0.6	14.1	12.3	5.2	10	8.5	5.3	4.3	2.2	3	4.7	4.3	2	2.7
R. acuminata	4	4.2	1.7	0.7	11.4	7.7	3.1	9	5.4	3.2	2.3	2.4	1	4.9	3.4	2	2.3
R. amplexicaulis	5	3	0.7	0	10	7.5	0.9	4	2.9	6.3	4.5	0.7	1	5.7	3.7	2	4.6
R. diffusa	4	4.2	1.2	0.3	3.8	2.3	0.4	2	1.1	2.7	1.4	0.9	1	1.8	1.4	1	1.5
R. spicata	3	3.6	0.9	0.3	4.4	3	0.5	2	1.6	2.7	1.7	1	1	1.7	1.5	1	1.3
R. schlechteriana	6.5	2.3	1.6	0.6	11.4	7.8	1.1	5.5	4.1	6.3	4.3	1.1	1	4.9	4	1	4.1
R. capensis	17.5	2.5	3	0.7	12.1	5.9	1.6	9.1	3.5	4.8	2.7	1.3	1	3.3	2.5	1	3
R. globosa	4.5	3	1.7	0.4	7.9	6.6	1.1	4.5	3.7	3.7	3.1	1.2	1	2.8	2.5	1	2.8

Species **Character number**

	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
R. racemosa	2.9	2	1.5	1	1.1	0.5	6.9	5.8	7.1	6.3	7	6.4	0.9	1	17.8	14.2
R. angulata	1.8	1.4	0.9	1	1.3	0.5	7.8	4.6	6	4.1	8	4.1	1.2	1	16.5	10.1
R. crispa	2.7	1.5	1.3	1	1.1	0.5	4.9	4.8	3.9	3.8	6.1	6	1.3	1.6	15	14
R. lancea	2.8	1.5	1.2	1	0.8	0.5	6.1	5.2	4	3.6	6.9	6.7	1.4	1.8	14.4	14.1
R. rostrata	2.5	1.8	1.4	1	1.2	0.6	7.6	6.9	7.6	6.9	8.4	7	1	1	14.7	12.9
R. vlokii	4.7	0.5	0.5	1	1.6	0.07	15	14.2	14.5	13.7	12.4	12.3	1	0.9	18	16.5
R. alata	4.1	4.3	2.9	1	1.4	0.7	13.4	10.3	13.3	9.8	13.3	10.1	1.1	1	19.5	15.2
R. crassifolia	2.6	1	0.9	1	1.6	0.4	12	11.2	10.9	10.1	11.7	10.7	1.1	1.1	18	15.6
R. elliptica	3.3	2.1	1.8	1	1.2	0.5	11	9.6	10.8	8.7	11.6	9.3	1.1	1.1	18.2	15.7
R. triflora	3.1	1.1	1	1	1.4	0.3	12.1	8.1	9.7	6.6	9.9	6.8	1.3	1	17.8	15.4
R. ovata	3.4	2.1	1.7	1	1.3	0.5	5.2	4.9	4.6	3.8	4	3.8	1.3	1	20.3	18.5
R. inaequalis	2.6	0.3	0.2	1	1.7	0.05	8.4	8.1	6.8	6.5	8.2	7.4	1.3	1.1	13.1	12.3
R. acuminata	2	1.5	1.2	1	1.7	0.6	8.2	5.6	8.6	5.6	8.2	5.4	1.1	1	14.1	11.6
R. amplexicaulis	3.4	3.5	2.4	1	1.1	0.7	3.9	3.2	4.3	3.6	4.3	3.5	0.9	1	16	13.7
R. diffusa	1.2	0.9	0.6	2	1.2	0.5	2.4	1.5	2.4	1.7	2.1	1.2	0.9	0.7	8.7	7.3
R. spicata	1.2	0.6	0.5	2	1.3	0.4	2.1	1.9	2.3	2.1	1.5	1.4	0.9	0.7	6.4	5.8
R. schlechteriana	3.4	2.2	1.8	2	1.2	0.5	5.8	4.6	6.4	4.9	5.3	3.8	1	0.8	11.9	10.2
R. capensis	2.1	1.6	1	2	1.2	0.5	6.3	3.5	8.7	3.7	5.7	3.5	1	0.9	12.8	8.2
R. globosa	2.3	1	0.9	2	1.1	0.5	4.4	3.8	4.6	3.9	3.9	3.7	1	1	14.3	10.8

Species **Character number**

	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
R. racemosa	1	1	13.8	12.3	1	7	12.7	11.3	1	2	1	1.3	1.2	1.4	1.2	1.1	1	1	1	2.2
R. angulata	1	1	15.3	8.5	1	12	14.7	9.5	1	2	1	1.1	0.9	1.4	1.2	1.4	1	1	2	3.1
R. crispa	1	1	15	14.7	1	6	14	13.5	1	2	1	1	1.1	2	2	1.9	1	1	2	2.3
R. lancea	1	1	13.4	12.6	1	8	12.1	11.6	1	2	1	1.2	1.1	1.2	1.2	1.1	1	1	2	2.3
R. rostrata	1	1	13.2	11.4	1	6	12.5	11	1	2	1	1.2	1.1	1.3	1.1	1	1	1	1	2.4
R. vlokii	1	1	14	13.4	1	7	13.5	13	1	2	1	1.3	1	0.9	0.7	0.7	1	1	1	3
R. alata	1	2	15.3	11.8	1	7	10.8	9.4	1	2	1	1.6	1.2	0.9	0.7	0.6	1	1	1	2.3
R. crassifolia	1	1	11.3	10.1	1	7	10.5	9.6	1	2	1	1.6	1	1.1	0.7	0.7	1	1	2	2.2
R. elliptica	1	2	16.5	13.2	1	9	16.5	12.4	1	2	1	1.3	1	1.2	1	1	1	1	1	3.3
R. triflora	1	2	15.7	14	1	7	14	13.1	1	2	1	1.2	1.1	1.5	1.4	1.3	1	1	2	2.7
R. ovata	1	2	18.8	17	1	9	15.9	14.2	1	2	1	1.2	1.2	2.4	2.2	1.9	1	1	1	2.9
R. inaequalis	1	1	9.4	8.4	1	7	11	10.2	1	2	1	1.2	0.8	0.9	0.6	0.7	1	1	2	2.3
R. acuminata	1	2	12.5	10.6	1	7	11	9.2	1	2	1	1.3	1.1	1.5	1.4	1.2	1	1	2	1.9
R. amplexicaulis	1	2	12.5	11.5	1	7	10.5	9.1	1	2	1	1.5	1.3	2.1	1.7	1.3	1	1	1	2.2
R. diffusa	1	1	7.6	6.2	1	6	7	5.9	2	1	2	1.3	1.1	2.7	2.4	2.2	1	2	1	0.9
R. spicata	1	1	6.5	5.6	2	4	6.3	5.1	2	1	2	1.2	1.1	1.6	1.5	1.4	1	2	1	1
R. schlechteriana	2	1	11.4	10.1	3	0	10	8.8	2	1	3	1.1	1.2	1.2	1.2	1	1	2	1	1.5
R. capensis	2	1	10.8	7.1	3	0	9.2	7.3	2	1	3	1.1	1	1.3	1.1	1.2	2	2	1	1.8
R. globosa	2	1	10.2	9.1	3	0	8.8	7.8	2	1	2	1.4	1.2	1.5	1.3	1.1	2	2	1	1.5

Species **Character number**

	74	75	76	77	78	79	80	81	82	83
R. racemosa	1.8	1.7	1.4	1	0.8	1.5	2.3	0.7	1	1
R. angulata	1.9	2.1	1.2	1	0.6	1.6	3	0.6	1	1
R. crispa	2.1	1.5	1.2	1	0.8	1.7	2.5	0.7	1	1
R. lancea	2	1.8	1.5	0.6	0.6	1.4	3.6	0.4	1	1
R. rostrata	2.2	1.6	1.4	1.2	1	1.4	2.3	0.6	1	1
R. vlokii	2.5	2.2	1.8	1.2	1.1	1.4	2.3	0.6	1	1
R. alata	1.9	1.6	1.2	1.3	0.8	1.8	2.5	0.7	1	1
R. crassifolia	2	1.1	0.8	0.5	0.4	2.8	4.7	0.7	1	1
R. elliptica	2.4	2.5	1.8	1.6	1	1.4	2.4	0.6	1	1
R. triflora	2.2	2	1.5	1.2	0.9	1.6	2.6	0.6	1	1
R. ovata	2.4	2.3	2	1.3	1	1.4	2.3	0.6	1	1
R. inaequalis	2.1	1.3	1.2	0.8	0.7	1.7	3	0.6	1	1
R. acuminata	1.6	1.2	0.9	0.8	0.6	1.8	2.3	0.8	1	1
R. amplexicaulis	2	1.6	1.4	0.9	0.8	1.5	2.6	0.6	1	1
R. diffusa	0.8	0.6	0.5	0.4	0.3	1.8	2.6	0.7	1	2
R. spicata	0.9	0.5	0.4	0.3	0.3	2.4	3.2	0.8	1	2
R. schlechteriana	1.3	0.7	0.6	0.7	0.5	2.3	2.9	1	2	2
R. capensis	1	1.5	0.6	0.7	0.4	1.8	2.8	0.7	2	2
R. globosa	1.4	1.2	1	0.5	0.4	1.3	3.3	0.4	2	2

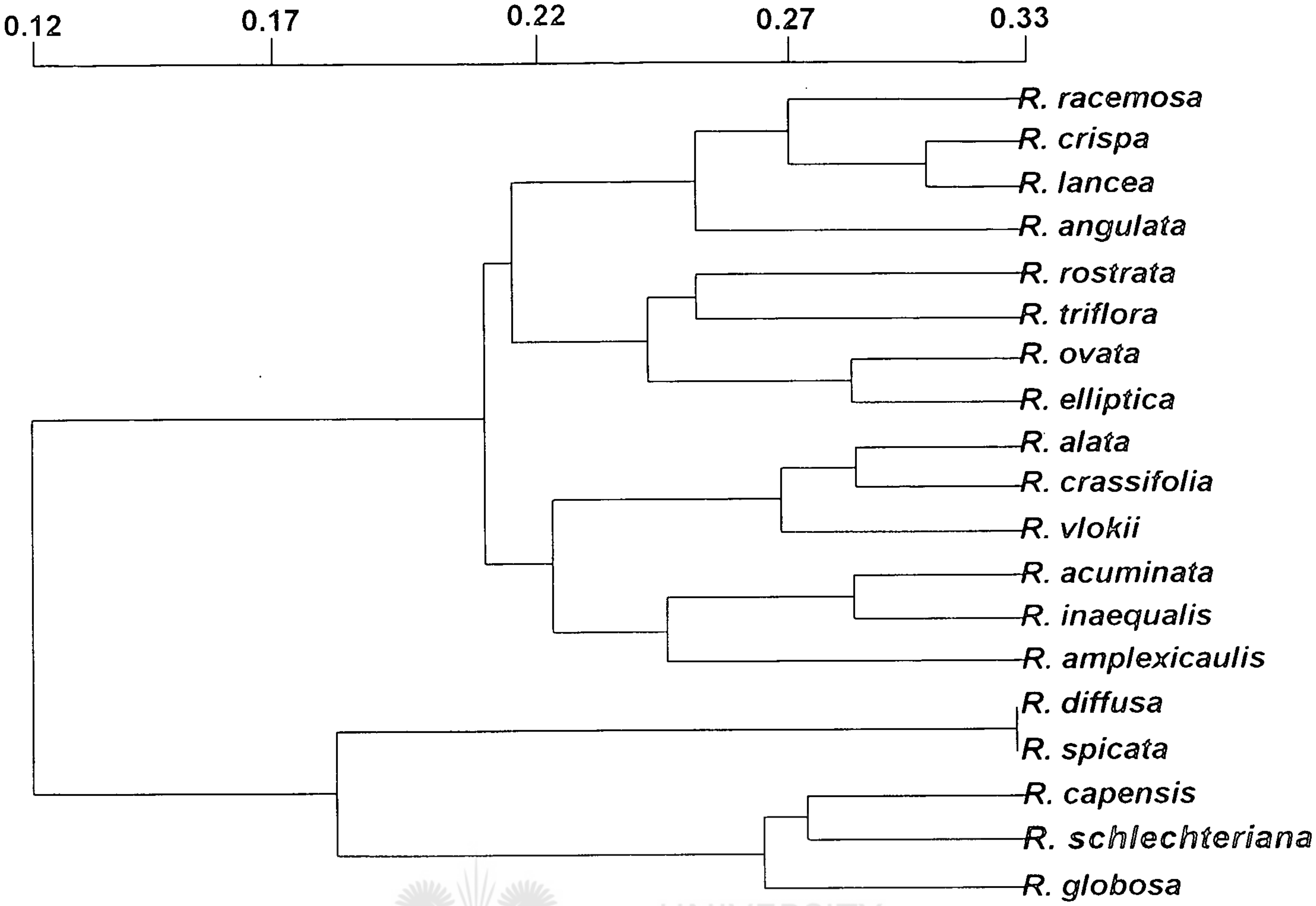


Figure 6.1 Phenogram of 19 species and 83 characters to illustrate phenetic similarity among species of *Rafnia*. The phenogram was constructed using the simple matching coefficient. Scale shows amalgamation distance.

CHAPTER 7

CLADISTIC ANALYSIS

Bentham (1843) provided a sectional classification for *Rafnia* and his ideas were followed by Harvey (1862). Due to the discovery of several new species and subspecies of *Rafnia* and an improved understanding of relationships among the taxa, these classifications have become outdated, hence a re-evaluation of relationships in *Rafnia* is necessary.

Linder (1988) reviewed the application of cladistic methodology in botany, and cladistics has been applied in the Fabaceae in the studies of Lavin (1987), Crisp & Weston (1987), Zandee & Geesink (1987), Schutte & Van Wyk (1990), Van Wyk & Verdoorn (1990), Van Wyk (1991a, b), Chappill (1995), Luckow & Hopkins (1995), Schrire (1995) and Van Wyk & Schutte (1995).

The work of Polhill (1976) provided new insight into characters within the Crotalarieae. Van Wyk & Schutte (1995) explored relationships within the tribes Podalyrieae, Liparieae and Crotalarieae and the cladistic approach led to a better understanding of relationships and improved evaluation of circumscriptions of taxa.

The cladistic method was used to propose an hypothesis of relationships and groupings within *Rafnia* and to recognize the patterns in character state distributions. These patterns were used to formulate a classification. The cladogram (Figure 7.1) provides a summary of the probable order of character development in *Rafnia* and represents a first explicit hypothesis of phylogenetic relationships at species level.

The outgroup method was used for the polarization of character states. *Aspalathus* was chosen as outgroup since it shares a number of characters with *Rafnia* and is considered to be the sister genus of *Rafnia* (Van Wyk & Schutte, 1995).

All discontinuous and logically polarizable characters in *Rafnia* were initially included in the analysis (Table 7.1). Character states occurring in both the outgroup and the study group were considered plesiomorphic, and those unique to *Rafnia* were considered apomorphic. Variable characters (where the plesiomorphic and apomorphic states co-occur) were encoded for the plesiomorphic state and autapomorphies and invariable characters were omitted from the analysis

Nineteen species and 26 characters were included in the final analysis (Table 7.1). Character states were assigned numerical values (0, 1, 2): plesiomorphic = 0, apomorphic = 1, and a taxon x character matrix was compiled (Table 7.1). The 'ie' and 'nelsen' commands of Hennig86 (Farris, 1988) were used, since these guarantee the shortest possible consensus tree or trees.

Various alternatives were investigated, using different combinations of characters and various polarizations, since there was often character conflict. Characters which created much homoplasy were removed from the analysis in various combinations, after investigating the 'x steps c' command of Hennig86, resulting in improved tree topologies. The resulting topology, of a tree with with a length of 39 steps, a retention index of 87 and a consistency index of 71, is shown in the cladogram in Figure 7.1.

Table 7.1 Characters and polarization of character states in *Rafnia*.

	Characters and character states												
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Outgroup	0	0	0	0	0	0	0	0	0	0	0	0	0
R. racemosa	0	0	0	0	0	0	0	0	0	0	0	0	0
R. angulata	0	0	0	0	0	0	0	0	0	0	0	0	0
R. crispa	1	0	0	0	0	0	0	0	0	0	0	0	0
R. lancea	1	0	0	0	0	0	0	0	0	0	0	0	0
R. rostrata	0	0	0	0	0	0	0	1	0	0	1	0	0
R. vlokii	0	0	0	0	1	1	0	1	1	1	0	1	0
R. alata	0	0	0	0	1	1	0	1	1	1	0	2	0
R. crassifolia	0	0	0	0	1	0	0	1	1	0	0	1	0
R. elliptica	0	0	0	0	0	0	0	1	1	0	0	1	0
R. triflora	1	0	1	0	0	0	0	1	1	0	0	1	1
R. ovata	1	0	1	0	0	0	0	0	1	0	0	1	1
R. inaequalis	0	1	1	0	1	0	0	1	1	0	0	2	0
R. acuminata	0	1	1	1	0	0	0	1	1	0	0	0	0
R. amplexicaulis	0	1	1	1	0	0	0	1	1	0	0	0	0
R. diffusa	0	0	0	0	0	0	1	0	0	0	1	0	0
R. spicata	0	0	0	0	0	0	1	0	0	0	1	0	0
R. schlechteriana	0	0	1	0	0	0	1	0	1	0	1	0	0
R. capensis	0	0	0	0	0	0	1	0	0	0	1	0	0
R. globosa	0	0	0	0	0	0	1	0	0	0	1	0	0

	Characters and character states												
Species	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Outgroup	0	0	0	0	0	0	0	0	0	0	0	0	0
R. racemosa	0	0	0	1	0	0	0	0	0	0	0	0	0
R. angulata	0	0	0	1	0	0	0	0	0	0	0	0	0
R. crispa	0	0	0	1	0	0	0	0	0	0	0	0	0
R. lancea	0	0	0	1	0	0	0	0	0	0	0	0	0
R. rostrata	0	0	0	1	0	0	0	0	0	0	0	0	0
R. vlokii	1	0	0	1	0	0	0	0	0	0	0	0	0
R. alata	1	0	0	1	0	0	0	0	0	0	0	0	0
R. crassifolia	1	0	0	1	0	0	0	0	0	0	0	0	0
R. elliptica	1	0	0	1	0	0	0	0	0	0	0	0	0
R. triflora	0	0	0	1	0	0	0	0	0	0	0	1	0
R. ovata	0	0	0	1	0	0	0	0	0	0	0	1	0
R. inaequalis	0	0	0	1	0	0	0	0	0	0	1	0	0
R. acuminata	0	0	0	1	0	0	0	0	0	0	0	0	0
R. amplexicaulis	0	0	0	1	0	0	0	0	0	0	0	0	0
R. diffusa	0	0	0	0	0	1	0	1	1	0	1	0	0
R. spicata	0	0	1	0	1	1	0	1	1	0	1	0	0
R. schlechteriana	0	1	2	0	1	1	1	1	1	0	0	0	1
R. capensis	0	1	2	0	1	1	1	1	1	1	1	0	1
R. globosa	0	1	2	0	1	1	1	1	1	1	1	0	1

1, Leaf pair below flowers: 0 = similar to vegetative leaves; 1 = reduced or absent. **2, Leaf shape:** 0 = non-cordate; 1 = cordate. **3, Width of basal leaves:** 0 = narrow (mean less than 40 mm); 1 = broad (mean equal to or more than 40 mm). **4, Leaf venation:** 0 = non-reticulate; 1 = reticulate. **5, Calyx length:that part of corolla exceeding calyx (maximum ratio):** 0 = less than 10; 1 = equal to or more than 10. **6, Calyx lobes:calyx tube (mean ratio):** 0 = short (less than 3); 1 = long (equal to or more than 3). **7, Calyx (trifid lower lip):** 0 = absent; 1 = present. **8, Calyx (upper lobe shape):** 0 = non-falcate; 1 = falcate. **9, Calyx (upper lobe width):** 0 = narrow (mean less than 3.5 mm); 1 = broad (mean equal to or more than 3.5 mm). **10, Calyx (lateral lobe width):** 0 = narrow (mean less than 4.5 mm); 1 = broad (mean equal to or more than 4.5 mm). **11, Calyx (carinal lobe):** 0 = shorter than or equal to other lobes; 1 = longer than other lobes. **12, Calyx (wing-like extension on tube between upper lobes):** 0 = absent; 1 = ridge-like extension present; 2 = wing-like extension present. **13, Calyx (upper sinus):** 0 = not much deeper than lateral sinus; 1 = much deeper than lateral sinus. **14, Calyx (depth of lower sinus):** 0 = shallow (mean less than 9 mm); 1 = deep (mean equal to or more than 9 mm). **15, Standard petal:** 0 = not folded in along edges; 1 = folded in along edges. **16, Wing petal sculpturing:** 0 = invariably present; 1 = present or absent; 2 = invariably absent. **17, Keel petal shape:** 0 = non-rostrate (beaked); 1 = rostrate (beaked). **18, Keel petal shape:** 0 = not lobed below apex; 1 = slightly lobed below apex; 2 = markedly lobed below apex. **19, Keel petal:** 0 = pocket indistinct; 1 = pocket distinct. **20, Staminal sheath:** 0 = even width; 1 = widened towards base. **21, Free parts of filaments:** 0 = more than half as long as fused part; 1 = less than half as long as fused part. **22, Stigma:** 0 = glabrous; 1 = fibrillose. **23, Stigma:** 0 = small; 1 = capitate. **24, Pods:** 0 = non-stipitate; 1 = stipitate. **25, Pod length:pod width (mean ratio):** 0 = less than 6; 1 = equal to or more than 6. **26, Seed sinus:** 0 = shallow; 1 = deep.

The monophyly of *Rafnia* is supported by three apomorphies, namely simple, sessile leaves, total glabrescence of the leaves and petals and the presence of minute hairs on the inner surfaces of the calyx, towards the apex of the bracts, bracteoles and sterile extensions of the rachis. There are two monophyletic groups within the genus which are formally treated in Chapter 9 as sections *Rafnia* (rostrate keels), including species from *R. racemosa* to *R. amplexicaulis* on the cladogram (Figure 7.1) and *Colobotropis* (truncate keels), including species from *R. diffusa* to *R. globosa* on the cladogram (Figure 7.1). Two clades that were always well resolved, proving to be convincing groups, include the '*acuminata*' clade, including *R. inaequalis*, *R. acuminata* and *R. amplexicaulis* (Figure 7.1), and the '*capensis*' clade, including *R. diffusa*, *R. spicata*, *R. schlechteriana*, *R. capensis* and *R. globosa* (Figure 7.1).

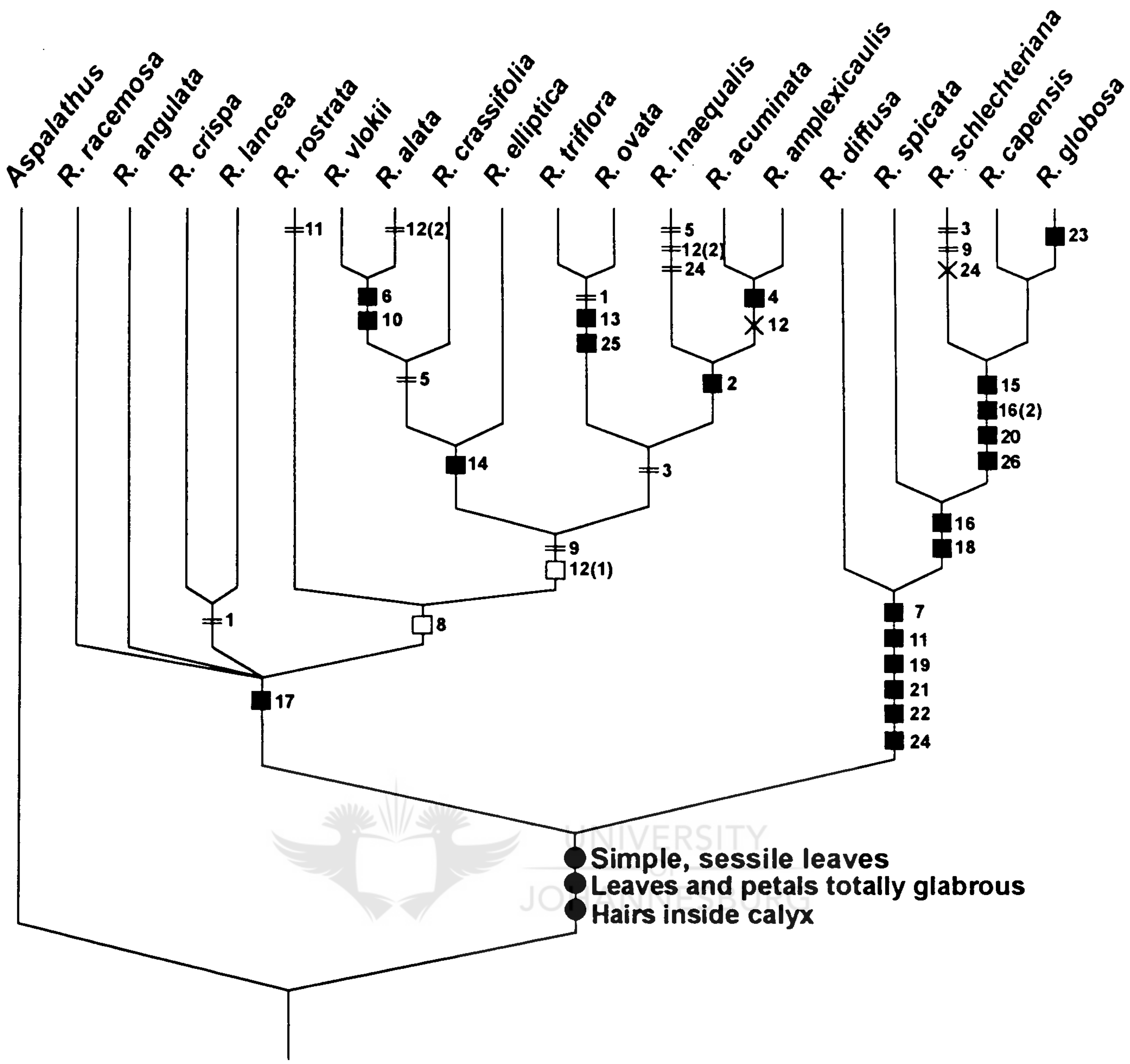


Figure 7.1 Cladogram of *Rafnia*, with *Aspalathus* as outgroup, showing hypothetical phylogenetic relationships among the species. The result was obtained with Hennig86 (Farris, 1988), using the 'ie' option (retention index 87; consistency index 71). Characters and character states are numbered as in Table 7.1. (■) = synapomorphies without reversals; (☐) = synapomorphies with reversals; (=) = convergences; (✕) = reversals; (●) = generic synapomorphies.

There was poor resolution in the basal part of the cladogram within section *Rafnia*, which may well be a paraphyletic assemblage, rather than monophyletic. There is still uncertainty about the true relationships among these species because overall similarities may confuse the real relationships. Since relationships in section *Rafnia* were not fully resolved, and to facilitate the arrangment of the species, this rather diverse section was divided into four informal groups. These include the paraphyletic '*racemosa*' group (including *R. racemosa*, *R. angulata*, *R. crispa*, *R. lancea* and *R. rostrata*), which has strongly rostrate keels and oblanceolate pods, the '*elliptica*' group (including *R. vlokii*, *R. alata*, *R. crassifolia* and *R. elliptica*), with calyx characters to support it, the '*triflora*' group (including *R. triflora* and *R. ovata*), based on inflorescence structure and the '*acuminata*' group (including *R. inaequalis*, *R. acuminata* and *R. amplexicaulis*), based on cordate, reticulate leaves.

Comparisons of graphic summaries of quantitative characters (Figures 3.6, 3.7, 4.4, 4.8 & 4.14) with the taxonomic structure of the phenogram in Figure 6.1 [and also the topology of the cladogram (see Figure 7.1)] improved our confidence in both the phenogram and cladogram, since phenetic trends compared favourably with phylogenetic trends. There is thus additional support for the grouping of taxa from some quantitative characters, although we could not logically polarize these for use in the cladistic analysis. This is an independent indication that the cladogram may be considered a close representation of phylogenetic trends in *Rafnia* (as far as it is possible to extrapolate these from the limited information presently available).

This result of a strongly monophyletic group (e.g. section *Colobotropis*) within an apparently paraphyletic assemblage (e.g. section *Rafnia*), is also found in other plant groups, with examples in the Bossiaeeae and Mirbelieae of the Fabaceae, the Apiaceae and Araliaceae, Lamiaceae and Verbenaceae. The merits for or against recognizing paraphyletic groups have been extensively debated in recent issues of *Taxon*, e.g. Van Welzen (1997).

The cladistic analysis of *Rafnia* provided insight into the previously misinterpreted relationships among the taxa, in spite of the extreme variation in characters and character states, as reflected in the new classification.

Since the best cladograms were only partially resolved, it is concluded that the true infrageneric phylogeny of *Rafnia* seems too complex to be reconstructed from morphological characters alone. The proposed cladogram nevertheless provides a working hypothesis for future studies, possibly using chemical and/or molecular techniques. Without this basic taxonomic framework, no sensible sampling strategy would be possible.

CHAPTER 8

CONCLUSIONS

This study showed that *Rafnia* has been relatively poorly known, collected and understood. There are numerous taxonomically valuable morphological characters in *Rafnia* and the study of these characters led to a better understanding of the complex relationships among the regional forms and taxa.

Field work resulted in the discovery of new regional forms and taxa, 10 of which are described for the first time, resulting in a total of 19 species and 31 taxa in the genus, compared with the 22 species previously recognized (Harvey, 1862).

Characters unique to *Rafnia* include the standard petal which is folded in along the edges and the truncate or emarginate shape of the keel in species of section *Colobotropis.* Habit, leaves, inflorescences, flowers, pods and seeds proved to be taxonomically valuable characters. Of particular interest are the highly derived inflorescences, which are often similar in appearance yet different in structure (non-homologous), as well as the mode of flowering in which the flowering branches persist to the following season. Enzymes may provide a rational strategy for unravelling species limits in some of the extremely complex species.

In spite of the exceptional regional variation among the different forms and combinations of characters and character states in *Rafnia*, a clear hypothesis of phylogenetic relationships among the species was obtained using the cladistic approach. This approach also led to new interpretations of character development in the genus.

CHAPTER 9

TAXONOMY OF THE GENUS *RAFNIA*

9.1 Generic position within the family

Bentham (1865) initially proposed the tribal classification of the subfamily Papilionoideae, which is still mostly the system used today. The Podalyrieae and subtribes of Genisteae were mainly defined by successive degrees of fusion of the filaments and the presence or absence of an aril. Hutchinson (1964) used a similar system, maintaining the Podalyrieae for genera with free stamens, but dividing the Genisteae *sensu lato* into nine tribes.

Polhill (1976) restructured the tribe Genisteae *sensu lato*, suggesting that genera in the three main centres (Mediterranean, Cape of South Africa and Australia) originated separately and were better placed in four tribes. The staminal arrangement, calyx shape and structure of the seed (not only the aril) were considered adequate criteria for subdividing the Genisteae *sensu lato* into the tribes Bossiaeeae (Australia), Liparieae (South Africa) [now included in the Podalyrieae (Schutte, 1998)], Crotalarieae (mainly Africa) and the Genisteae *sensu stricto* (predominantly the north temperate region).

Polhill (1976) placed *Rafnia* near the beginning of the predominantly African exarillate genera of the Crotalarieae. The Crotalarieae is distinguished from the Genisteae by the staminal sheath, which is open on the upper side, not forming a closed tube as in the latter (Van Wyk, 1991a). The Crotalarieae is the largest tribe of the Papilionoideae in southern Africa, in terms of number of species, and most of the diversity at generic level is centred in southern Africa.

Based on Polhill's (1976) interpretation of morphological similarity, the Crotalarieae consisted of two major groups, namely the 'Cape group' of genera, including *Lebeckia*, *Wiborgia*, *Rafnia* and *Aspalathus* and the '*Lotononis* group', including all the genera with zygomorphic calyces, namely *Lotononis* (DC.) Eckl. & Zeyh., *Pearsonia* Dümmer, *Rothia* Pers. and *Robynsiophyton* Wilczek. *Crotalaria* L., *Bolusia* Benth. and *Spartidium* Pomel were placed between these two groups. The genera *Argyrolobium* Eckl. & Zeyh., *Polhillia* Stirton, *Dichilus* DC. and *Melolobium* Eckl. & Zeyh. were shown to be a monophyletic group, due to the presence of α-pyridone alkaloids and bilabiate calyces found only in these genera and nowhere else in the tribe (Van Wyk, 1991a).

Cladistic analyses based on morphological and alkaloidal data revealed the presence of two clades within the Crotalarieae (Van Wyk & Verdoorn, 1990; Van Wyk, 1991a). This confirmed that the four genera with a trifid lower calyx lip formed a monophyletic group. Van Wyk & Schutte (1995) analyzed the Podalyrieae, Liparieae and Crotalarieae cladistically and established more certainty about relationships amongst the 'Cape genera' and the sister group relationships between *Aspalathus* and *Rafnia* (based on the absence of a petiole and the asymmetrically convex upper suture of the pod) and between *Lebeckia* and *Wiborgia*. It was concluded that the *Argyrolobium* group (with *Anarthrophyllum* Benth.) was clearly misplaced in the Crotalarieae and would be better accommodated in the Genisteae *sensu stricto*, with which it shares the trifid lower lip of the calyx and a characteristic combination of alkaloids (Van Wyk & Schutte, 1995).

9.2 Historical overview of the taxonomy of *Rafnia*

The most important contributions made to the present knowledge of *Rafnia* and its species are discussed below.

Thunberg (1800a) first described the monotypic genus *Oedmannia*, containing the species *O. lancea.* De Candolle (1825) later made the new combination *R. lancea* (Thunb.) DC., with *Oedmannia* becoming a synonym of *Rafnia*. The genus *Rafnia* was first described by Thunberg (1800a) and generic characters included the bilabiate calyx, with the lower lip dentate and the carinal lobe filiform-subulate. *Rafnia* comprised 13 species, six of which are in current use, namely *R. amplexicaulis* (L.) Thunb., *R. elliptica* Thunb., *R. triflora* (L.) Thunb., *R. angulata* Thunb., *R. spicata* Thunb. and *R. diffusa* Thunb.

Willdenow (1802) made the new combination *R. perfoliata* (L.) Willd. for the first time, but this name is based on an illegitimate basionym, and the species is currently known as *R. acuminata* (E. Mey.) G.J. Campbell & B-E. van Wyk *ined.* De Candolle (1825) described the genus *Vascoa*, incorporating the species with cordate, reticulate leaves, and made the species *V. amplexicaulis* (L.) DC. and *V. perfoliata* (Thunb.) DC. Meyer (1832) later described *Vascoa acuminata* E. Mey.

Ecklon & Zeyher (1836) described six new species, namely *R. fastigiata* Eckl. & Zeyh., *R. alpina* Eckl. & Zeyh., *R. racemosa* Eckl. & Zeyh., *R. dichotoma* Eckl. & Zeyh., *R. pauciflora* Eckl. & Zeyh. and *R. humilis* Eckl. & Zeyh. *R. racemosa* is in current use and the status of *R. dichotoma* and *R. humilis* has changed.

Meyer (1836) described three new species of *Rafnia* and placed a number of existing species and new species in the genus *Pelecynthis* E. Mey., which contained species with truncate keels. He divided *Pelecynthis* into three sections, namely *Colobotropis* E. Mey., *Hybotropis* E. Mey. and *Caminotropis* E. Mey.

Walpers (1839) also divided *Rafnia* into three sections: *Vascoa* (DC.) Walp., *Rafnia* (E. Mey.) Walp. and *Pelecynthis* (E. Mey.) Walp. Section *Pelecynthis* was divided into three series, namely *Colobotropis*, *Hybotropis* and *Caminotropis*. Walpers (1839) described two new species and in 1843, raised section *Pelecynthis* to generic status, containing nine species, with the series raised to sections.

Bentham (1843) reunited *Vascoa* and *Pelecynthis* with *Rafnia* since he quite rightly believed that *Rafnia* was a very natural genus. He argued that the genus could "well be divided into four sections, by characters of nearly equal value, but scarcely of importance enough to break up into distinct genera, so natural, and at the same time so small a group". He distinguished *Rafnia* from the simple-leaved Genisteae by the glabrescence, glaucous leaves and the fact that the plants turn black when dry. He also argued that the leaves are not many-nerved from the base as in *Borbonia*, the inflorescence is not racemose as in *Crotalaria*, and the peduncles are dichotomous, with foliaceous bracts frequently opposite at their ramifications, except in the very few cases where they are simple and one-flowered. Bentham's four sections included *Vascoa*, *Eu-Rafnia*, *Pelecynthis* and *Caminotropis*.

Harvey (1859) described the new species *R. crassifolia* Harv. and *R. thunbergii* Harv., and in his Flora Capensis (1862), distinguished the four sections of Bentham, including 19 species. Harvey (1862) described *Rafnia* as glabrous, often glaucous shrubs or suffrutices with simple, entire, alternate, exstipulate leaves and yellow flowers. This work was the last complete revision of *Rafnia* to have been published.

The contribution of Schinz (1894) included the new combination *R. capensis* (L.) Schinz. Druce (1914) made the superfluous new combination *R. capensis* (L.) Druce.

More recent contributions include the description of *R. ericifolia* Salter (1946) and *R. crispa* C.H. Stirton (1982).

In a preliminary unpublished revision of *Rafnia*, Richardson (1986) distinguished 21 species. Unfortunately, there are some serious interpretative errors in this work and the nomenclature and circumscription of species leaves much to be desired. As a result, the study of Richardson (1986) was not very useful and did not influence the concepts developed during this study.

Rafnia is here divided into two sections, namely section *Rafnia*, containing the species with rostrate keels, and section *Colobotropis*, containing the species with obtuse or truncate to emarginate keels (see below). There are 19 species in total, four of which are divided into subspecies, making a total of 31 taxa.

9.3 The genus *Rafnia* Thunb.

Rafnia Thunb., Gen. Nov. Pl.: 144 (1800a), Prodr. Pl. Cap. 2: 123 (1800b); Willd., Sp. Pl. 3: 949 (1802); Thunb., Fl. Cap.: 563 (1823); DC., Prodr. 2: 118 (1825), Mém. Lég.: 184 (1826); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 159 (1836); E. Mey., Comm. Pl. Afr. Austr. 1(1): 11 (1836); Harv., Gen. S.A. Pl. 1: 74 (1838); Walp. in Linnaea 13: 462 (1839); Benth. in Ann. Wien. Mus. 2: 142 (1839); Walp., Rep. Bot. Syst. 2: 578 (1843) [*excl. descr.*], Suppl. 1: 833 (1843); Benth. in Hook., Lond. J. Bot. 2: 463 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 31 (1862); Benth. & Hook., Gen. Pl. 1: 440 (1867); Walp. in Ann. Bot. 7: 670 (1868); Harv., Gen. S.A. Pl. 2: 73 (1868); Hutch., Gen. Fl. Pl. 1: 345 (1964); Polhill in Bot. Syst. 1: 321 (1976); Van Wyk, Contr. Bolus Herb. 13: 280 (1991a); Van Wyk & Schutte in Crisp & Doyle, Advances in legume systematics 7: phylogeny: 306 (1995). Type: *Rafnia amplexicaulis* (L.) Thunb.

= *Oedmannia* Thunb., Gen. Nov. Pl.: 136 (1800a), Prodr. Pl. Cap. 2: 123 (1800b) [*excl. descr.*]; Willd., Sp. Pl. 3: 925 (1802); Thunb., Fl. Cap.: 561 (1823). Type: *Oedmannia lancea* Thunb. [now *Rafnia lancea* (Thunb.) DC.]

= *Vascoa* DC., Prodr. 2: 119 (1825), Mém. Lég.: 186 (1826); Harv., Gen. S.A. Pl. 1: 74 (1838). Type: *Vascoa amplexicaulis* (L.) DC. [now *Rafnia amplexicaulis* (L.) Thunb.].

= *Pelecynthis* E. Mey., Comm. Pl. Afr. Austr. 1(1): 13 (1836); Walp., Rep. Bot. Syst. 2: 579 (1843) [*excl. descr.*]. Type: *Pelecynthis rhomboidea* E. Mey. [now *Rafnia capensis* (L.) Schinz].

Glabrous, multi-stemmed resprouting shrubs or suffrutices, rarely small trees up to 2.5 m tall; stems erect, procumbent or prostrate, often dichotomously much-branched in the upper parts. *Leaves* simple, sessile, invariably glabrous, estipulate, variable in shape, linear to round, venation usually indistinct or less often distinctly reticulate or penninerved; cauline leaves alternate; leaves on flowering branches mostly opposite or subopposite or rarely alternate; basal leaves often much larger than upper leaves; coppice leaves often larger and different in shape from mature leaves. *Inflorescences* variable, terminal or axillary racemes, mostly single-flowered and pseudopedunculate or less often few- to multi-flowered and pedunculate, occasionally the racemes secondarily aggregated into leafy pseudoracemes. *Flowers* variable in size, invariably yellow, sometimes fading pink, orange or brown; bracts and bracteoles simple, often with a few hairs towards the apex; bracts narrowly triangular, often minute, rarely ± leafy; paired bracteoles narrowly triangular to subulate, minute or absent (reduced leaves below inflorescence sometimes mistaken for bracteoles). *Calyx* subequally lobed or sometimes forming a trifid lower lip; upper lobes falcate or non-falcate, sometimes much broader than lateral lobes; lateral lobes sometimes falcate; carinal lobe invariably narrowest; wing-like ridges or extensions sometimes present on calyx tube. *Standard* ovate to elliptic or suborbicular, sometimes with basal callosities; apex sometimes with an apical cusp or obtuse or rarely retuse if not cusped; edges of lamina sometimes folded inwards, or upper two thirds reflexed at anthesis. *Wings* oblong, shorter or longer than the keel, sometimes minutely ciliate near the base; sculpturing present, invariably upper basal, or absent. *Keel* rostrate or obtuse, without a lobe below the apex, sometimes symmetrically or asymmetrically truncate or emarginate, with a lobe below the apex; with or without a lateral pocket (spur); sometimes minutely ciliate near the base. *Stamens* fused into a sheath open on the upper side, rarely diadelphous (vexillary stamen partially or completely free from staminal sheath); anthers distinctly dimorphic, 4 long, basifixed anthers alternating with 5 ovate, dorsifixed anthers, carinal anther usually intermediate in size and shape. *Pistil* usually short-stipitate or sometimes long-stipitate; style upcurved, slender, tapering; ovules 2–many; stigma terminal, small or capitate, glabrous or fibrillose. *Pods* usually compressed, sometimes slightly inflated, sessile to long-stipitate, obliquely lanceolate to oblanceolate or narrowly to broadly oblong; upper margin usually narrowly winged, sometimes broadly winged; 1–5-seeded; dehiscent. *Seeds* exarillate, oblong-reniform to oblique-cordiform; radicular lobe prominent; colour variable, pale yellow to brown or black; hilum small, elliptic to round, often sunken; testa surface smooth to rough.

Rafnia species are glabrous, resprouting shrubs or suffrutices with simple, sessile leaves. The basal or coppice leaves are often larger and different in shape from the upper leaves. The plants usually turn black when dry and are totally glabrous (even on the back of the standard petal), except for minute hairs on the inside of the calyx (and also mostly on the bracts, bracteoles and sterile extension of the rachis). *Rafnia* species occur throughout the fynbos region, from Nieuwoudtville in the north-west, through the entire Western and Eastern Cape Provinces and extending into southern KwaZulu-Natal.

The species occupy diverse habitats, from dry or semi-arid montane, coastal or grassy fynbos, to sandveld or renosterveld. They occur in low-lying coastal areas or high mountainous areas and are often found in disturbed places, such as along roadsides, mountain passes, in plantations etc., and especially in recently burnt veld. The species grow on gentle or steep rocky, bouldery slopes, in foothills or on sand flats and are associated with shallow or deep TMS-derived, granitic or limestone soils. Some species have been found on shale flats and exposed quartzitic outcrops.

9.4 Key to the sections of *Rafnia*

1. Keel rostrate, without lobes near the apex or a calloused lateral pocket (spur), lower calyx lobes not fused higher up to form a trifid lip, edges of standard petal not folded in, wing petals invariably sculptured, staminal sheath of even width, not widening towards the base, free parts of filaments long .... **Section *Rafnia***

2. Keel obtuse or truncate to emarginate, sometimes rostrate but then with a distinct lobe below the apex and with a calloused lateral pocket (spur), lower calyx lobes fused higher up to form a trifid lip, edges of standard petal folded in, wing petals usually without sculpturing (except in *R. diffusa* and occasionally in *R. spicata*), staminal sheath usually widening towards the base, free parts of filaments short................................. .... **Section *Colobotropis***

9.5 Key to the species of *Rafnia*

1a. Keel rostrate 2

1b. Keel obtuse or truncate to emarginate 15

2a. Upper calyx lobes broadly falcate 3

2b. Upper calyx lobes triangular or slightly falcate 8

3a. Leaves not cordate 4

3b. Leaves cordate 6

4a. Calyx without wing-like extensions between the lobes 5

4b. Calyx with wing-like extensions between all the lobes .... ***R. alata***

5a. Pod obliquely oblanceolate, inflorescence pedunculate, lower calyx lobe hair-like, seed testa longitudinally striate, swollen ring around hilum .... ***R. vlokii***

5b. Pod obliquely lanceolate .... ***R. triflora***

6a. Pod sessile 7

6b. Pod stipitate, young leaves recurved, upper calyx lobes broadly falcate, wing-like extension between upper calyx lobes, lower calyx lobe hair-like .... ***R. inaequalis***

7a. Upper margin of pod proximally upturned, convex, large woody shrub, leaves reniform, cordate, reticulately veined, bracteoles absent ...... ***R. amplexicaulis***

7b. Lower margin proximally convex, trailing shrub, leaves cordate, reticulately veined .... ***R. acuminata***

8a. Inflorescences invariably single-flowered 9

8b. Inflorescences single- or few- or multi-flowered 11

9a. Calyx lotononoid, with upper and lateral lobes fused higher up in pairs on either side, inflorescence pedunculate, pod proximally curved .... ***R. lancea***

9b. Calyx not lotononoid, without upper and lateral lobes fused higher up in pairs on either side 10

10a. Inflorescences pedunculate, leaf margins crisped, venation penninerved, lateral calyx sinus shallower than others .... ***R. crispa***

10b. Inflorescences not pedunculate, leaves bright green, margins red, inflorescence axis absent, standard subpanduriform .... ***R. crassifolia***

11a. Inflorescences multi-flowered, woody shrub or procumbent perennial, calyx subequally lobed .... ***R. racemosa***

11b. Inflorescences single- or few-flowered 12

12a. Leaves acuminate, pod short-stipitate, upper suture of pod winged .... ***R. ovata***

12b. Leaves not acuminate 13

13a. Leaves linear to narrowly obovate, keel sharply beaked, style long, free parts of filaments very long .... ***R. angulata***

13b. Leaves not linear to narrowly obovate 14

14a. Keel long-rostrate, strongly upcurved, erect or procumbent shrub, inflorescence few- or single-flowered, leaves cuneate or obovate .... ***R. rostrata***

14b. Keel shortly-rostrate, not strongly upcurved, leaves elliptic, standard cordate, rarely retuse .... ***R. elliptica***

15a. Keel rarely rostrate, mostly obtuse 16

15b. Keel obtuse, truncate or emarginate, never rostrate 17

16a. Wings invariably sculptured, diffuse form, coppice leaves larger than mature leaves .... ***R. diffusa***

16b. Wings sometimes sculptured, spicate pseudoracemes .... ***R. spicata***

17a. Leaves on flowering branches subopposite to opposite, woody shrub or herbaceous perennial, trifid lower calyx lip, standard reflexed, pods stipitate .... ***R. capensis***

17b. Leaves on flowering branches invariably opposite 18

18a. Pod stipitate, globose pseudoracemes, keel slightly lobed below apex .... ***R. globosa***

18b. Pod sessile, obliquely triangular, broadly winged on upper suture, large, conical pseudoracemes, basal leaves often round, much larger than upper leaves, ... ***R. schlechteriana***

9.6 The sections, species and subspecies of *Rafnia*

Section 1: ***Rafnia*** (DC.) Walp. in Linnaea 13: 463 (1839), Rep. Bot. Syst. 2: 579 (1843).

≡ *Vascoa* DC., Prodr. 2: 119 (1825), Mém. Lég.: 186 (1826); Harv., Gen. S.A. Pl. 1: 74 (1838).

≡ Section *Vascoa* (DC.) Walp. in Linnaea 13: 462 (1839), Rep. Bot. Syst. 2: 578 (1843); Benth. in Hook., Lond. J. Bot. 2: 464 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 31 (1862); Schinz in Bull. Herb. Boiss. 2: 198 (1894).

= Section *Eu-Rafnia* Benth. in Hook., Lond. J. Bot. 2: 465 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 31 (1862); Schinz in Bull. Herb. Boiss. 2: 198 (1894). Type species: *Rafnia ovata* E. Mey.

Diagnostic characters. Section *Rafnia* differs from section *Colobotropis* in the rostrate (beaked) keel petals, which do not have a lobe below the apex or a calloused lateral pocket (spur), the absence of a trifid lower calyx lip, the edges of the standard petal which are not folded in, the invariable presence of sculpturing on the wing petals, the staminal sheath not widening towards the base and the long free parts of the filaments (fused much higher up in *Colobotropis*). The pods are sessile (except in *R. ovata* and *R. inaequalis*), not stipitate as in all the species of *Colobotropis* (apart from *R. schlechteriana*, which has sessile pods).

1. ***Rafnia racemosa*** Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (1836); Walp. in Linnaea 13: 465 (1839); Harv. in Harv. & Sond., Fl. Cap. 2: 34 (1862); Schinz in Bull. Herb. Boiss. 2: 199 (1894). Type: South Africa, Western Cape Province, in arenosis (altit. III) collium inter "Hassaquaskloof et Breederivier" (Swellendam), *Ecklon & Zeyher 1188* (SAM!, specimen on far right, lectotype, designated here).

≡ *Pelecynthis racemosa* (Eckl. & Zeyh.) Walp., Rep. Bot. Syst. 2: 579 (1843).

Robust, woody shrub, up to 1.5 m tall or a procumbent, clump-forming shrublet, up to 0.2 m tall. *Leaves* lanceolate or elliptic; leaves on flowering branches invariably alternate, 25–45 mm long, 6–16 mm wide; basal leaves 13–60 mm long, 5–24 mm wide. *Inflorescences* few- to multi-flowered, 2–19 flowers. *Flowers* 11–19 mm long. *Pedicel* 4–7 mm long. *Bract* 1–2 mm long. *Bracteoles* 0.5–1 mm long. *Calyx* subequally lobed; lobes triangular or narrowly triangular, as long as or longer than tube, 4–7 mm long; upper sinus rarely deeper than others; tube 3–6 mm long. *Standard* ovate or broadly elliptic, (9–) 13–18 mm long, 11–15 mm wide, sometimes with basal callosities; claw 2–4 mm long. *Wings* oblong, longer than keel, (9–) 12–14 mm long, 5–6 mm wide, with 5–6 rows of sculpturing; apex obtuse or obliquely obtuse; claw 3–5 mm long. *Keel* shortly rostrate, 8–13 mm long, 4–6 mm wide, with a broad or narrow basal pocket; claw 4–6 mm long. *Pistil* short- or long-stipitate; ovary oblong to narrowly ovate; style shorter than ovary, strongly upcurved; ovules 4–many.

1a. ***Rafnia racemosa*** Eckl. & Zeyh. subsp. ***racemosa***

Erect, robust, much-branched woody shrub, up to 1.5 m tall. *Leaves* on flowering branches 9–16 mm wide; basal leaves 41–60 mm long, 14–24 mm wide. *Inflorescences* multi-flowered, 5–12 (–19) flowers. *Calyx* lobes triangular, as long as tube. *Wings* with apex obliquely obtuse. *Keel* mostly with a broad basal pocket. *Pistil* short-stipitate; ovules 4. *Pods* obliquely lanceolate, (27–) 30–36 mm long, 6–10 mm wide; upper margin straight; lower margin proximally convex. *Seeds* narrowly oblong to broadly reniform, 3–5 mm long, 3–4 mm wide; testa smooth.

Diagnostic characters. *R. racemosa* subsp. *racemosa* (Figure 9.1) is distinguished by the erect, woody habit (Figure 9.1a), the invariably alternate leaves and the terminal, multi-flowered racemes (Figure 9.1b). It differs from *R. angulata* and *R. rostrata* in the lanceolate or elliptic leaves (ericoid or linear to broadly obovate in *R. angulata*; obovate in *R. rostrata* subsp. *rostrata*). It also differs from *R. rostrata* in the calyx lobes which are ± as long as the tube (the lobes are longer than the tube in *R. rostrata*) and the shortly rostrate keel, which is not strongly upcurved (the keel is long-rostrate and strongly upcurved in *R. rostrata*).

Distribution and habitat. *R. racemosa* subsp. *racemosa* is mostly restricted to mountainous areas, from the Montagu district in the west to Willowmore in the east (see Map 9.1). It occurs in dry to semi-arid montane fynbos, or renosterbos, and occupies various habitats, from rocky slopes to flat sandy plains, mostly in TMS-derived soils and occasionally in deep soils.

Specimens examined.

—**3320** (Montagu): Anysberg (-BC), *Van Wyk 3186* (JRAU); between Montagu and triangle, Kochmanskloof (-CC), *Michell 43* (BOL, PRE); Touwsberg (-DB), *Wurts 1355* (NBG); Tradouw's Pass (-DC), *Levyns & Levyns 627* (NBG); Boosmansbos wilderness area, Langeberg, upper reaches of Brandrivier north-east of Grootberg, near path between Grootberg and Witbooisrivier (-DD), *McDonald 1243, 1558* (NBG, PRE).

—**3321** (Ladismith): Rietvleikloof, Laingsburg division (-AC), *Bond 242* (NBG), *Compton 8642* (NBG), *Lewis 760* (SAM); Klein Swartberg, Buffelsrivier (-AC), *Marshall 216* (NBG); Seweweekspoort mountains (-AD), *Bamard s.n. sub SAM 46319* (SAM), *Glen 782* (BOL), *Levyns 2336* (BOL), *Stokoe 1756* (BOL); Waterkloof, about 3 km from Ladismith (-AD), *Hugo 602* (PRE); Klein Swartberg (-AD), *Levyns 2098, 2740, 9111* (BOL); between Vleiland and Seweweekspoort (-AD), *Moffett & Steensma 3839* (NBG, PRE), *Thompson 3176* (NBG, PRE), *C.M. van Wyk 531* (NBG, PRE); between Withoek and Santo, south-south-east of Laingsburg (-AD), *Van Wyk 2156* (JRAU, 1 & 2); 6.4 km after entrance to Rietvlei farm, Laingsburg-Seweweekspoort road (-AD), *Van Wyk 2171, 2172* (JRAU); Klein Swartberg above Aasvoëlkrans (-AD), *Vlok 164* (NBG, PRE); north of Ladismith (-AD), *Wurts 1345* (NBG); Elandsberg, north of Klein Swartberg (-AD), *Wurts 1498* (NBG); Die Nek, Gamkasberg Reserve, Calitzdorp (-BC), *Boshoff P285* (NBG); Kliphuisvlei, Swartberg (-BD), *Laughton 139* (BOL), *s.n. sub PRE 60938* (PRE), *Marshall 265* (NBG, PRE); Swartberg, north-west of Waboomsberg (-BD), *Oliver 5550* (NBG, PRE); Rooiberg, Bailey Peak (-CB), *Oliver 5455* (NBG, PRE), *Taylor 9633* (NBG); Garcia's Pass, north of toll house (-CC), *Van Wyk 2976* (JRAU); top of Rooiberg Pass (-DA), *Acocks 20373* (PRE), *Goldblatt 8038* (NBG, PRE), *Mauve, C.M. van Wyk & Pare 25* (NBG, PRE), *Oliver 5307* (NBG), *Wurts 1641* (NBG); between Breederivier and Attaquaskloof (-DD), *Ecklon & Zeyher 1188* (SAM); Cloete's Pass, Mossel Bay division (-DD), *Muir 1071* (BOL, PRE); Goliathsberg, Langeberg, Mossel Bay division (-DD), *Muir 2176* (BOL); Attaquaskloof, near summit of old Voortrekker Pass (-DD), *Thompson 1610* (NBG); road between Bonnydale and Woeska (-DD), *Van Wyk 3174* (JRAU, 1 & 2); Mossel Bay, Attaquaskloof, on road to Perdekop (-DD), *Vlok 86, 1139* (PRE).

—**3322** (Oudtshoorn): Swartberg Pass, Prince Albert district (-AC), *Acocks & Hafström 710* (PRE), *Bolus 11464* (BOL, PRE), *Bond 1551* (NBG, PRE) [atypical specimens], *Compton 10418* (NBG), *Gentry & Barclay 19097* (PRE), *Pocock S75* (PRE), *Schelpe 92* (BOL), *Stokoe s.n. sub SAM 55812* (SAM), *Thome s.n. sub NBG 14318* (NBG), *Van Wyk 2971* (JRAU, 1–4), *Vlok 35* (NBG, PRE), *Wedermann & Oberdieck 830* (PRE); Swartberg Pass, Gamkaskloof (-AC), *Campbell & Van Wyk 7* (JRAU), *Campbell, Van Wyk*

& Vlok 155 (BOL, JRAU, K, NBG, PRE), *Stirton 10311* (NBG), *Vlok 1650* (PRE).

—**3323** (Willowmore): Uniondale, 11 miles (17.6 km) west of Avontuur (-CA), *Acocks 16036* (BOL, PRE); 74 km from Joubertina to George (-CA), *Stirton 6367* (PRE, 1 & 2).

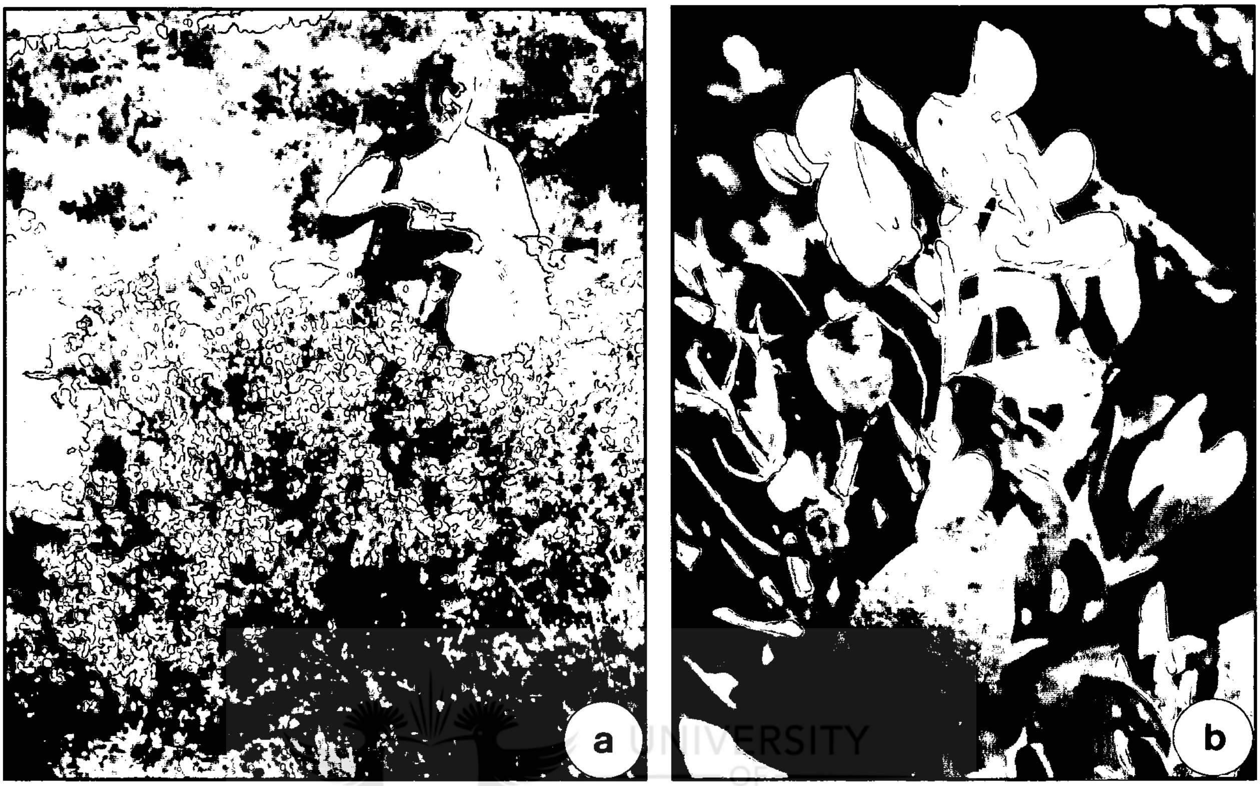


Figure 9.1 Habit, inflorescences and flowers of *R. racemosa* subsp. *racemosa*: **a,** much-branched, woody shrub; **b,** racemose inflorescence.

1b. *Rafnia racemosa* Eckl. & Zeyh. subsp. ***pumila*** G.J. Campbell & B-E. van Wyk subsp. nov., a subsp. *racemosa* habitu procumbenti caespitoso, foliis minoribus, lobis calycis longioribus (in subsp. *pumila* tubo longiores; in subsp. *racemosa* tubo aequilongi), et pistillo longe stipitato (in subsp. *racemosa* breve stipitato), differt. Type: South Africa, Western Cape Province, Worcester, between Goudini Sneeukop and Deception Peak, *Esterhuysen 33444* (BOL!, holotype).

Procumbent, clump-forming shrublet, much-branched from base, up to 0.2 m tall. *Leaves* lanceolate; leaves on flowering branches 25–35 mm long, 6–10 mm wide; basal leaves (13–) 17–22 mm long, 5–7 mm wide. *Inflorescences* few-flowered, 2–5 flowers. *Flowers*

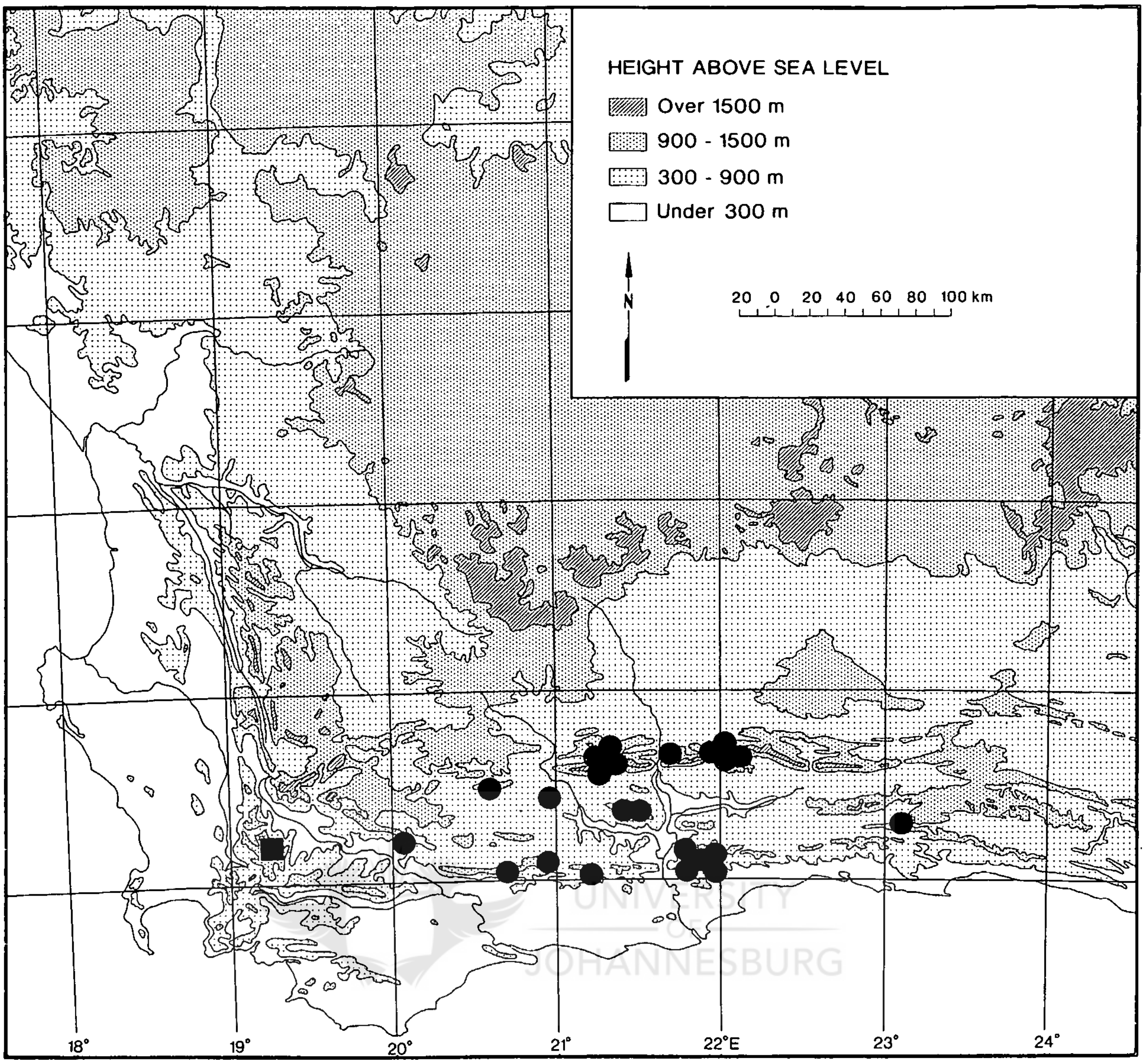
14–16 mm long. *Pedicel* 5–6 mm long. *Bract* ± 1 mm long. *Bracteoles* ± 0.5 mm long. *Calyx* lobes narrowly triangular, longer than tube, 4–5 mm long; upper sinus as deep as others; tube ± 3 mm long. *Standard* broadly elliptic, 13–18 mm long, ± 14 mm wide, without basal callosities. *Wings* 12–14 mm long, ± 5 mm wide, with 5 rows of sculpturing; apex obtuse. *Keel* 11–13 mm long, with a narrow basal pocket. *Pistil* long-stipitate; ovary oblong; ovules many (up to 9). Mature pods and seeds unknown.

Diagnostic characters. R. racemosa subsp. *pumila* differs from subsp. *racemosa* in the procumbent, clump-forming habit, the smaller leaves, the basal leaves which are smaller than the upper leaves (basal leaves are larger than the upper leaves in subsp. *racemosa*), the longer, narrowly triangular calyx lobes (longer than the tube in subsp. *pumila*; as long as the tube and triangular in subsp. *racemosa*) and the long-stipitate pistil (short-stipitate in subsp. *racemosa*).

Distribution and habitat. R. racemosa subsp. *pumila* is geographically isolated from subsp. *racemosa* and known only from the Worcester area, between Goudini Sneeukop and Deception Peak (Map 9.1), where it grows in montane fynbos on sandy, rocky slopes.

Specimen examined.

—**3319** (Worcester): Between Goudini Sneeukop and Deception Peak (-CD), *Esterhuysen 33444* (BOL).



Map 9.1 The known geographical distribution of *R. racemosa* subsp. *racemosa* (dots) and *R. racemosa* subsp. *pumila* (square).

2. ***Rafnia angulata*** Thunb. Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16425* (UPS, microfiche!, lectotype, designated here).

≡ *Rafnia angulata* Thunb., Gen. Nov. Pl.: 147 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 564 (1823); DC., Prodr. 2: 119 (1825); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836); E. Mey., Comm. Pl. Afr. Austr. 1(1): 13 (1836); Walp. in Linnaea 13: 464 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 467 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 35 (1862); Schinz in Bull. Herb. Boiss. 2: 200 (1894).

≡ *Rafnia angulata* var. *angulata* as '*R. angulata* Thunb. var. *latifolia* Harv.' in Harv. & Sond., Fl. Cap. 2: 35 (1862).

= *Rafnia angustifolia* Thunb., Gen. Nov. Pl.: 147 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 564 (1823); DC., Prodr. 2: 119 (1825); E. Mey. in Linnaea 7: 148 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16428* (UPS, microfiche!, lectotype, designated here).

≡ *Rafnia angulata* var. *angustifolia* (Thunb.) E. Mey., Comm. Pl. Afr. Austr. 1(1): 13 (1836); Walp. in Linnaea 13: 464 (1839), Rep. Bot. Syst. 2: 579 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 35 (1862).

= *Rafnia filifolia* Thunb., Gen. Nov. Pl.: 148 (1800a) *pro parte*, Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 565 (1823); DC., Prodr.

2: 119 (1825); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16435* (UPS, microfiche!, lectotype, designated here). [Note: We intentionally choose this specimen as lectotype to avoid confusion with *Rafnia thunbergii* Harv. (*q.v.*), which was based on one of the three sheets in the Thunberg Herbarium.]

≡ *Rafnia angulata* var. *filifolia* (Thunb.) E. Mey., Comm. Pl. Afr. Austr. 1(1): 13 (1836); Walp. in Linnaea 13: 464 (1839), Rep. Bot. Syst. 2: 579 (1843).

= ?*Rafnia erecta* Thunb., Gen. Nov. Pl.: 149 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 565 (1823); DC., Prodr. 2: 119 (1825); Walp. in Linnaea 13: 463 (1839), Rep. Bot. Syst. 2: 579 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 38 (1862). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16433* (UPS, microfiche!). [Note: As Harvey (1862) pointed out, it is virtually impossible to decide on the identity of this species, because the type specimen is a mere fragment.]

Robust, virgate suffrutex, up to 2.2 m tall or a virgate shrublet, up to 0.5 m tall or a procumbent shrublet, up to 0.3 m tall. *Leaves* variable, ericoid or linear or obovate; leaves on flowering branches usually subopposite to opposite or rarely invariably alternate, 6–46 mm long, 0.5–14 mm wide; basal leaves 9–45 mm long, 0.5–18 mm wide. *Inflorescences* single- or less often few-flowered, 2–6 flowers. *Flowers* 8–20 mm long. *Pedicel* 4–11 mm long. *Bract* narrowly triangular, ± leafy or not ± leafy, 0.5–2 mm long. *Bracteoles* 0.2–1 mm long. *Calyx* lobes triangular to narrowly triangular, slightly shorter than, much shorter than, ± as long as or longer than tube, 1–7 mm long; upper lobes non-falcate, falcate or broadly falcate, often broader or much broader than others; lateral lobes triangular or falcate; carinal lobe shorter or longer than others; upper sinus often deeper than others; tube 2–6 mm long. *Standard* ovate or obovate or elliptic or round, 6–17 mm long, 5–18 mm wide, often with an apical cusp; claw 1–5 mm long. *Wings* oblong or subtriangular or obliquely triangular, shorter than or ± as long as keel, 5–15 mm long, 2–7 mm wide, with 4–12 rows of sculpturing; apex narrow or obtuse or obliquely obtuse; claw 2–7 mm long. *Keel* shortly rostrate to long-rostrate, 6–15 mm long, 3–7 mm wide, with a broad upper basal pocket; claw 2–5 mm long. *Stamens* usually monadelphous or rarely diadelphous. *Pistil* with the ovary oblong or linear; style shorter than or ± as long as or longer than ovary, strongly upcurved; stigma usually glabrous or rarely fibrillose; ovules 2–5. *Pods* obliquely oblanceolate or rarely obliquely lanceolate or ± oblong, 15–35 mm long, 4–8 mm wide; upper margin asymmetrically convex; lower margin ± straight. *Seeds* narrowly oblong to oblong or broadly reniform, 3–6 mm long, 2–4 mm wide; testa smooth.

Key to the subspecies of *R. angulata*

1a. Pod obliquely oblanceolate 2

1b. Pod obliquely lanceolate, upper calyx lobes broadly falcate, wing-like extension between upper calyx lobes, carinal calyx lobe longest .... **subsp. *montana***

2a. Calyx lobes as long as or longer than the tube 3

2b. Calyx lobes minute, much shorter than the tube, stems unbranched, leaves bright green, stems with spicate pseudoracemes .... **subsp. *thunbergii***

3a. Wings oblong 4

3b. Wings obliquely triangular, leaves linear, coriaceous, sparsely flowered .... **subsp. *humilis***

4a. Leaves linear to broadly obovate, virgate, glaucous, upper calyx lobes often slightly falcate, upper calyx sinus deepest.............................**subsp. *angulata***

4b. Leaves ericoid..**subsp. *ericifolia***

2a. ***Rafnia angulata*** Thunb. subsp. ***angulata***

Erect, virgate suffrutex, up to 2.2 m tall, to a procumbent shrublet, up to 0.3 m tall. *Leaves* narrowly to broadly linear or narrowly to broadly obovate or suborbicular; leaves on flowering branches 9–32 mm long, 1–14 mm wide; basal leaves 9–43 mm long, 1–18 mm wide. *Flowers* 8–17 mm long. *Pedicel* 4–11 mm long. *Bract* ± leafy. *Calyx* lobes slightly shorter than, ± as long as or longer than tube, 2–7 mm long; upper lobes falcate, often broader than others; carinal lobe sometimes shorter than others. *Standard* ovate or elliptic or round, 6–14 mm long, 7–13 mm wide. *Wings* oblong, shorter than keel, 3–5 mm wide, with 4–8 rows of sculpturing; apex narrow or obtuse. *Keel* 6–15 mm long, 3–7 mm wide, sometimes long-rostrate. *Pistil* with ovary oblong to linear; style ± as long as or more often longer than ovary. *Pods* obliquely oblanceolate, 20–35 mm long, rarely proximally gradually tapering into a narrow stipe. *Seeds* narrowly oblong to oblong.

Diagnostic characters. *R. angulata* subsp. *angulata* (see Figure 9.2a & b), differs from the other species in the upper calyx sinus which is often deepest, the strongly rostrate keel (see Figure 9.2b), which often tapers towards the apex and the pods which are usually obliquely oblanceolate with the upper margin asymmetrically convex and the lower margin more or less straight.

Distribution and habitat. This subspecies is relatively widely distributed in the Western Cape Province, from the Gifberg near Vanryhnsdorp in the north, southwards to the Cape Peninsula and eastwards to Swellendam and the Seweweekspoort mountains (see Map 9.2). It grows in coastal or montane fynbos or fynbos on sand dunes, or dry sandveld, and occupies a wide range of habitats, from gentle foothills to steep granite slopes near the coast, or river valleys, often on dry, sandy, rocky slopes. It is usually associated with TMS-derived soils and is occasionally found in deep sand.

Regional variation. *R. angulata* subsp. *angulata* is variable, with numerous geographical forms. The geographical variation is represented by morphological differences between the forms in different localities. The Cedarberg form is very variable: on the Gifberg, the shrubs may reach 2 m in height, and the basal leaves may be very large and broadly obovate to suborbicular, while the upper leaves are much smaller and obovate; at Kriedouw in the Cedarberg, a robust form occurs, which has large, obovate leaves. The typical form of the suspecies is virgate and has narrowly to broadly linear leaves. An unusual form has been collected on the Matroosberg, which resembles *R. globosa* in appearance, but has flowers typical of *R. angulata*. In Malmesbury and on the Cape Peninsula there are broad and narrow leaved forms, which vary in size, and very small leaved forms occur in the Boland mountains. The Hermanus form has up to 6-flowered racemes and the form in Swellendam resembles the typical form, but is generally smaller.

Specimens examined.

—**3118** (Vanrhynsdorp): Gifberg (-DC), *Esterhuysen 22143* (BOL, 1 & 2), *Van Wyk s.n.* (NBG); 20 miles (32 km) from Clanwilliam to Klawer (-DC), *Grobbelaar 1139* (PRE).

—**3119** (Calvinia): Glenridge, Nieuwoudtville (-AC), *Barker 9648* (NBG); 2 miles (3.2 km) along national road from Nieuwoudtville to Vanrhynsdorp (-AC), *Snijman 44* (NBG).

—**3218** (Clanwilliam): Olifantsrivier valley, national road north of Clanwilliam (-BB), *Barker 10333* (NBG, 1 & 2); Citrusdal district, Kriedouw farm, Algeria road, eastern slope of Graskop (-BD), *Van Wyk 3679* (K, NBG, PRE); half way between Vredenburg and Hopefield (-CC), *Grobbelaar 2193* (PRE); Piquetberg, Versveld Pass (-DC), *Campbell & Van Wyk 35*, 1 & 2, *76* (JRAU), *Campbell, Van Wyk & De Castro 136* (JRAU, 1 & 2), *Grobbelaar 2667* (PRE); Piquetberg, De Rust (-DC?), *Compton 12669* (NBG); between Piquetberg and De Rust (-DC?), *Esterhuysen 7134* (BOL); Piquetberg, around edges of dam east of Levant Peak (-DC), *Goldblatt 6514* (PRE); Versveld Pass, Piquetberg district, turn-off to New Caledonia (-DC), *Van Wyk 3226* (JRAU).

—**3219** (Wupperthal): Langberg, Cedarberg, Clanwilliam district (-AC), *Bond 1385* (NBG), *Esterhuysen 7310* (BOL); Apollo Peak, southern Cedarberg (-CA), *Taylor 11157* (NBG); Dwarsberg, Ceres, between Koue Bokkeveld mountains and Ceres-Karoo (-CB), *Hanekom 985* (PRE); near Gideonskop, north-western border of Ceres division (-CB), *Stokoe s.n. sub SAM 54501* (SAM); Ceres division, Bokkeveld, Tafelberg (-CD), *Compton 10078* (NBG), *Esterhuysen 3922* (BOL), *Thompson 245* (NBG, PRE); Rietrivier, on road to Zuurvlak (-DC), *Bean & Viviers 1977* (BOL); Ceres, Swartruggens, along Swartrug division road to Ceres-Karoo (-DC), *Campbell & Van Wyk 143* (JRAU), *146* (JRAU, NBG, PRE).

—**3318** (Cape Town): 8.8 km west-north-west of Hopefield (-AB), *Acocks 24470* (PRE); near Hopefield, Malmesbury division (-AB), *Bolus 20934* (BOL), *Clarkson 371* (BOL), *Compton 18918*, *18920* (NBG), *Leighton 2447* (BOL), *2453* (BOL, PRE); Zonquasfontein, 12.5 miles (20 km) from Darling (-AB), *Boucher 58* (NBG); 10 km from Hopefield to Vredenburg (-AB), *Grobbelaar 2194* (PRE); Elandslaagte, west of Hopefield (-AB), *hompson 3604* (NBG, PRE); about 10 miles (16 km) south of Darling (-AD), *Grobbelaar 290* (PRE); Platteklip, near Cape Town (-AD), *Marloth 1804* (PRE), *Zeyher 4895* (SAM); Grootepost farm near Mamre, Malmesbury district (-AD), *Middlemost 1838* (NBG, 1 & 2); between Darling and Yzerfontein, Malmesbury district (-AD), *Rycroft 1810* (NBG); between Mamre and Darling, about 56 km north of Cape Town on west coast road, near entrance to Rondeberg farm (-AD), *Van Wyk 2689* (JRAU, 1–3); Riebeek Kasteel, Malmesbury division (-BD), *Zinn s.n. sub SAM 54233* (SAM); Springfontein, Mamre, Malmesbury (-CB), *Axelson 378* (NBG); Malmesbury, 4 km from west coast road to Mamre (-CB), *Campbell & Van Wyk 138* (JRAU, NBG), *Penfold 241* (NBG); Malmesbury, about 56 km along west coast road from Cape Town, 2 km from turn-off to Mamre (-CB), *Campbell & Van Wyk 139* (JRAU); near Mamre (-CB), *Salter 2991* (BOL); 24 km from Melkbosstrand to Velddrif (-CB), *Stirton 11195* (NBG, PRE); Camp's Bay (-CD), *Alexander-Prior s.n. sub PRE 53123* (PRE), *Galpin 3919* (PRE), *Thode A7*

(PRE); Table Mountain (-CD), *Andreae 268b* (NBG), *Bolus 2750* (BOL, SAM), *Campbell & Van Wyk 28* (JRAU, 1 & 2), *Drège s.n. sub PRE 11850* (PRE), *Ecklon & Zeyher 1196* (SAM), *Froembling s.n. sub SAM 65269* (SAM), *Grobbelaar 199, 2196* (PRE), *MacOwan 52* (PRE, 1 & 2, SAM), *Moss 7800* (J), *Penfold s.n. sub SAM 52756* (SAM, 1 & 2), *Young s.n. sub TM 26462* (PRE); about 2.2 km along national road from Llandudno to Camp's Bay (-CD), *Campbell & Van Wyk 29*, 1 & 2, *106* (JRAU); Table Mountain, Devil's Peak (-CD), *Ecklon & Zeyher 1197* (SAM, 1 & 2), *Esterhuysen 20829* (BOL), *Penfold 186, s.n. sub NBG 14240* (NBG), *Thode 6072* (NBG), *Tyson 3356* (PRE); Rapenburg, near Cape Town (-CD), *Guthrie 188* (BOL, 1 & 2); Malmesbury district, near Pella, Burger's Post farm (-DA), *Boucher & Shepherd 4288* (PRE), *Strauss 5* (NBG); Paarlberg Nature Reserve (-DB), *Campbell & Van Wyk 23* (JRAU, 1 & 2); Malmesbury division, southern foot of Paardeberg (-DB), *Van Niekerk 356* (BOL); Vygerkraal (-DC), *Wolley-Dod 724* (BOL); Bottelary, Stellenbosch division (-DD), *Compton 12931* (NBG), *Esterhuysen 7680* (PRE); Simonsberg, Stellenbosch (-DD), *Compton 14191* (NBG, PRE), *Wolley-Dod 290* (BOL); Drakenstein mountains, Banghoek, Stellenbosch (-DD), *Ihlenfeldt & Meyer 1743* (PRE); Stellenbosch district, Onderpapegaaisberg (-DD), *Taylor 7038* (NBG).

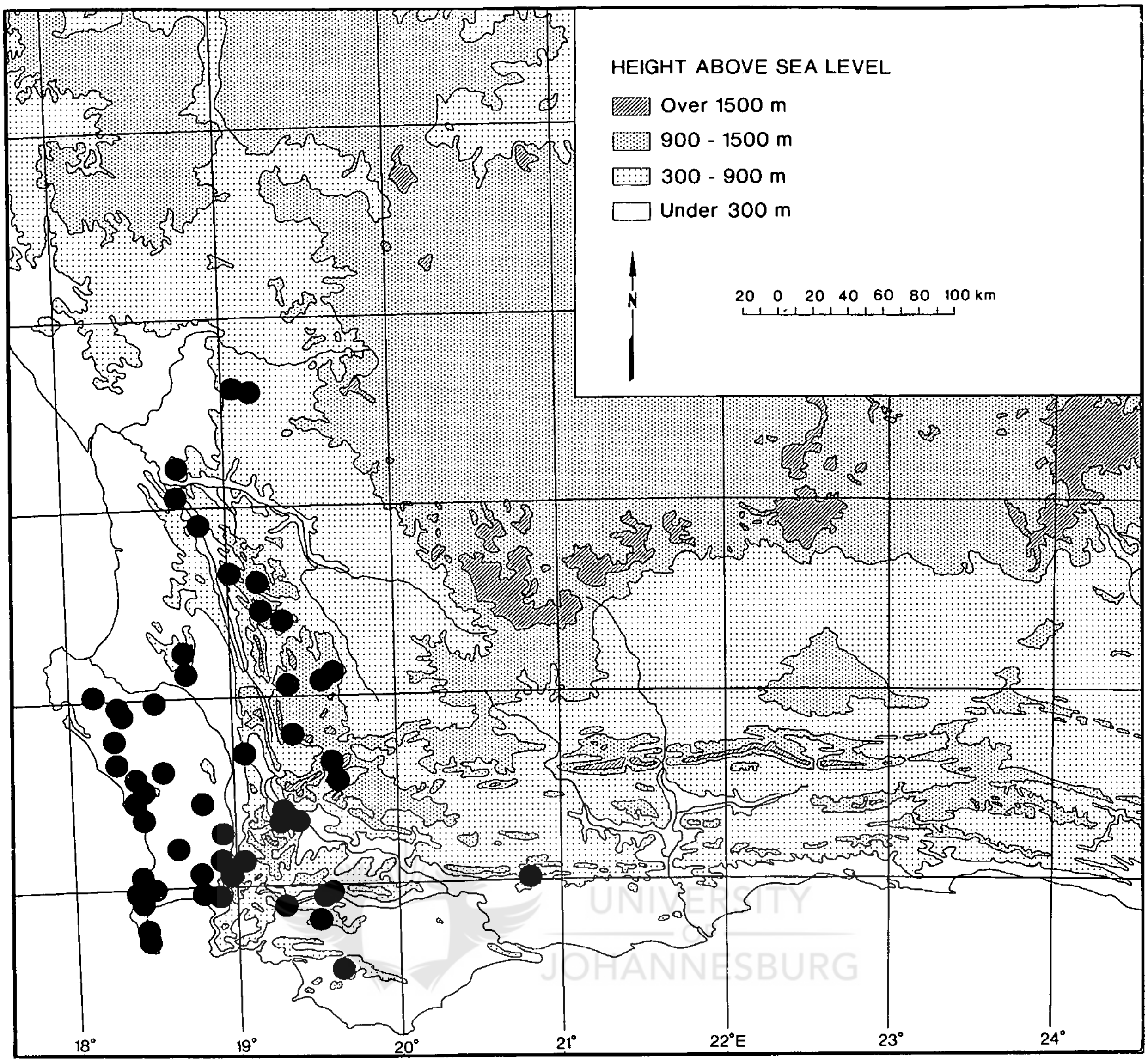
—**3319** (Worcester): Ceres division, Hansiesberg (-AB), *Compton 16709* (NBG), *Lewis 905* (SAM); Gydo, Ceres district (-AB), *Compton 18728* (NBG), *Leighton 2214* (BOL); Tulbagh waterfall (-AC), *Ecklon & Zeyher 1195* (SAM); Matroosberg (-BC), *Bolus 3960* (NBG) [atypical specimen], *Marloth 2225* (PRE) [atypical specimen]; Matroosberg, near Lakenvlei, Ceres division (-BC), *Phillips 1929* (SAM); Ceres, near Klondyke Cherry farm (-BC), *Van Wyk 2288* (JRAU); 1 km along national road from Jan du Toit bridge to Worcester (-CB), *Campbell & Van Wyk 20* (JRAU, 1–3, NBG, PRE); *Campbell, Van Wyk & De Castro 132* (BOL, JRAU, K, NBG, PRE); Hex River valley (-CB), *Compton 8366* (NBG), *Esterhuysen 1537* (PRE), *Tyson 754* (NBG); Rawsonville (-CB), *Le Roux s.n. sub PRE 53143* (PRE); near Goudini (-CB), *Schlechter 135a* (BOL, PRE), *9947* (BOL, PRE, 1 & 2); Bothashall siding (-CB), *Van Bredá 1552* (PRE); Divisional Council property opposite Groenrivier, Botha (-CB), *Walters 2539* (NBG); Wemmershoek, Paarl district (-CC), *Compton 10142* (NBG).

—**3320** (Montagu): Swellendam division, Langeberg, Strawberry Hill (-DD), *Stokoe s.n. sub NBG 9901* (NBG), *s.n. sub SAM 68747* (SAM); Swellendam division, Strawberry Hill farm, Langeberg, between Lemoenshoek and Naauwkrantz (-DD), *Stokoe s.n. sub NBG 100842* (NBG).

—**3418** (Simonstown): Wynberg Hill (-AB), *Bolus 7954* (BOL), *Salter 8916* (PRE), *9008* (NBG, PRE, SAM); Chapman's Peak (-AB), *Compton 8487* (NBG, 1 & 2), *Goulimis s.n. sub BOL 42873* (BOL), *Van Niekerk 470* (NBG); Miller's Point (-AB), *Gillett 3425* (NBG), *Whellan 1728* (PRE); Constantiaberg (-AB), *Lamb 1364* (SAM), *Salter 7959* (BOL, 1 & 2), *Van Wyk 2757* (JRAU), *Viviers 164* (NBG, PRE); Constantia, Bergvliet farm, Ladies' Mile (-AB), *Purcell 334*, *399*, *s.n. sub SAM 89675* (SAM); Noordhoekberg (-AB), *Salter 7989* (BOL); slopes north of Kloofnek (-AB), *Wolley-Dod 2335* (BOL); near Constantia (-AB), *Zeyher s.n. sub SAM 15209* (SAM); between Buffelsfontein and Cape Point (-AD), *Bolus s.n. sub BOL 50520* (BOL); Cape of Good Hope Nature Reserve (-AD), *Campbell & Van Wyk 31*, *152* (JRAU), *Van Wyk 3008* (JRAU, 1 & 2); Smitswinkel, hillside (-AD), *Compton 12576*, *15515*, *16658*, *16937* (NBG), *Gillett 1497* (BOL), *Lewis 489* (SAM), *Salter 8004* (BOL); veld near Strand road (-BB), *Anon. 367* (NBG); hills near Faure (-BB), *Compton 10371* (NBG); Hellshoogte near Stellenbosch (-BB), *Galpin 12266* (PRE); Vergelegen, Somerset West (-BB), *Johnson s.n. sub NBG 14245* (NBG); Somerset West, Stellenbosch (-BB), *Parker 3643* (NBG); Helderberg, Stellenbosch division (-BB), *Parker 3957* (BOL, NBG); Voëltjiesdorp, below powerline on boundary of Middelvlei, near cottages (-BB), *Taylor 7038* (PRE, 1 & 2); Somerset West, at Steynsrust turn-off (-BB), *Van Wyk 2788* (JRAU).

—3419 (Caledon): Swartberg (-AB), *Elbrecht s.n. sub TM 19008* (PRE); Ezeljacht, near Villiersdorp (-AB), *Walters 1932* (NBG); Happy Valley, Riviersonderend mountains, near Greyton (-BA), *Esterhuysen 20807* (NBG, PRE); Genadendal (-BA), *Schlechter 135* (PRE), *10283* (BOL, PRE, 1 & 2); Stanford district, 10 km from Stanford along gravel road to Salmonsdam Nature Reserve (-BC), *Campbell 161* (JRAU, K, PRE); Hermanus, Stanford, near Papiesvlei farm, road to Salmonsdam Nature Reserve (-BC), *Schutte & Vlok 762* (JRAU, NBG).

Precise locality unknown: *Ecklon 51* (PRE, 1 & 2); 'e Cap. b. spei', *LINN 895.22* [right hand specimen], *LINN 895.23*, *LINN 895.25* (LINN) [microfiche only]; *Marloth 8677*, *9322* (PRE); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16425*, *s.n. sub THUNB-UPS 16426*, *s.n. sub THUNB-UPS 16428*, *s.n. sub THUNB-UPS 16429*, *s.n. sub THUNB-UPS 16435*, *s.n. sub THUNB-UPS 16436* (UPS) [microfiche only].



Map 9.2 The known geographical distribution of *R. angulata* subsp. *angulata*.

2b. *Rafnia angulata* Thunb. subsp. ***thunbergii*** (Harv.) G.J. Campbell & B-E. van Wyk stat. nov. Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16434* (UPS, microfiche!, lectotype, designated here).

≡ *R. thunbergii* Harv. in Harv. & Sond., Fl. Cap. 2: 36 (1862).

= *Rafnia filifolia* Thunb., Gen. Nov. Pl.: 148 (1800a) pro parte minore, excluding *THUNB-UPS 16435* and *16436*, Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 565 (1823); DC., Prodr. 2: 119 (1825); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845).

Erect, robust suffrutex, often with all stems herbaceous and not much-branched, up to 1.5 m tall. *Leaves* linear, bright green, often remaining so when dry; leaves on flowering branches subopposite to opposite, 9–20 (–27) mm long, 1–2 mm wide; basal leaves 20–35 (–45) mm long, 1–5 mm wide. *Inflorescences* single- or few-flowered, 2–3 flowers, aggregated into spike-like pseudoracemes. *Flowers* 12–20 mm long. *Pedicel* 4–8 mm long. *Bract* not ± leafy. *Bracteoles* 0.3–0.8 mm long. *Calyx* lobes minute, ± triangular, much shorter than tube, 1–2 mm long; carinal lobe often shorter than others. *Standard* ovate, 10–13 (–17) mm long, 7–12 (–18) mm wide; claw 3–5 mm long. *Wings* oblong or subtriangular, shorter than keel, with 8–12 upper and central basal rows of sculpturing; apex narrow to obtuse. *Keel* rostrate, 10–15 mm long. *Pistil* with ovary oblong; style long, longer than ovary; ovules 2–4; stigma glabrous. *Pods* obliquely oblanceolate, 20–22 mm long, 7–8 mm wide. *Seeds* 3–5 mm long, ± 3 mm wide.

Diagnostic characters. *R. angulata* subsp. *thunbergii* (see Figure 9.2c & d) differs from the typical subspecies in the unbranched stems (see Figure 9.2c), the bright green leaves (mostly glaucous in subsp. *angulata*) (see Figure 9.2d), the spicate pseudoracemes (inflorescences not aggregated into spicate pseudoracemes in subsp. *angulata*) (see Figure 9.2c), the minute calyx lobes (much shorter than the tube in subsp. *thunbergii*; usually ± as long as or longer than the tube in subsp. *angulata*) and the many rows of petal sculpturing on the wing petals (up to 12 rows in subsp. *thunbergii*; up to 8 rows in subsp. *angulata*).

Distribution and habitat. R. angulata subsp. *thunbergii* is limited to the Worcester area, in the Hex River valley near De Doorns and the Breederivier (see Map 9.3). It frequently occurs along disturbed roadsides and in foothills, in stony TMS soil.

Specimens examined.

—**3319** (Worcester): Hex River valley, near De Doorns (-BC), *Bolus 13080* (BOL, PRE, 1–3), *Van Bredá 4218* (PRE), *Van Wyk 2908* (JRAU, 1 & 2), *Walters 1331* (NBG); 7.2 km from Sandhills turn-off to De Doorns (-BC), *Campbell, Van Wyk & De Castro 130* (JRAU, NBG, PRE); near De Doorns, about 3 miles (4.8 km) north of Worcester (-BC), *Schlieben & Van Bredá 9933* (PRE), *Thorne s.n. sub NBG 14263* (NBG); De Doorns, about 75 m before turn-off to Orchard from Touwsrivier road (-BC), *Van Wyk 3015* (JRAU); near Worcester, Breederivier (-CB), *Bayliss BRI B 1240* (PRE), *Compton 24446* (NBG, 1–4); Breederivier, 4 miles (6.4 km) south of Worcester (-CB), *Gentry 18981* (PRE); 12–14 miles (19.2–22.4 km) north-east of Worcester (-CB), *Gentry, Barclay & Van Bredá 18722* (PRE); 9 miles (14.4 km) west of Worcester (-CB), *Lewis 3583* (SAM, 1 & 2); Breederivier bridge, national road from Cape Town to Worcester (-CB), *Rycroft 2094* (NBG, 1–3); Rawsonville (-CB), *Walters 147* (NBG); Wangenheim farm, Rawsonville (-CB), *Walters 677* (NBG); Three Bridges, road from Worcester to Rawsonville (-CB), *Walters 1440* (NBG).

Precise locality unknown: 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16434* (UPS) [microfiche only].

2c. ***Rafnia angulata*** Thunb. subsp. ***humilis*** (Eckl. & Zeyh.) G.J. Campbell & B-E. van Wyk stat. nov. Type: South Africa, Western Cape Province, in lateribus montis "Tafelberg" prope "Constantia", *Ecklon & Zeyher 1198* (SAM!, lectotype, designated here).

≡ *Rafnia humilis* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836); Walp. in Linnaea 13: 464 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 467 (1843); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845); Harv. in Harv. & Sond., Fl. Cap. 2: 35 (1862).

= ?*Rafnia ecklonis* E. Mey., Comm. Pl. Afr. Austr. 1(1): 13 (1836); Harv. in Harv. & Sond., Fl. Cap. 2: 35 (1862). Type not seen.

Procumbent shrublet, much-branched from base, up to 0.2 m tall. *Leaves* linear; leaves on flowering branches subopposite to opposite, 20–35 (–46) mm long, 1–2 mm wide; basal leaves 14–22 (–27) mm long, 1–2 mm wide. *Inflorescences* single-flowered. *Flowers* few, 9–11 mm long. *Pedicel* 7–11 mm long. *Bract* not ± leafy, 0.6–0.9 mm long. *Bracteoles* 0.3–0.5 mm long. *Calyx* lobes narrowly triangular, longer than tube, 5–6 mm long; upper lobes falcate, slightly broader than others; carinal lobe slightly longer than others; tube 3–4 mm long. *Standard* obovate or elliptic, 8–9 mm long, 6–7 mm wide; claw 1–3 mm long. *Wings* obliquely triangular, shorter than keel, 5–7 mm long, 2–3 mm wide, with 4–5 rows of sculpturing; apex narrow; claw 3–4 mm long. *Keel* rostrate, 7–8 mm long, 3–4 mm wide; claw 3–4 mm long. *Stamens* monadelphous. *Pistil* with the ovary oblong; style long, ± as long as or longer than ovary; ovules 2; stigma glabrous. Mature pods and seeds unknown.

Diagnostic characters. R. angulata subsp. *humilis* differs from the typical subspecies in the very narrow, longer leaves, the basal leaves which are smaller than the upper leaves (basal leaves are larger than the upper leaves in subsp. *angulata*), the presence of few flowers, the sometimes obovate standard petal (ovate or elliptic or round in subsp. *angulata*) and the obliquely triangular wing petals (wings oblong in subsp. *angulata*).

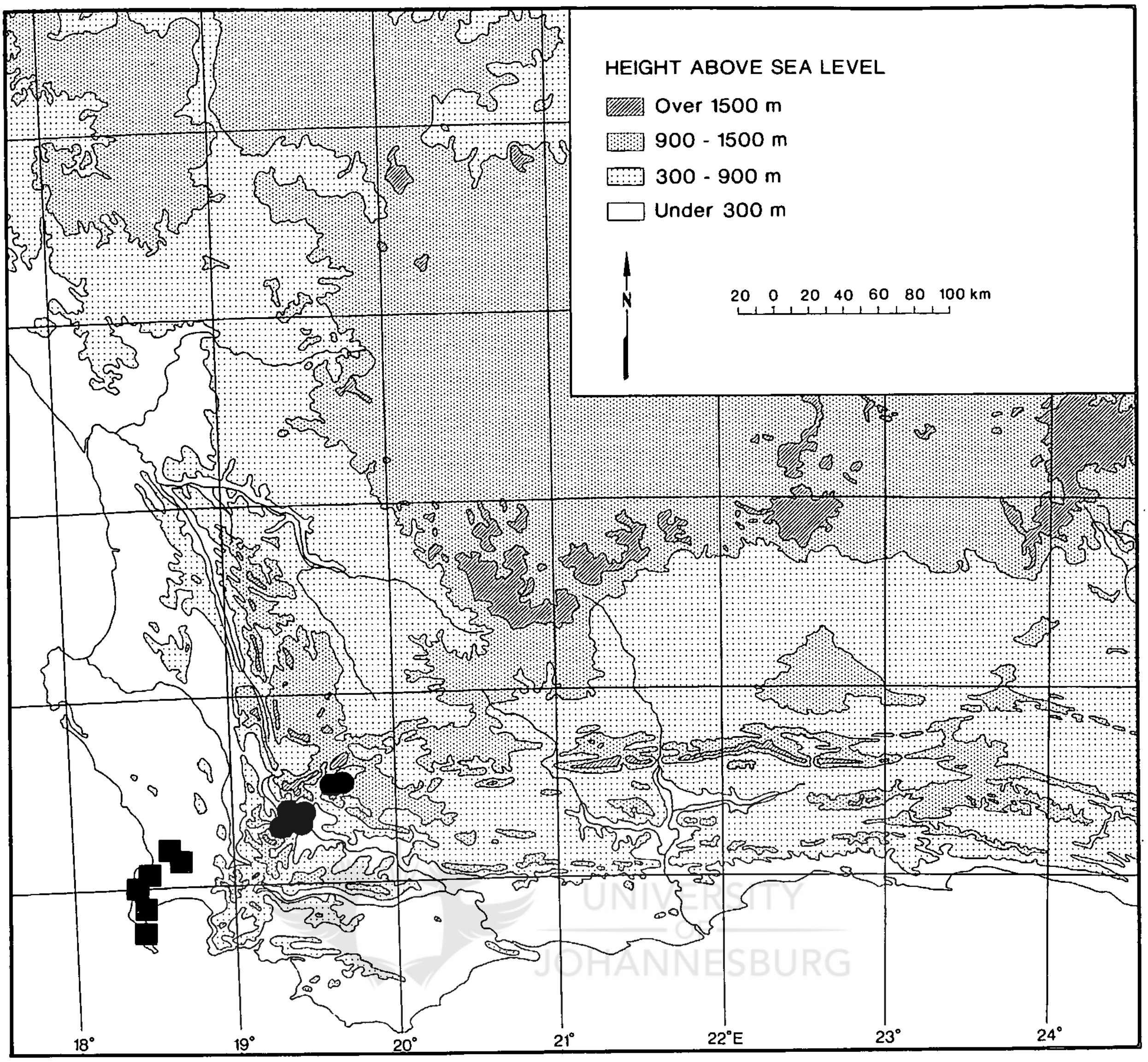
Distribution and habitat. This subspecies is mostly limited to the Cape Peninsula (Map 9.3) and grows on sandy flats.

Specimens examined.

—3318 (Cape Town): Rapenburg, near Cape Town (-CD), *Bolus 7072* (BOL), *Guthrie 188* (BOL); Table Mountain, near Constantia (-CD), *Ecklon & Zeyher 1198* (SAM); 0.5 miles (0.8 km) north of Pineland's station (-CD), *Salter 8271* (BOL, 1 & 2); near Modderdam (-DC), *Leighton 1474* (BOL); Paarl, road near Kraaifontein (-DC), *Salter 3988* (BOL); *Young 176* (BOL), *s.n. sub TM 27329* (PRE); between Uitvlugt and Vygerkraal (-DC), *Wolley-Dod 2091* (BOL).

—3418 (Simonstown): Flats west of Klaasjagersberg (-AB), *Salter 2875* (BOL); flats below Steenberg (-AB), *Salter 4013* (BOL).

Precise locality unknown: 'e Cap. b. spei', *LINN 895.24* (LINN) [microfiche only]; Woodbush, *Van Warmelo 243* (PRE).



Map 9.3 The known geographical distribution of *R. angulata* subsp. *thunbergii* (dots) and *R. angulata* subsp. *humilis* (squares).

2d. *Rafnia angulata* Thunb. subsp. ***ericifolia*** (Salter) G.J. Campbell & B-E. van Wyk stat. nov. Type: South Africa, Western Cape Province, near Hercules Pillar, *Salter 6567* (BOL!, holotype; K!, BM!, isotypes; PRE!, isosyntype).

≡ *R. ericifolia* Salter in J. S. Afr. Bot. 12: 40 (1946).

Virgate, much-branched shrublet, up to 0.5 m tall. *Leaves* very small, ericoid or narrowly linear; leaves on flowering branches subopposite to opposite, 6–14 mm long, 0.5–1 mm wide; basal leaves (5–) 9–16 mm long, 0.5–1.5 mm wide; coppice leaves 19–23 mm long, 2–5 mm wide. *Inflorescences* single-flowered. *Flowers* 8–11 mm long. *Pedicel* 7–10 mm long. *Bract* not ± leafy, ± 0.6 mm long. *Bracteoles* 0.3–0.4 mm long. *Calyx* lobes narrowly triangular, as long as or longer than tube, 4–6 mm long; tube 3–4 mm long. *Standard* ovate or elliptic, 7–9 mm long, 5–7 mm wide; claw ± 2 mm long. *Wings* oblong, shorter than keel, 6–7 mm long, 2–3 mm wide, with 6–7 rows of sculpturing; apex obtuse; claw 2–3 mm long. *Keel* shortly rostrate, 6–8 mm long, ± 3 mm wide; claw ± 3 mm long. *Pistil* with the ovary oblong; style longer than ovary; ovules 3–4; stigma glabrous. *Pods* ± oblong, 18–22 mm long, 6–7 mm wide; upper margin ± straight; lower margin convex. *Seeds* unknown.

Diagnostic characters. R. angulata subsp. *ericifolia* differs from subsp. *angulata* in the smaller, narrower ericoid leaves (leaves linear to obovate in subsp. *angulata*), the narrower standard petal, the obtuse standard apex (acute or narrow in subsp. *angulata*), the shortly rostrate keel petal (keel sometimes long-rostrate in subsp. *angulata*), and the smaller, oblong pods (pods obliquely oblanceolate in subsp. *angulata*).

Distribution and habitat. R. angulata subsp. *ericifolia* occurs in the Paarl area (see Map 9.4), in fynbos or veld that is a transition from fynbos to renosterveld, on gentle slopes, in sandy, quartzitic or clay soils.

Specimens examined.

—3318 (Cape Town): Klipheuwel radio station (-DA), *Boucher 3535* (PRE), *Oliver 8665* (PRE); Bulelwa, Agter-Paarl (-DB), *Van Zyl 3583* (NBG, PRE, 1 & 2); Durbanville Nature Reserve (-DC), *Vlok & Schutte 108* (JRAU); Klapmuts, Paarl (-DD), *Barker 8862* (NBG, 1 & 2); Joostenberg farm, Muldersvlei, Stellenbosch (-DD), *Burtt-Davy s.n. sub PRE 12516* (PRE); near Paarl, road to Cape Town (-DD), *Esterhuysen 28056* (BOL); between Durbanville and Paarl, Hercules Pillar (-DD), *Salter 4346* (BOL), *6567* (BOL, PRE).

2e. *Rafnia angulata* Thunb. subsp. ***montana*** G.J. Campbell & B-E. van Wyk subsp. nov., a subspecie *angulata* habitu valde minori, procumbenti, caespitoso, lobo carinali longo (ceteris lobis longior in subsp. *montana*; brevior vel aequilongus in subsp. *angulata*), extensione aliformi inter lobos calycis supernos (in subsp. *angulata* abest), et legumine minori, oblique lanceolato (in subsp. *angulata* oblique oblanceolato), differt. Type: South Africa, Western Cape Province, Klein Swartberg, crest of mountain above Sand River, on flat area about 2.5 km west of Seweweekspoort Peak, *Van Wyk & Schutte 3323* (NBG!, holotype).

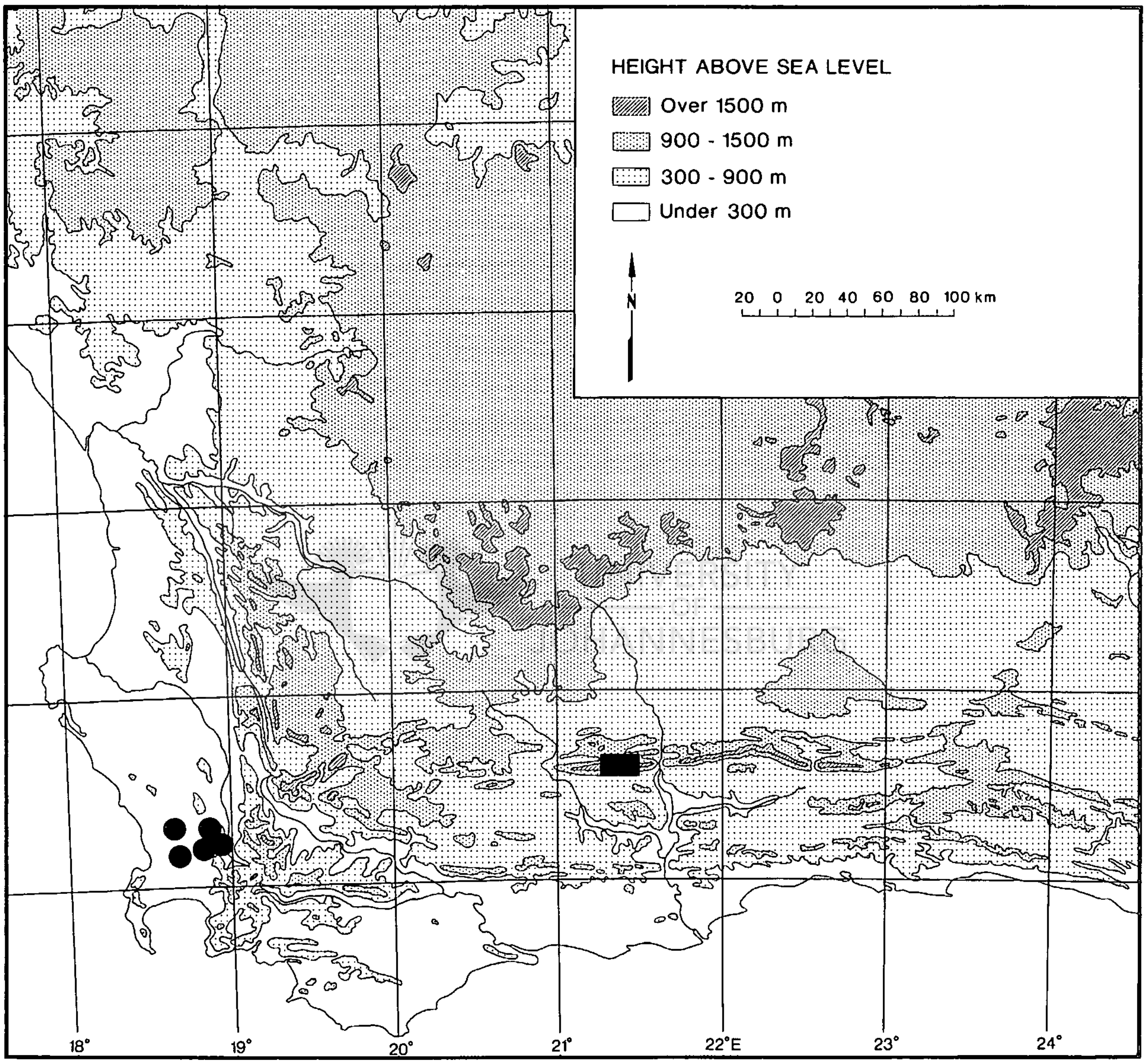
Procumbent, clump-forming shrublet, up to 0.15 m tall, 1 m wide. *Leaves* narrowly obovate; leaves on flowering branches opposite to subopposite, 12–18 mm long, 2–3 mm wide; basal leaves 9–12 mm long, 1–2 mm wide. *Inflorescences* single-flowered. *Flowers* 10–11 mm long; buds leaf-like. *Pedicel* 6–8 mm long. *Bract* not ± leafy, 0.5–0.7 mm long. *Bracteoles* 0.2–0.4 mm long. *Calyx* lobes longer than tube, 5–6 mm long; upper lobes broadly falcate, much broader than others; lateral lobes falcate; carinal lobe longer than others; tube with a wing-like extension between upper lobes, 3–5 mm long. *Standard* elliptic, 8–9 mm long and wide; claw 1–2 mm long. *Wings* oblong, ± as long as keel, 7–8 mm long, ± 3 mm wide, with 4–5 rows of sculpturing; apex obliquely obtuse; claw 2–3 mm long. *Keel* shortly-rostrate, ± 7 mm long, ± 4 mm wide; claw 2–3 mm long. *Pistil* with ovary oblong; style shorter than ovary; ovules 2–3. *Pods* obliquely lanceolate, 15–16 mm long, ± 7 mm wide; upper margin ± straight; lower margin ± straight, proximally convex. *Seeds* unknown.

Diagnostic characters. R. angulata subsp. *montana* (see Figure 9.2e & f) differs from the typical subspecies in the much smaller, procumbent, clump-forming habit (see Figure 9.2e), the smaller, narrowly obovate leaves (see Figure 9.2f), the basal leaves which are smaller than the upper leaves (basal leaves larger than the upper leaves in subsp. *angulata*), the long carinal calyx lobe (longer than the other lobes in subsp. *montana* and shorter than or as long as the other lobes in subsp. *angulata*). In subsp. *montana*, the broadly falcate upper calyx lobes are much broader than the other lobes (not broadly falcate and usually only slightly broader than the other lobes in subsp. *angulata*). The calyx tube has a wing-like extension between the upper lobes (wing absent in subsp. *angulata*) and the pods are smaller and obliquely lanceolate (obliquely oblanceolate in subsp. *angulata*).

Distribution and habitat. R. angulata subsp. *montana* is the only subspecies that is geographically isolated from *R. angulata*—the other subspecies fall within the distribution area of *R. angulata*. It is known only from the Seweweekspoort mountains in the Ladismith area (Map 9.4) and occurs on flat areas or mountain peaks and frequents burnt slopes.

Specimens examined.

—**3321** (Ladismith): Prince Albert district, Seweweekspoort mountains, northern side of Ridge Peak (-AD), *Andreae 1245* (BOL, PRE); Klein Swartberg, crest of mountain above Sandrivier, on flat area about 2.5 km west of Seweweekspoort Peak (-AD), *Van Wyk & Schutte 3323* (NBG).



Map 9.4 The known geographical distribution of *R. angulata* subsp. *ericifolia* (dots) and *R. angulata* subsp. *montana* (squares).

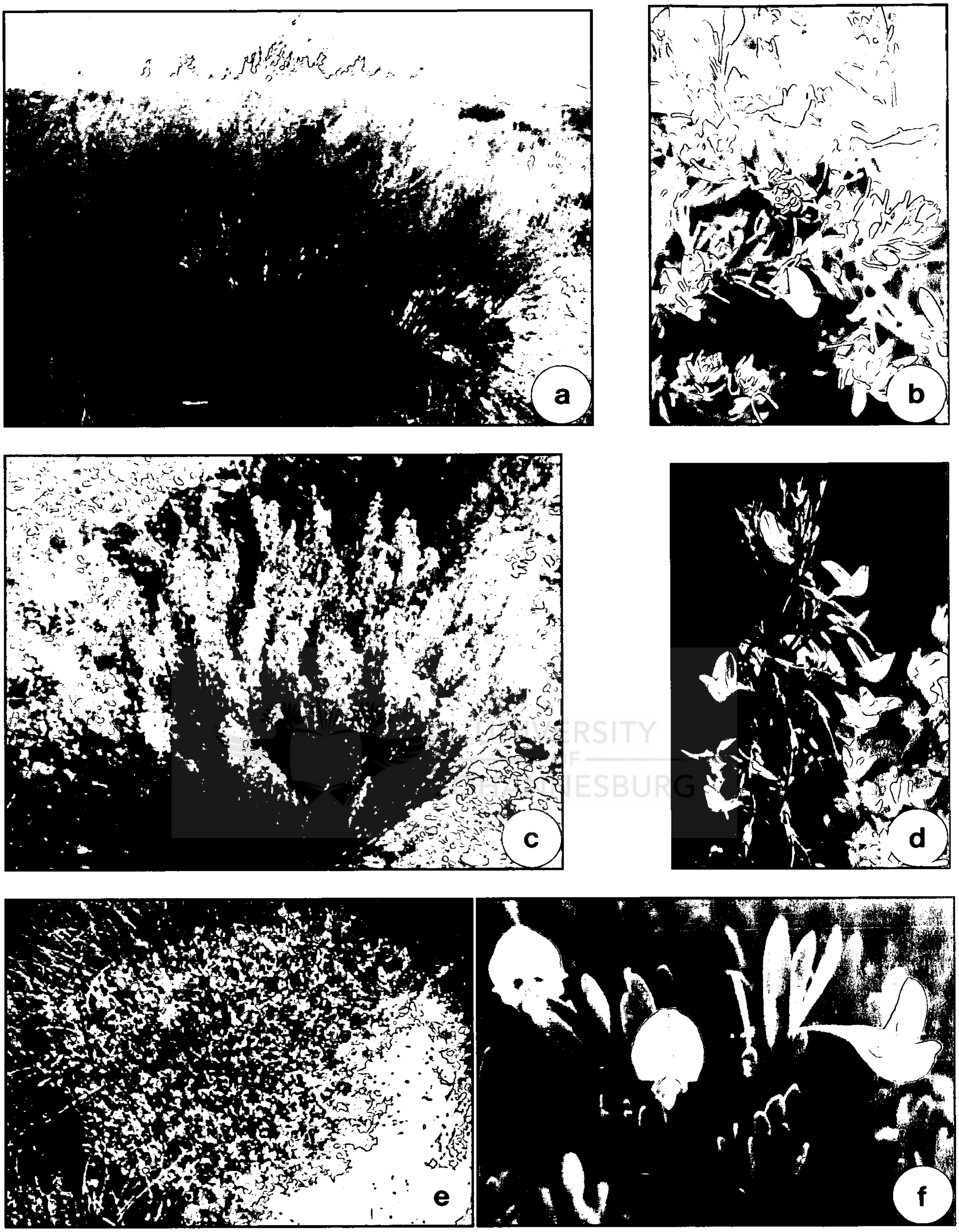


Figure 9.2 Habit, inflorescences and flowers of *R. angulata* subsp. *angulata* (a & b), *R. angulata* subsp. *thunbergii* (c & d) and *R. angulata* subsp. *montana* (e & f): **a,** virgate, multi-stemmed shrub; **b,** single-flowered inflorescences, and note the flower fading orange and the rostrate keel; **c,** unbranched, herbaceous shrub with spicate pseudoracemes; **d,** bright green leaves, single-flowered inflorescences and young pods; **e,** prostrate, clump-forming shrublet; **f,** narrowly obovate leaves and single-flowered inflorescences.

3. ***Rafnia crispa*** C.H. Stirton in Bothalia 14(1): 74 (1982). Type: South Africa, Western Cape Province, south-west of Wolseley, on flats at Kluitjieskraal, *Stirton 8439* (PRE!, holotype).

Procumbent shrublet, much-branched from base, up to 0.4 m tall. *Leaves* lanceolate, penninerved; margins distinctly cartilaginous; leaves on flowering branches invariably alternate, (43–) 50–63 (–70) mm long, 7–13 mm wide; basal leaves 41–55 mm long, 11–15 mm wide. *Inflorescences* single-flowered, pedunculate. *Flowers* 13–15 mm long. *Pedicel* 1–2 mm long. *Bract* ± 2 mm long. *Bracteoles* ± 1 mm long. *Calyx* subequally lobed; lobes triangular, ± as long as or shorter than tube, ± 3 mm long; carinal lobe shorter than others; upper sinus deeper than others; lateral sinus shallower and narrower than others; tube ± 4 mm long. *Standard* ovate, 14–15 mm long and wide; claw ± 3 mm long. *Wings* broadly oblong, ± 15 mm long, ± 8 mm wide, with 5–6 rows of sculpturing; apex obovate; claw ± 6 mm long. *Keel* long-rostrate, strongly upcurved, ± 14 mm long, ± 7 mm wide; claw ± 5 mm long. *Pistil* with the ovary ± narrowly ovate; style ± as long as ovary, strongly upcurved; ovules 2. Mature pods and seeds unknown.

Diagnostic characters. *R. crispa* is similar to *R. lancea* but differs in the larger, distinctly penninerved leaves (venation indistinct in *R. lancea*), which have strongly cartilaginous margins (margins entire in *R. lancea*), the basal leaves which are shorter and broader than the upper leaves (basal leaves are slightly shorter than but as broad as the upper leaves in *R. lancea*), the smaller flowers and the calyx which is not distinctly lotononoid as in *R. lancea*, but has the lateral sinus shallower and narrower than the other sinuses. In *R. crispa*, the carinal calyx lobe is shorter than the others (as long as the others in

R. lancea), the standard blade ovate (elliptic or round in *R. lancea*), the petal claws are shorter than in *R. lancea*, the wing apex is obovate (obtuse in *R. lancea*), the ovary narrowly ovate (± oblong in *R. lancea*) and the style is strongly upcurved (basally downcurved, distally upcurved in *R. lancea*).

Distribution and habitat. *R. crispa* has been collected only at Kluitjieskraal in the Worcester area (see Map 9.6), growing on sandy, stony flats or gentle slopes.

Specimen examined.

—**3319** (Worcester): South-west of Wolseley, on flats at Kluitjieskraal (-AC), *Stirton 8439* (PRE).

4. ***Rafnia lancea*** (Thunb.) DC., Prodr. 2: 119 (1825); E. Mey. in Linnaea 7: 147 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (1836); E. Mey., Comm. Pl. Afr. Austr. 1(1): 12 (1836); Walp. in Linnaea 13: 464 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 466 (1843); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845); Harv., Thes. Cap. 1: 45, t. 72 (1859), in Harv. & Sond., Fl. Cap. 2: 34 (1862); Walp. in Ann. Bot. 7: 671 (1868); Schinz in Bull. Herb. Boiss. 2: 200 (1894). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16348* (UPS, microfiche!, lectotype, designated here).

≡ *Oedmannia lancea* Thunb., Gen. Nov. Pl.: 137 (1800a), Prodr. Pl. Cap.: 122 (1800b), Fl. Cap.: 561 (1823).

Procumbent shrublet, much-branched from base, up to 0.3 m tall. *Leaves* lanceolate; leaves on flowering branches invariably alternate, 32–46 mm long, 5–10 mm wide; basal leaves 22–32 (–40) mm long, 4–10 mm wide. *Inflorescences* single-flowered, pedunculate. *Flowers* 18–24 mm long. *Pedicel* 2–3 mm long. *Bract* 1–2 mm long. *Bracteoles* 0.5–1 mm long. *Calyx* lotononoid, upper and lateral lobes fused higher up in pairs on either side; lobes triangular, shorter than or ± as long as tube, 5–7 mm long; upper lobes sometimes slightly falcate; upper sinus shallower than lower sinuses; tube 5–8 mm long. *Standard* elliptic or round, ± 14 mm long, 11–14 mm wide; claw long, 7–10 mm long. *Wings* oblong, 12–13 mm long, 5–7 mm wide, with 6–8 rows of sculpturing; apex obtuse; claw long, 6–10 mm long. *Keel* sometimes long-rostrate, ± strongly upcurved, 11–12 mm long, 5–6 mm wide, with central pocket ± indistinct; claw long, 7–9 mm long. *Pistil* with ovary ± oblong; style long, longer than ovary, basal part gently downcurved, distal part upcurved; ovules 2–4. *Pods* obliquely oblong, 18–23 mm long, 5–7 mm wide; upper and lower margins straight, proximally curved. *Seeds* unknown.

Diagnostic characters. *R. lancea* is distinguished from all the other species of *Rafnia* by the lotononoid calyx in which the upper and lateral lobes are fused higher up on either side, the long petal claws, which are rather long relative to the petal blades in comparison with the other species, the curvature of the style, which is proximally downcurved and distally upcurved and the proximally curved pod.

Distribution and habitat. This species occurs in the north-west near Wupperthal, and continues south through Malmesbury, Paarl and Worcester to Faure (Map 9.5). It grows in coastal renosterveld, on gentle or steep slopes or sand flats, often in clay sands.

Specimens examined.

—3219 (Wupperthal): Wupperthal, Clanwilliam (-AC), *Leipoldt 3401* (SAM).

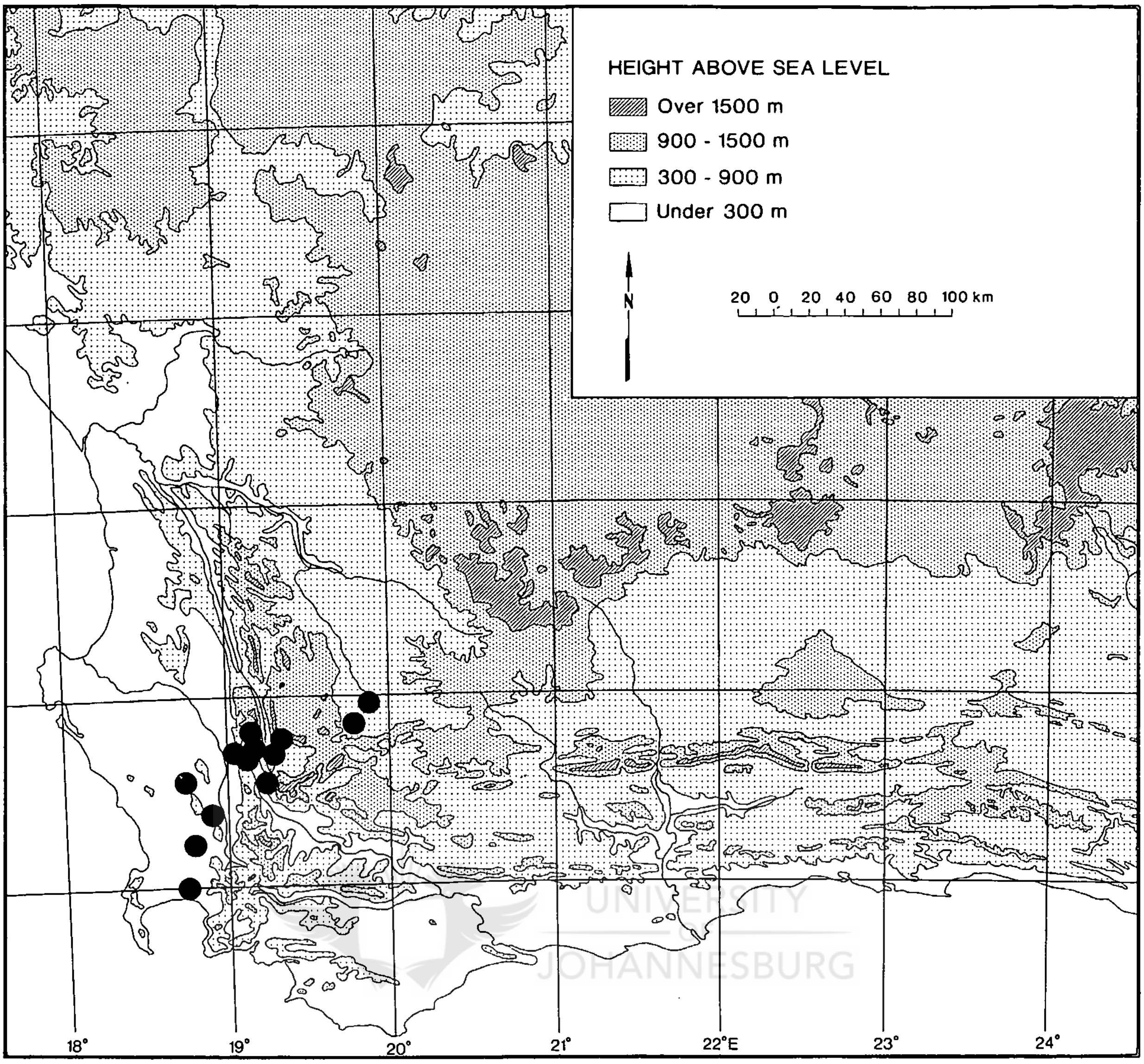
—3318 (Cape Town): Malmesbury (-BC), *Anon. s.n. sub BOL 50553* (BOL); Malmesbury, Gansekraal

(-BC), *Barker 1002* (NBG); Paarl district, 6.4 km west-north-west of Windmill (-DB), *Acocks 24519* (PRE); Paarl division, east of Paardeberg, Klip valley (-DB), *Salter 7669* (BOL); Paarl division, 2 miles (3.2 km) south of Joostenberg (-DD), *Pillans 9259* (BOL, NBG, PRE).

—**3319** (Worcester): Tulbaghkloof (-AA), *Bolus s.n. sub BOL 42987* (BOL), *Stokoe s.n. sub SAM 65707* (PRE, 1 & 2, SAM); Ceres division, Gydo (-AB), *Leipoldt 4023* (BOL); Romansrivier, railway crossing between Baineskloof and Mitchell's Pass (-AC), *Johnson 481* (NBG, 1 & 2), *Lewis 3587* (SAM); Tulbagh division, Gouda (-AC), *Lewis 5739* (NBG), *Loubser 773* (BOL); between Vogel valley and Tulbaghkloof (-AC), *Zeyher s.n. sub SAM 15207* (SAM); Ceres road station (-AD), *Guthrie 3382* (BOL, NBG); Mostertberg, near Mitchell's Pass (-AD), *MacOwan 1601* (SAM); Doornrivier (-BB), *Walters 203*, *948* (NBG).

—**3418** (Simonstown): Faure (-BB), *Esterhuysen 11936* (BOL).

Precise locality unknown: Probably Cape Town, *Anon. 4707* (BOL); *Drège s.n. sub PRE 9511* (PRE); 'Tierberge, Kleinrivier, Caledon', *Ecklon & Zeyher 1194* (SAM); 'e Cap. b. spei', *LINN 895.18* (LINN) [microfiche only]; 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16348* (UPS) [microfiche only].



Map 9.5 The known geographical distribution of *R. lancea*.

5. *Rafnia rostrata* G.J. Campbell & B-E. van Wyk sp. nov., *R. racemosae* similis sed foliis obovatis (in *R. racemosa* lanceolatis vel ellipticis), racemis unifloris (in *R. racemosa* pauci- vel multifloris), et petalo carinali longe rostrato, acute sursum curvato (in *R. racemosa* breve rostrato, recto), differt. Type: South Africa, Western Cape Province, Swartruggens, Swartrug Division Road to Ceres-Karoo, Katbakkies Pass, *Campbell & Van Wyk 145* (NBG!, holotype; BOL!, JRAU!, K!, MO!, NBG!, PRE!, UPS!, isotypes).

Erect or procumbent shrublet, much-branched from base, up to 0.4 m tall. *Leaves* obovate to angular-obovate, or lanceolate to obovate-lanceolate; leaves on flowering branches invariably alternate or subopposite to opposite, 13–40 mm long, 3–15 mm wide; basal leaves 16–32 mm long, 3–24 mm wide. *Inflorescences* single-flowered or few-flowered, 2–5 flowers. *Flowers* 12–19 mm long. *Pedicel* 5–8 mm long. *Bract* 0.5–2 mm long. *Bracteoles* triangular or minute, 0.2–0.7 mm long. *Calyx* lobes triangular or narrowly triangular, longer than tube, 5–8 mm long; upper lobes falcate, broader than others; lateral lobes sometimes falcate; carinal lobe often slightly longer than others; upper sinus sometimes slightly deeper than others; tube 4–6 mm long. *Standard* ovate or elliptic or suborbicular, 10–15 mm long and wide; claw 2–5 mm long. *Wings* oblong, ± as long as keel, 8–13 mm long, 3–5 mm wide, with 4–6 rows of sculpturing; apex obliquely obtuse or tapering; claw 3–5 mm long. *Keel* ± long-rostrate, strongly upcurved, 9–13 mm long, 4–6 mm wide; claw 3–5 mm long. *Stamens* monadelphous or rarely diadelphous. *Pistil* with ovary oblong-ovate; style ± as long as or shorter than ovary, strongly upcurved; ovules 4–5. *Pods* obliquely lanceolate, 21–30 mm long, 7–9 mm wide; upper margin ± straight; lower margin proximally convex. *Seeds* unknown.

5a. *Rafnia rostrata* G.J. Campbell & B-E. van Wyk subsp. ***rostrata*** subsp. nov.

Erect shrublet. *Leaves* obovate to angular-obovate; leaves on flowering branches subopposite to opposite, 13–20 (–24) mm long, 6–15 mm wide; basal leaves 5–16 (–24) mm wide. *Inflorescences* single-flowered. *Bract* ± 0.5 mm long. *Bracteoles* minute, 0.2–0.3 mm long. *Calyx* lobes narrowly triangular; upper lobes slightly broader than others; lateral lobes sometimes slightly falcate; upper sinus deeper than others. *Standard* ovate or elliptic, 10–13 mm wide. *Wings* with apex obliquely obtuse. *Pistil* with style ± as long as ovary.

Diagnostic characters. R. rostrata subsp. *rostrata* (Figure 9.3) is similar to *R. racemosa* but differs in the smaller, obovate leaves (leaves lanceolate or elliptic in *R. racemosa*) (Figure 9.3b), the single-flowered racemes (few- to multi-flowered in *R. racemosa*), the falcate upper calyx lobes which are broader than the other lobes (lobes triangular and subequal in *R. racemosa*), the wings which are as long as the keel (longer than the keel in *R. racemosa*) and the long-rostrate, strongly upcurved keel petal (shortly rostrate and straight in *R. racemosa*). It also differs from *R. racemosa* subsp. *racemosa* in the subopposite to opposite leaf arrangement on the flowering branches (invariably alternate in *R. racemosa*) and the long calyx lobes (lobes longer than the tube in subsp. *rostrata* and as long as the tube in subsp. *racemosa*).

Distribution and habitat. R. rostrata subsp. *rostrata* is geographically isolated from *R. racemosa* and occurs in the Swartruggens mountains in the north as far east as the Laingsburg area (see Map 9.6), in dry fynbos, on sand dunes, sandy or dry shale flats or rocky mountain slopes.

Specimens examined.

—**3219** (Wupperthal): Rietrivier valley, on track to Zuurvlak (-DC), *Bean & Viviers 1976* (BOL); Swartrug division road to Ceres-Karoo, Katbakkies Pass, 5.9 km from turn-off to Kagga Kamma (-DC), *Campbell & Van Wyk 145* (BOL, 1 & 2, JRAU, 1–4, K, 1 & 2, MO, 1 & 2, NBG, 1–3, PRE, 1 & 2, UPS, 1 & 2); Swartruggens, Ceres district, 5.4 miles (8.6 km) along farm road north from summit of Katbakkies Pass (-DC), *Taylor 6087* (NBG, PRE); 15–20 km before Katbakkies turn-off to Ceres-Calvinia road (-DC), *C.M. van Wyk 486* (NBG, PRE) [coppice].

—**3319** (Worcester): Bonteberg (-BD), *Compton 9900* (NBG); Ceres, Bonteberg, Vaalkloof (-BD), *Marloth 9092* (PRE, 1 & 2).

—**3320** (Montagu): Cabidu, Laingsburg (-AB), *Barker 2358* (BOL, NBG), *Compton 22221* (NBG, 1 & 2); Touwsrivier (-AC), *Bolus 8372* (BOL); Witteberg, Laingsburg division (-BC), *Compton 2721, 3576* (BOL), *Esterhuysen s.n. sub BOL 61265* (BOL); Bantamskop, Witteberg, Laingsburg (-BC), *Compton 12126* (NBG), *Van Wyk 2175* (JRAU); Fisantekraal, Laingsburg (-BC), *Compton 21135* (NBG, PRE); Witteberg, above Matjiesfontein (-BC), *Young s.n. sub TM 26461* (PRE).

Precise locality unknown: Worcester division, Gouronna, *Esterhuysen 3727* (BOL).

Figure 9.3 Habit, inflorescences, flowers and pod of *R. rostrata* subsp. *rostrata*: **a,** erect shrublet with grey leaves; **b,** obovate leaves, single-flowered inflorescences and oblanceolate pod.

5b. *Rafnia rostrata* G.J. Campbell & B-E. van Wyk subsp. ***pauciflora*** G.J. Campbell & B-E. van Wyk subsp. nov., a subsp. *rostrata* habitu procumbenti caespitoso, foliis maioribus lanceolatis (in subsp. *rostrata* obovatis), et racemis 2- ad 5-floris (in subsp. *rostrata* unifloris), differt. Etiam a *R. racemosa* forma petalo carinali et floribus plerumque paucioribus differt. Type: South Africa, Western Cape Province, Oudtshoorn, Swartberg Pass, *Esterhuysen 28833* (BOL!, holotype).

Procumbent, clump-forming shrublet. *Leaves* lanceolate to obovate-lanceolate; leaves on flowering branches invariably alternate, (16–) 25–40 mm long; basal leaves 20–32 mm long, 3–8 mm wide. *Inflorescences* few-flowered, 2–5 flowers. *Flowers* 15–17 mm long. *Bract* 1–2 mm long. *Bracteoles* triangular, 0.5–0.7 mm long. *Calyx* lobes triangular; upper lobes broader than others; lateral lobes sometimes falcate; upper sinus sometimes slightly deeper than others. *Standard* ovate or suborbicular, 12–15 mm long and wide. *Wings* 12–13 mm long; apex tapering. *Keel* 11–12 mm long. *Stamens* monadelphous. *Pistil* with style shorter than ovary. *Pods* 25–30 mm long.

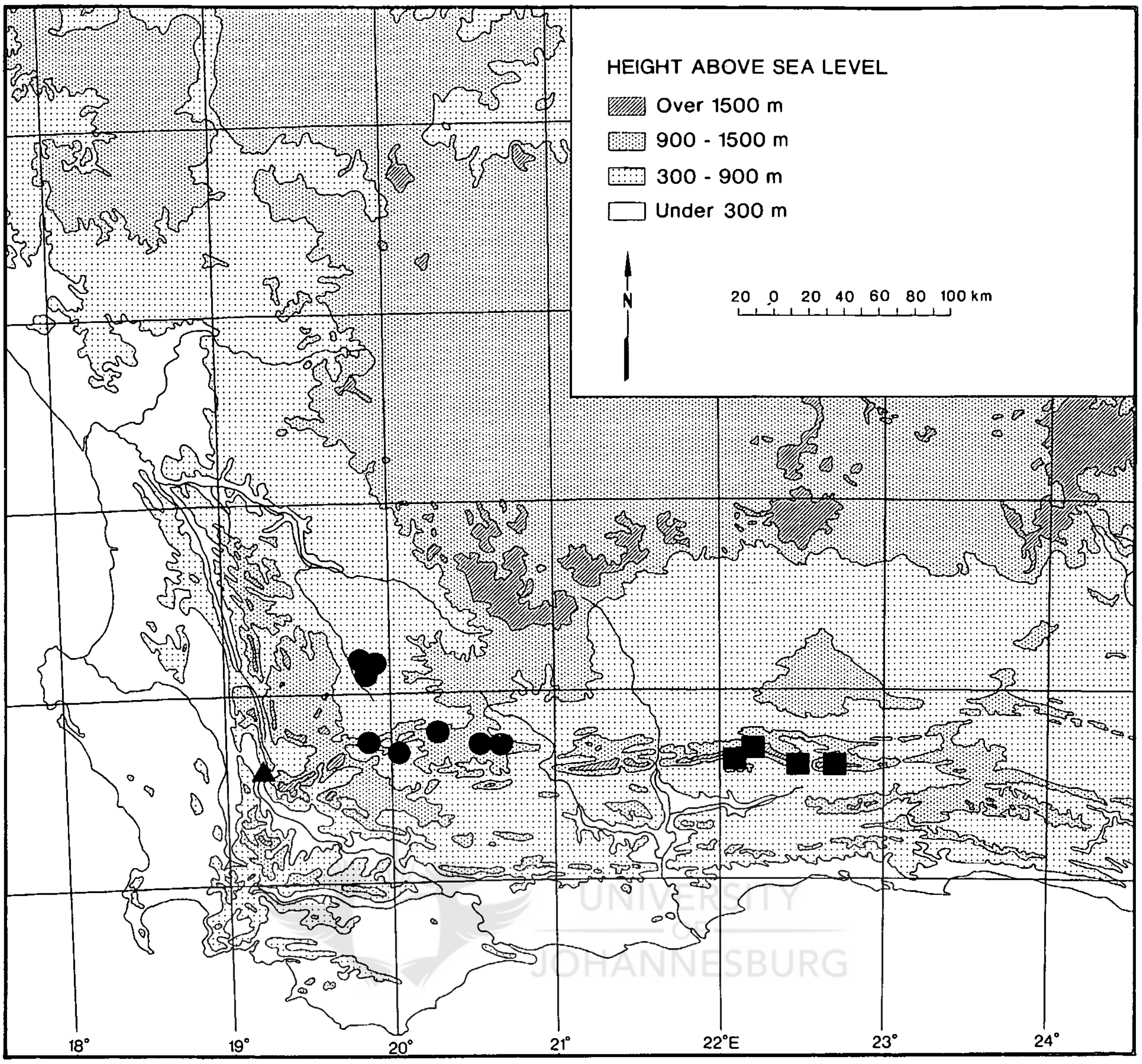
Diagnostic characters. R. rostrata subsp. *pauciflora* differs from the typical subspecies in the procumbent, clump-forming habit, the invariably alternate leaf arrangement on the flowering branches (subopposite to opposite in subsp. *rostrata*), the basal leaves which are smaller than the upper leaves (basal leaves larger than the upper leaves in subsp. *rostrata*), the larger, lanceolate leaves (leaves obovate in subsp. *rostrata*), the 2–5-flowered racemes (single-flowered in subsp. *rostrata*), the triangular calyx lobes (lobes narrowly triangular in subsp. *rostrata*), the tapering wing apex (apex obliquely obtuse in subsp. *rostrata*) and the short style (shorter than the ovary in subsp. *pauciflora* and ± as long as the ovary in subsp. *rostrata*). It also differs from *R. racemosa* in the shape of the keel petal and the generally smaller number of flowers (up to 5 flowers in subsp.

pauciflora and up to 19 flowers in *R. racemosa*).

Distribution and habitat. *R. rostrata* subsp. *pauciflora* is geographically isolated from subsp. *rostrata*, and is limited to the Swartberg (Map 9.6). The subspecies occupies montane or open grassy fynbos and grows on gentle or steep dry rocky, sandy slopes.

Specimens examined.

—**3322** (Oudtshoorn): Prince Albert, Swartberg, Blouberg Peak (-AC), *Bean & Viviers 1991* (BOL); Swartberg, Botha's road (-AC), *Bond 1622* (NBG); Swartberg Pass, along summit ridge (-AC), *Esterhuysen 28833* (BOL); Swartberg, summit ridge south-east of Blouberg (-AC), *Thompson 2211* (NBG, PRE, 1 & 2); forestry track near Blouberg on crest of mountain (-AC), *Vlok 892* (PRE, 1 & 2); Spitzkop, about 5 miles (8 km) west of Meiringspoort (-AD), *Thorne s.n. sub SAM 50193* (SAM); Swartberg, main peak in ridge east of Blesberg (-BC), *Oliver 5640* (NBG).



Map 9.6 The known geographical distribution of *R. rostrata* subsp. *rostrata* (dots), *R. rostrata* subsp. *pauciflora* (squares) and *R. crispa* (triangle).

6. *Rafnia vlokii* G.J. Campbell & B-E. van Wyk sp. nov., *R. alatae* et *R. ellipticae* similis sed inflorescentiis semper pedunculatis (in *R. alata* et *R. elliptica* pseudopedunculatis), lobo carinali calycis filiformi (in *R. alata* et *R. elliptica* triangulari), legumine maiori, oblique oblanceolato (in *R. alata* et *R. elliptica* oblique lanceolato), seminibus 6 mm longis (in *R. alata* et *R. elliptica* 3–5 mm longis), hilo seminis cum annulo tumido (in *R. alata* et *R. elliptica* sine annulo tumido), et testa seminis striata (in *R. alata* aspera et in *R. elliptica* laevi), differt. Type: South Africa, Western Cape Province, George, northern slopes of Outenikwas at eastern end of Waboomskraal, *Vlok 534* (NBG!, holotype; PRE!, isotype).

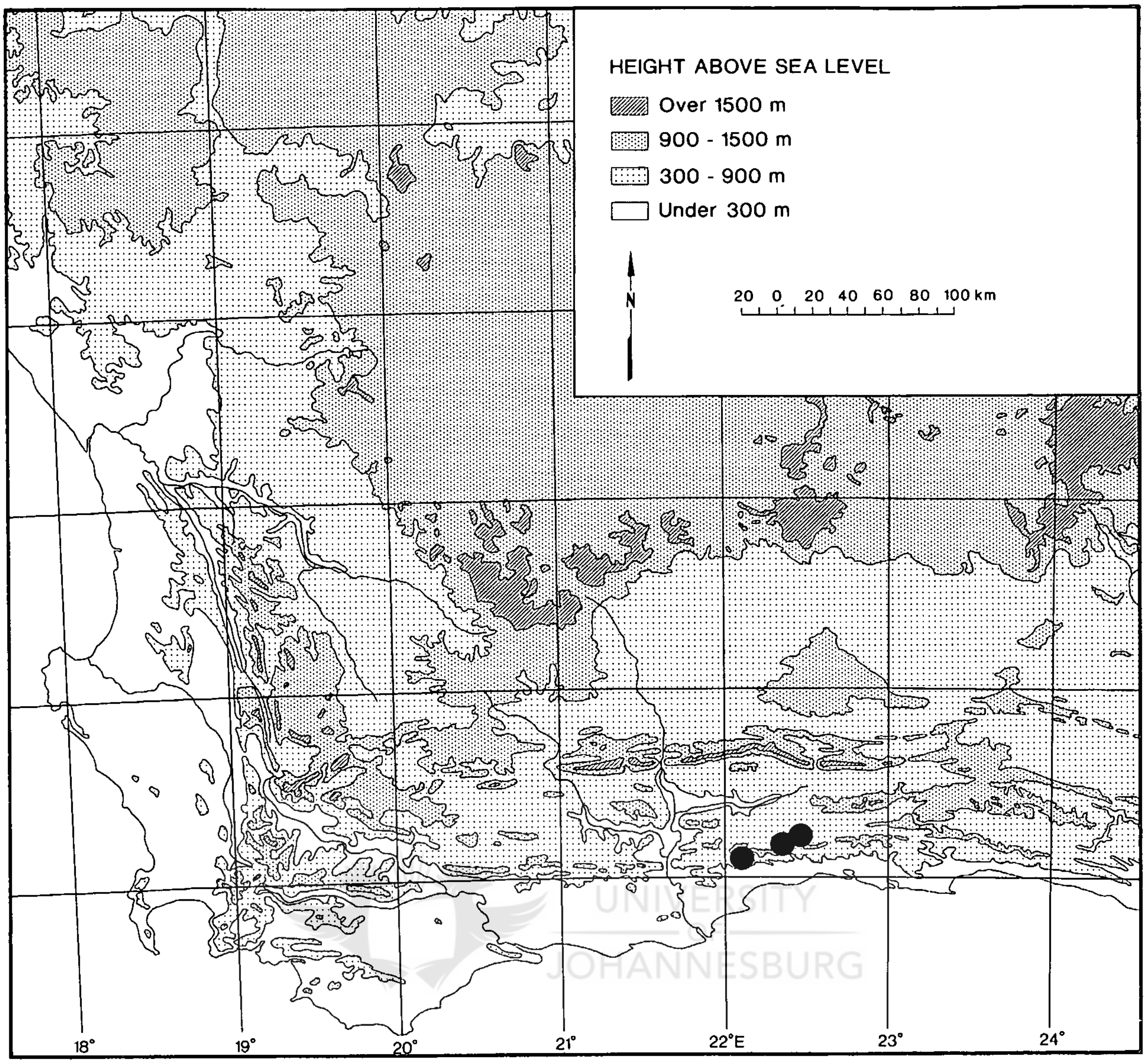
Erect, robust, much-branched suffrutex, up to 2 m tall. *Leaves* lanceolate to elliptic; leaves on flowering branches 30–55 mm long, (7–) 10–15 (–18) mm wide; basal leaves 45–55 (–87) mm long, 14–27 (–33) mm wide. *Inflorescences* single-flowered, pedunculate. *Flowers* large, 19–25 mm long; buds leaf-like. *Pedicel* 5–6 mm long. *Bract* ± 1 mm long. *Bracteoles* ± 0.3 mm long. *Calyx* long, very large; lobes much longer than tube, 13–15 mm long; upper lobes broadly falcate, much broader than others; lateral lobes falcate; carinal lobe very narrow, shorter than others; tube 4–5 mm long, with a ridge between upper lobes. *Standard* round, ± 17 mm long and wide; claw ± 3 mm long. *Wings* oblong, ± as long as keel, ± 13 mm long, ± 7 mm wide, with 7 rows of sculpturing; apex obtuse; claw ± 5 mm long. *Keel* ± 13 mm long, ± 7 mm wide; claw ± 4 mm long. *Pistil* with ovary oblong; style ± as long as ovary, strongly upcurved; ovules 2. *Pods* obliquely oblanceolate, 40–53 mm long, 10–13 mm wide; upper margin asymmetrically convex; lower margin ± straight. *Seeds* cordate-reniform to subtriangular or broadly oblong-reniform, 5–6 mm long, 4–5 mm wide; hilum surrounded by a swollen ring; testa longitudinally striate.

Diagnostic characters. R. vlokii (Figure 9.4) is similar to *R. alata* and *R. elliptica* but differs in the invariably pedunculate inflorescences (pseudopedunculate in *R. alata* and mostly in *R. elliptica*), the filiform carinal calyx lobe (triangular in *R. alata* and *R. elliptica*), the larger, obliquely oblanceolate pod (obliquely lanceolate in *R. alata* and *R. elliptica*), the 6 mm long seeds (3–5 mm long in *R. alata* and *R. elliptica*), the seed hilum with a swollen ring (without a swollen ring in *R. alata* and *R. elliptica*) and striate seed testa (rough in *R. alata* and smooth in *R. elliptica*).

Distribution and habitat. R. vlokii is known only from the Outeniqua mountains and Moerasrivier (Map 9.7) and its distribution in the Outeniqua mountains coincides with that of the Outeniqua form of *R. alata*. It grows in veld that is a transition from renosterveld to dry grassy fynbos, along disturbed roadsides or on lower slopes in dry, rocky, loamy or sandy soil.

Specimens examined.

—3322 (Oudtshoorn): 4 km from Moerasrivier bridge to Mossel Bay (-CC), *Campbell & Van Wyk 156* (K, PRE); Moerasrivier farm (-CC), *Van Wyk 3172* (JRAU, NBG); Outeniqua mountains, eastern end of Waboomskraal (-CD), *Vlok 534* (NBG, PRE); Outeniqua mountains next to forestry track along Groot Doringrivier (-CD), *Vlok 823* (PRE).



Map 9.7 The known geographical distribution of *R. vlokii.*

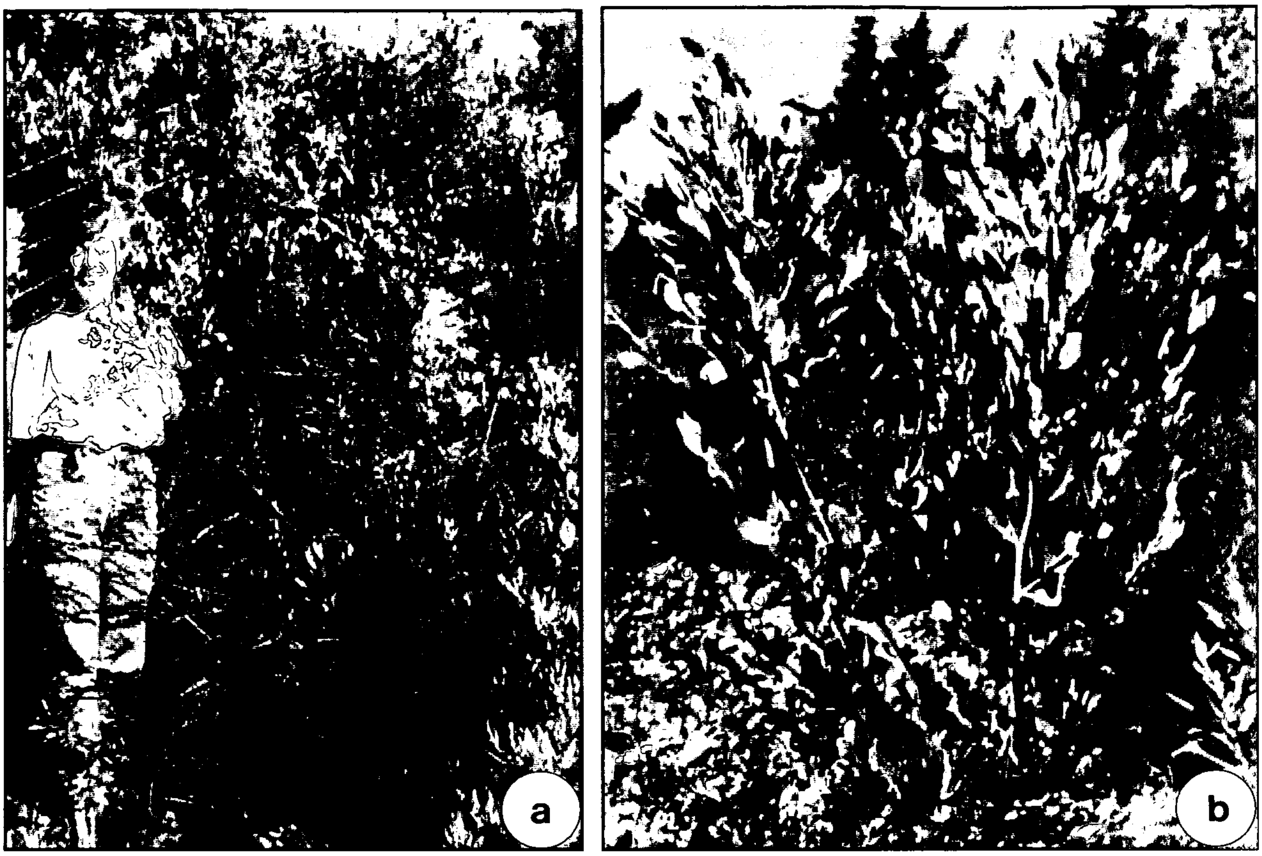


Figure 9.4 Habit and leaves of *R. vlokii*: **a,** erect, robust, much-branched suffrutex; **b,** large, elliptic leaves.

7. ***Rafnia alata*** G.J. Campbell & B-E. van Wyk sp. nov., a *R. vlokii* et *R. elliptica* habitu minori procumbenti caespitosi et extensionibus magnis aliformibus inter lobos calycis (absunt in *R. vlokii* et *R. elliptica*). Type: South Africa, Western Cape Province, Oudtshoorn, Swartberg Pass, 1.3 km along Gamkaskloof Road towards Prince Albert side, *Campbell, Van Wyk & Vlok 154* (NBG!, holotype; BOL!, JRAU!, K!, MO!, NBG!, PRE!, UPS!, isotypes).

Procumbent, clump-forming shrublet, up to 0.4 m tall. *Leaves* obovate to round or lanceolate; leaves on flowering branches 25–51 mm long, 7–19 mm wide; basal leaves 18–54 mm long, 3–32 mm wide. *Inflorescences* single-flowered. *Flowers* 14–25 mm long. *Pedicel* 3–8 mm long. *Bract* narrowly lanceolate, large, leaf-like or narrowly triangular or absent, 1–5 mm long. *Bracteoles* 0.3–0.9 mm long. *Calyx* long; lobes longer than tube, 7–16 mm long; upper lobes broadly falcate, much broader or not much broader than others; lateral lobes slightly falcate; tube with wing-like extensions between all lobes, 3–8 mm long. *Standard* ovate or broadly elliptic, 11–19 mm long, 12–23 mm wide, often with basal callosities; apex obtuse or retuse; claw 2–5 mm long. *Wings* oblong or obovate, 8–15 mm long, 4–10 mm wide, with 4–6 rows of sculpturing; claw 3–5 mm long. *Keel* rostrate, often ± strongly upcurved, 8–11 mm long, 4–6 mm wide; claw 4–6 mm long. *Pistil* with ovary oblong; style shorter than or ± as long as ovary, upcurved or strongly upcurved; ovules 2. *Pods* narrowly obliquely lanceolate, 20–30 mm long, 3–5 mm wide; upper margin straight; lower margin proximally convex.

Diagnostic characters. R. alata (Figure 9.5) differs from *R. vlokii* and *R. elliptica* in the smaller, procumbent, clump-forming habit (Figure 9.5a) and the large, wing-like extensions between the calyx lobes (wings absent in *R. vlokii* and *R. ellpitica*) (Figure 9.5b).

Regional variation. Three regional forms of *R. alata* are distinguished, namely the Swartberg (typical form), Outeniqua mountains and Bredasdorp forms. The Cape Infanta locality is unique to *R. alata*, while the other two forms coincide geographically with *R. vlokii* and *R. elliptica* to a certain extent.

Swartberg form (Typical form). *Leaves* obovate to round; leaves on flowering branches 25–35 (–40) mm long, 10–15 (–19) mm wide; basal leaves 30–50 mm long, 15–25 (–32) mm wide. *Flowers* 14–18 (–21) mm long. *Pedicel* 5–8 mm long. *Bract* large, narrowly lanceolate, leaf-like, 4–5 mm long. *Bracteoles* 0.7–0.9 mm long. *Calyx* lobes 7–12 mm long; upper lobes much broader than others; tube 5–8 mm long. *Standard* broadly elliptic, 14–16 mm long, (12–) 17–19 mm wide; apex retuse; claw 2–

3 mm long. *Wings* oblong, (8–) 12–13 mm long, 4–6 mm wide. *Keel* not strongly upcurved. *Pistil* with style shorter than ovary, strongly upcurved. *Pods* (20–) 23–25 mm long. *Seeds* broadly oblong to broadly reniform, 3–4 mm long, 2–3 mm wide; testa rough.

Diagnostic characters. The typical form of *R. alata* differs from the other forms in the obovate to round leaves (leaves lanceolate in the other forms), the large, narrowly lanceolate, leaf-like bracts (bracts small and narrowly triangular in the Outeniqua form and absent in the Bredasdorp form) and the long calyx tube (5–8 mm long in the typical form, 3 mm long in the Outeniqua form and 3–5 mm long in the Bredasdorp form).

Distribution and habitat. This form occurs only on the Swartberg (see Map 9.8) in grassy montane fynbos on low or higher slopes, in dry, sandy soil or deep, moist, loamy soil.

Outeniqua form. *Leaves* lanceolate; leaves on flowering branches 35–43 mm long, 7–9 mm wide; basal leaves 18–29 mm long, 3–7 mm wide. *Flowers* 17–18 mm long. *Pedicel* 3–5 mm long. *Bract* narrowly triangular, ± 1 mm long. *Bracteoles* ± 0.3 mm long. *Calyx* lobes 8–9 mm long; upper lobes much broader than others; tube ± 3 mm long. *Standard* broadly elliptic, ± 11 mm long, ± 13 mm wide; apex obtuse; claw ± 3 mm long. *Wings* oblong, ± 9 mm long, ± 4 mm wide; claw ± 3 mm long. *Keel* not strongly upcurved, ± 8 mm long. *Pistil* with style shorter than ovary, strongly upcurved. Mature pods and seeds unknown.

Diagnostic characters. The Outeniqua form of *R. alata* differs from the other forms in the basal leaves which are smaller than the upper leaves (basal leaves larger than the upper leaves in the other forms), the smaller flowers, the very small bracteoles (large in the typical form and absent in the Bredasdorp form) and the obtuse standard apex (apex retuse in the other forms).

Distribution and habitat. This form occurs in the Outeniqua mountains, in a locality similar to that of *R. vlokii* (see Map 9.8), and grows in foothills in dry, rocky, sandy soil.

Bredasdorp form. *Leaves* lanceolate; leaves on flowering branches 7–12 mm wide; basal leaves 6–15 mm wide. *Flowers* 22–25 mm long. *Bract* and *bracteoles* absent. *Calyx* lobes 12–6 mm long; upper lobes not much broader than lateral lobes; tube 3–5 mm long. *Standard* ± 19 mm long, ± 23 mm wide; apex retuse; claw ± 5 mm long. *Wings* obovate, ± 15 mm long, ± 10 mm wide; apex very broad. *Keel* ± strongly upcurved, ± 11 mm long. *Pistil* with style upcurved. *Pods* 25–30 mm long. *Seeds* unknown.

Diagnostic characters. The Bredasdorp form of *R. alata* differs from the other forms in the large flowers, the absence of bracts and bracteoles (these are present in the other forms), the upper calyx lobes which are not much broader than the other lobes (upper lobes much broader than the other lobes in the other forms), the obovate wings (wings oblong in the other forms) and the strongly upcurved keel (keel not strongly upcurved in the other forms).

Distribution and habitat. This form is known only from the Potberg and Cape Infanta (Map 9.8). It grows on plains in coastal fynbos, on TMS gravel flats or in deep, moist, sandy soil.

Specimens examined.

—**3322** (Oudtshoorn): Prince Albert division, Swartberg Pass (-AC), *Bolus s.n. sub BOL 61264* (BOL), *Esterhuysen 28822* (BOL), *Pocock S136* (PRE), *Stokoe 8782* (BOL), *s.n. sub SAM 55811*, *s.n. sub SAM 65712* (SAM), *s.n. sub SAM 68744* (PRE, SAM); Swartberg Pass, 1.3 km along Gamkaskloof road (-AC), *Campbell & Van Wyk 8* (JRAU), *Campbell, Van Wyk & Vlok 154* (BOL, JRAU, K, MO, NBG, 1 & 2, PRE, 1 & 2, UPS); Swartberg, next to track behind Oliewenberg (-AC), *Vlok 1246* (PRE); Groot Swartberg, Blesberg (-BC), *Vlok 108* (NBG, PRE), *1761* (PRE); Outeniqua mountains, near Groot Doringrivier (-CD), *Vlok 736* (PRE, 1 & 2).

—**3420** (Bredasdorp): De Hoop, Potberg Nature Reserve, Potberg near Boskloof (-BC), *Burgers 1404* (PRE); Cape Infanta, about 1 km north of town (-BD), *Vlok 1713* (PRE, 1 & 2).

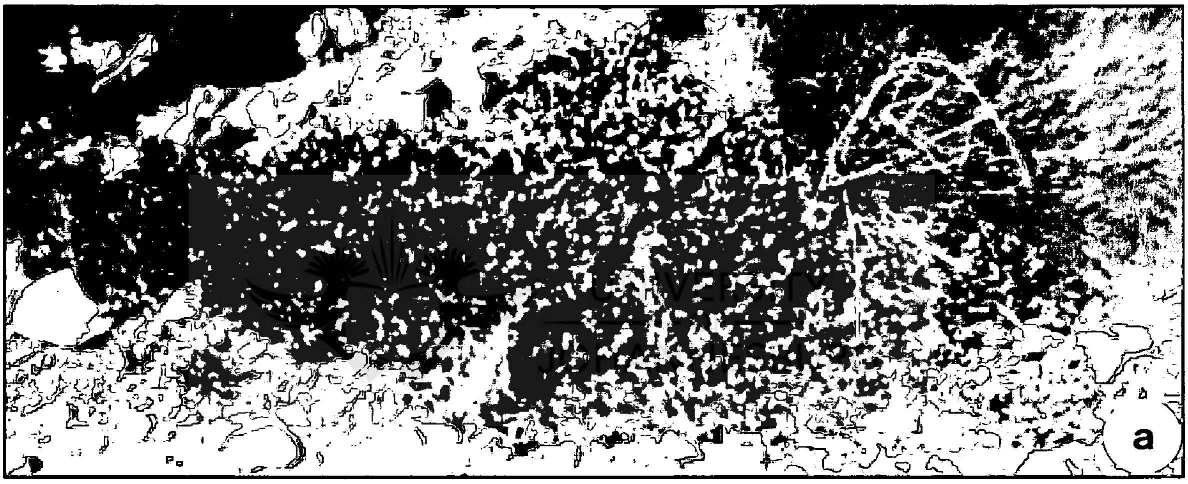
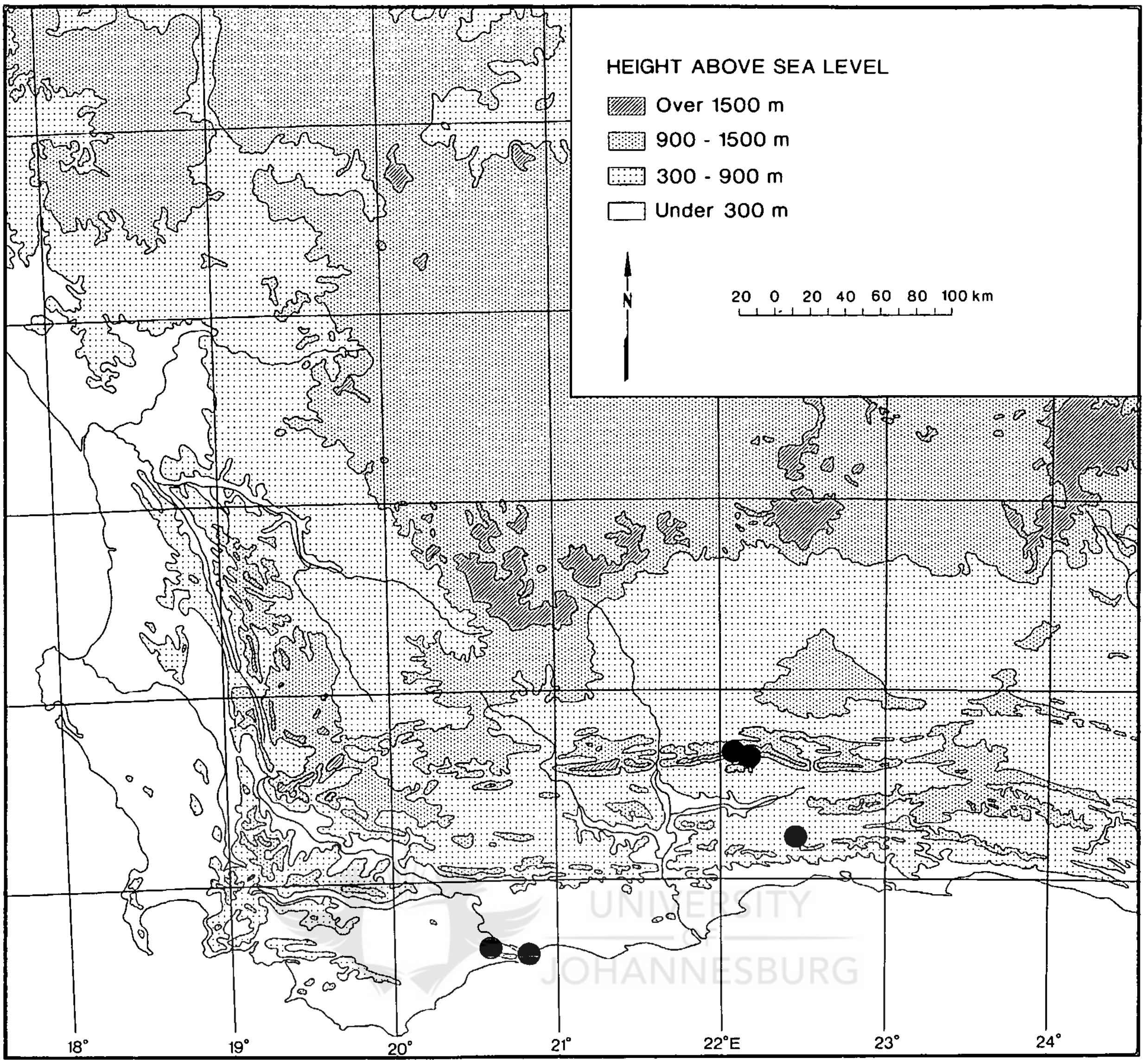


Figure 9.5 Habit, inflorescences and flowers of *R. alata* (Swartberg/typical form): **a,** prostrate, clump-forming shrublet; **b,** single-flowered inflorescences, and note the winged calyx.



Map 9.8 The known geographical distribution of *R. alata*.

8. ***Rafnia crassifolia*** Harv., Thes. Cap. 1: 45, t. 71 (1859); Harv. in Harv. & Sond., Fl. Cap. 2: 34 (1862); Walp. in Ann. Bot. 7: 670 (1868); Schinz in Bull. Herb. Boiss. 2: 200 (1894). Type: South Africa, Western Cape Province, in lateribus (altit. III) montium "Hottentottshollandsberge" prope "Palmietrivier" et ad "Klynriviersberge" (Stellenbosch, Caledon), *Ecklon & Zeyher 1192* (SAM!, lectotype, designated here).

= *Rafnia axillaris* sensu Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (1836) non Thunb.

Procumbent shrublet, stems not much-branched, up to 0.6 m tall. *Leaves* lanceolate, bright green, often remaining so when dry; leaves on flowering branches 28–44 mm long, 8–13 mm wide; basal leaves (25–) 35–55 mm long, 7–17 mm wide. *Inflorescences* single-flowered, without a peduncle or pseudopeduncle. *Flowers* 13–16 (–20) mm long. *Pedicel* elongate, 12–16 (–18) mm long. *Bract* 0.7–0.8 mm long. *Bracteoles* subulate to linear-triangular, 0.5–0.7 mm long. *Calyx* long; lobes much longer than tube, 10–13 mm long; upper lobes falcate, slightly broader than others; lateral lobes slightly falcate; carinal lobe sometimes shorter than others; tube with a ridge between upper lobes, 4–5 mm long. *Standard* obovate to subpanduriform, tapering towards claw, 13–18 mm long, 9–14 mm wide; claw 1–2 mm long. *Wings* oblong, ± as long as or longer than keel, 9–11 mm long, 3–5 mm wide, with 6–7 rows of sculpturing; apex obovate to broadly obtuse; claw 3–4 mm long. *Keel* 9–11 mm long, ± 5 mm wide; claw ± 4 mm long. *Pistil* with ovary ± oblong; style long, ± as long as or longer than ovary, upcurved; ovules 2. *Pods* obliquely lanceolate, 34–39 mm long, 8–11 mm wide; upper margin straight; lower margin proximally convex. *Seeds* obliquely oblong-reniform, ± 4 mm long, ± 3 mm wide; testa rough.

Diagnostic characters. *R. crassifolia* (see Figure 9.6) is distinguished from the other species of *Rafnia* by the somewhat succulent, bright green leaves (Figure 9.6b) which have red margins, the inflorescence which lacks a peduncle or pseudopeduncle, the elongated pedicels (about as long as the flowers) and the subpanduriform standard petal which tapers into the claw.

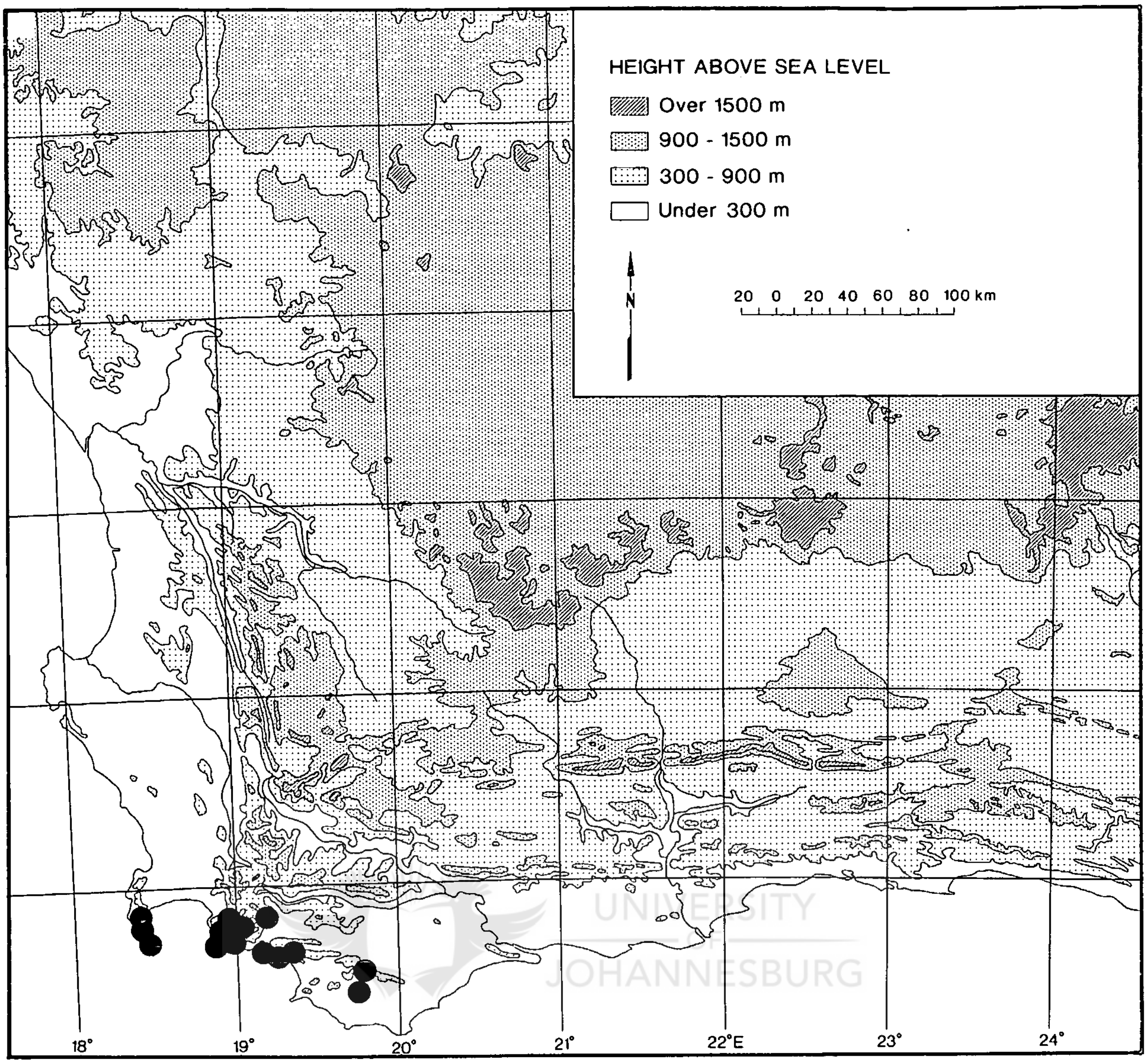
Distribution and habitat. R. crassifolia is limited to the Cape Peninsula, Palmietrivier and Hermanus areas (Map 9.9). This species grows in montane or coastal fynbos, in disturbed areas, in moist sand flats near rivers, or gentle to moderate sandy, rocky slopes, in TMS and quartzitic deep or shallow soils.

Specimens examined.

—3418 (Simonstown): Simon's Bay (-AB), *Alexander-Prior s.n. sub PRE 53116* (PRE); Cape of Good Hope Nature Reserve, road to Olifantsbos (-AB), *Campbell & Van Wyk 107* (JRAU), *150* (JRAU, K, NBG, PRE); between Klaasjagersberg and Hestersdam (-AB), *Galpin 12547* (PRE); Cape of Good Hope Nature Reserve, Klaasjagersrivier (-AB), *Greuter 21857* (PRE); near Houtrivier, Teefontein, Cape of Good Hope Nature Reserve (-AB), *Grobbelaar 1052* (PRE); Klaasjager's farm (-AB), *Minicki s.n. sub SAM 51791* (SAM); Klawer valley, near Simonstown (-AB), *Moss 7734* (J), *Salter 7830* (NBG), *Wolley-Dod s.n. sub BOL 42925* (BOL); Kromrivier (-AB), *Taylor 6751* (NBG, PRE); near Smith's farm (-AD), *Acocks & Hafström 711* (PRE), *Moss 6102* (J); Sirkelsvlei (-AD), *Baker 1175* (NBG), *Barker 3953* (NBG); Smitswinkel (-AD), *Barker 4302* (NBG), *Phillips s.n. sub PRE 53114* (PRE), *s.n. sub SAM 27584* (SAM); Cape Point (-AD), *Compton 12516, 20240* (NBG), *Schlechter 7303* (BOL); Boyskraalrivier, Cape Point Nature Reserve (-AD), *Compton 16664* (NBG); Cape of Good Hope Nature Reserve, near Brightwater (-AD), *Grobbelaar 2659* (PRE); Rooihoogte (-AD), *Leighton 868* (BOL); Sir Lowry's Pass, slopes north of Steenbras siding (-BB), *Andreae 20* (PRE); Highlands, Caledon (-BB), *Bond 1525* (NBG); Elephant Rock Estates, near Palmietrivier (-BD), *Boucher 1039* (NBG, PRE); Buffelsrivierdam (-BD), *Boucher 1823* (NBG, PRE); Hangklip, Caledon (-BD), *Compton 6089* (NBG), *Lavranos 12059* (PRE), *Pillans 8246* (BOL); Caledon division, Palmietrivier mouth (-BD), *Esterhuysen s.n. sub BOL 42923* (BOL); between Rooiels and Hangklip (-BD), *Grobbelaar 303* (PRE); 5 km from Rooiels to Kleinmond (-BD), *Grobbelaar 2763* (PRE); Kleinmond, Kogelberg State Forest, about 1 km north of Oudebosch homestead (-BD), *Kruger 861* (NBG, PRE), *Vlok & Schutte 258* (JRAU); road to reservoir behind Pringle Bay, Caledon (-BD), *Levyns 10387* (BOL); Caledon division, Palmietrivier mountains, Oudebosch (-BD), *Stokoe s.n. sub SAM 65710* (SAM); Betty's Bay (-BD), *A.E. van Wyk 229* (PRE).

—3419 (Caledon): Palmietrivier, Grabouw (-AA), *Stokoe s.n. sub PRE 53120* (PRE), *s.n. sub STE 32071* (NBG); Hermanus (-AC), *Compton 23224* (NBG); Kleinmond (-AC), *De Vos 364* (NBG), *Goldblatt 7630* (NBG, PRE); Palmietrivier mountains (-AC), *De Vos 1406* (PRE), *Stokoe s.n. sub SAM 61406* (PRE, SAM), *C.M. van Wyk 1129* (NBG, PRE); Fernkloof Nature Reserve, Hermanus (-AC), *Schutte 438* (JRAU); Sandbaai, Hermanus (-AC), *Walters 595* (NBG); Elandskloof (-BD), *Schlechter 9760*, *s.n. sub TM 1459* (PRE); Paardeberg (-BD), *Stokoe s.n. sub PRE 53121* (PRE); Elim (-DB), *Bolus 3773* (NBG), *8535* (BOL, NBG, PRE, 1 & 2).

Precise locality unknown: Cape Town Wild Flower Show, Peninsula exhibit (-AB), *Anon. s.n. sub BOL 15818* (BOL); 'Hottentotsholland mountains near Palmietrivier and Kleinrivier mountains', *Ecklon & Zeyher 1192* (SAM); 'Knoflookskraal, Kleinriviershoek and Klein Houhoek mountains', *Ecklon & Zehyer 2281* (PRE, 1 & 2, SAM); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16427* (UPS) [microfiche only].



Map 9.9 The known geographical distribution of *R. crassifolia.*

Figure 9.6 Habit, leaves, inflorescences, flowers and pods of *R. crassifolia*: **a,** procumbent shrublet; **b,** succulent, bright green leaves.

9. ***Rafnia elliptica*** Thunb., Gen. Nov. Pl.: 145 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 949 (1802); Thunb., Fl. Cap.: 563 (1823); DC., Prodr. 2: 118 (1825); E. Mey. in Linnaea 7: 147 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 160 (1836); Walp. in Linnaea 13: 463 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 466 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 33 (1862); Schinz in Bull. Herb. Boiss. 2: 200 (1894). Type: South Africa, Eastern Cape Province, in montibus ad van Stadens river, *Zeyher s.n. sub SAM 15205* (SAM!, neotype). [Note: Harvey (1862) mentioned the existence of a type specimen in the Thunberg Herbarium but there is no longer any original material in this herbarium. We are left with no choice but to choose a neotype.]

= *Rafnia elliptica* var. *erecta* Harv. in Harv. & Sond., Fl. Cap. 2: 33 (1862). Type South Africa, Eastern Cape Province, in lapidosis (altit. III) laterum montium in "Langekloof et Van Stadensriviersberge" (George, Uitenhage), *Ecklon & Zeyher 1186* (K!). [Note: The type is incorrectly cited as *Ecklon & Zeyher 1168* by Harvey.]

= *Rafnia elliptica* var. *acuminata* Harv. in Harv. & Sond., Fl. Cap. 2: 33 (1862).

= *Rafnia axillaris* Thunb., Gen. Nov. Pl.: 146 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd. ex Walp., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 564 (1823); DC., Prodr. 2: 119 (1825); E. Mey. in Linnaea 7: 148 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (1836) non Thunb.; Walp. in Linnaea 13: 465 (1839); Harv. in Harv. & Sond., Fl. Cap. 2: 35 (1862). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16430* (UPS, microfiche!, lectotype, designated here).

= *Pelecynthis axillaris* sensu E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (1836); Walp., Rep. Bot. Syst. 2: 580 (1843).

= *Rafnia affinis* Harv. in Harv. & Sond., Fl. Cap. 2: 36 (1862), nom. nov. pro *R. axillaris* Benth. in Hook., Lond. J. Bot. 2: 463 (1843) non Thunb.; Schinz in Bull. Herb. Boiss. 2: 199 (1894). Type: South Africa, Klynriviersberge, *Ecklon s.n.*, not seen. [Note: Harvey (1862) proposed this as a new name for *Rafnia axillaris* sensu Benth. non Thunb.; the material in Kew is *R. elliptica*.]

= *Rafnia erecta* sensu Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 160 (1836) non Thunb.

= *Rafnia retroflexa* sensu Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 160 (1836) non Thunb.

= *Rafnia cuneifolia* sensu E. Mey., Comm. Pl. Afr. Austr. 1(1): 12 (1836) non Thunb.

= *Rafnia intermedia* Vog. ex Walp. in Linnaea 13: 463 (1839); Benth. in Hook., Lond. J. Bot. 2: 466 (1843); Schinz in Bull. Herb. Boiss. 2: 199 (1894). Type not seen.

= *Rafnia elliptica* var. *intermedia* Harv. in Harv. & Sond., Fl. Cap. 2: 33 (1862). Type:

South Africa, Eastern Cape Province, in locis apertis (altit. III) collium gramine vestitorum in "Adow" (Uitenhage), *Ecklon & Zeyher 1187* (K!, SAM!).

Erect, robust, much-branched suffrutex, up to 0.9 m tall. *Leaves* lanceolate to elliptic, penninerved, sometimes involute when young; leaves on flowering branches (37–) 45–55 mm long, 9–20 mm wide; basal leaves 53–85 (–98) mm long, 16–31 mm wide. *Inflorescences* single- or rarely few-flowered, 2–3 flowers, sometimes pedunculate. *Flowers* large, (12–) 15–23 mm long. *Pedicel* 7–11 mm long. *Bract* 1.5–2 mm long. *Bracteoles* 0.3–1 mm long. *Calyx* lobes longer than tube, 6–10 (–13) mm long; upper lobes falcate to broadly falcate, broader than others; upper sinus sometimes deeper than others; tube with a ridge between upper lobes, 5–6 mm long. *Standard* ovate or broadly elliptic or suborbicular, 13–19 mm long and wide, often with basal callosities; apex obtuse or retuse; base cordate; claw 2–4 mm long. *Wings* oblong to oblong-obovate, ± as long as keel, 10–17 mm long, 4–8 mm wide, with 6–9 rows of sculpturing; apex obliquely obtuse; lower margin broadly convex; claw 5–7 mm long. *Keel* narrowly rostrate, sometimes ± strongly upcurved, 9–17 mm long, 4–7 mm wide; claw 5–7 mm long. *Pistil* with the ovary oblong to narrowly ovate; style shorter than ovary, gently to strongly upcurved; ovules 2. *Pods* obliquely lanceolate, 30–49 mm long, 8–11 mm wide, surface often prominently veined; upper margin straight; lower margin straight, proximally convex. *Seeds* broadly oblong-reniform, 4–5 mm long, 3–4 mm wide; testa smooth.

Diagnostic characters. R. elliptica (see Figure 9.7) is similar to *R. vlokii* but differs in the longer pedicels, the smaller calyx, the broader carinal lobe which is about as long as the other lobes (not very narrow and shorter than the other lobes in *R. vlokii*), the basal callosities on the standard petal (basal callosities absent in *R. vlokii*), the broadly convex lower margin of the wing petal (margin more or less straight in *R. vlokii*), the style that is shorter than the ovary (about as along as the ovary in *R. vlokii*), the obliquely lanceolate pods (obliquely oblanceolate in *R. vlokii*) (see Figure 9.7d) and the smaller seeds which have a smooth testa (seeds with a striate testa in *R. vlokii*). *R. elliptica* also differs from *R. alata* in the much larger size (see Figure 9.7a & b) and the presence of a ridge between the upper lobes on the calyx tube (wing-like extensions between all the lobes in *R. alata*).

Distribution and habitat. *R. elliptica* is the most widely distributed species and has a much wider distribution than *R. vlokii* or *R. alata*. It occurs from the Langeberg in the east, through the Eastern Cape province to southern KwaZulu-Natal (see Map 9.10). The species grows in sandy, grassy coastal fynbos or in veld that is a transition between renosterveld and dry fynbos, and mostly occupies foothills or gentle slopes and is often associated with TMS.

Specimens examined.

—**3029** (Kokstad): Mtamvuna River (-DA), *Hilliard & Burtt 6760* (PRE).

—**3030** (Port Shepstone): Black Trail, Oribi (-CB), *Davidson 2589* (J), *Glen 498* (J); Oribi Gorge, The Rocks (-CB), *Mantell & Vassilatos 46* (J, PRE); south coast, Marina Beach (-CD), *Mogg 13245* (PRE); Uvongo (-CD), *Stirton 8058* (PRE); beach terminus, near Boboyi River (-CD), *Thode 3240* (NBG); Izotsha, south coast (-CD), *Thode 3241* (NBG).

—**3129** (Stanger): Transkei, Mkambate Game Reserve (-BD), *Shackleton 154* (PRE); Port St John's district, Lusikisiki, Egoso forest (-BC), *Blenkinson s.n. sub J 16138* (J, 1–3); Ngogwana River falls, Lusikisiki district (-BC?), *Galpin 9428* (PRE).

—**3130** (Port Shepstone): Port Edward (-AA), *A.E. van Wyk 5343* (PRE); national road, about 10 km before Port Edward (-AA), *Venter 7464* (PRE).

—**3228** (Butterworth): Kei mouth, Komgha district (-CB), *Flanagan 1816* (BOL, PRE, 1 & 2, SAM).

—**3320** (Montagu): Langeberg wilderness area (-DD), *Van der Merwe 162* (NBG, PRE).

—3321 (Ladismith): Waterkloof (-BD), *Gillett 1937* (BOL, 1 & 2), *Hutchinson 1106* (PRE).

—3322 (Oudtshoorn): 0.3 km after road stall on Oudtshoorn-George road (-CB), *Campbell & Van Wyk 157* (JRAU, 1–3); Robinson Pass (-CC), *Taylor 10060* (BOL); Outeniqua mountains, near Leeukloof (-CC), *Vlok 1661* (PRE); Swartrivier Gorge, George (-CD), *Acocks 21531* (PRE); near George (-CD), *Bolus 8645* (BOL), *Guthrie 4300* (NBG); George division, Zebra, near top of Outeniqua Pass (-CD), *Compton 24419* (NBG, 1–3), *Lewis 3586* (SAM); Kamanassie mountains (-DA?), *Zinn s.n. sub SAM 54414* (SAM); Buffelsdrif, Kamanassie mountains, Mannetjiesberg (-DB), *Vlok 1314* (PRE), *Vlok & Schutte 352* (JRAU); 33 km from Oudtshoorn-George road to Uniondale (-DC), *Campbell & Van Wyk 158* (JRAU, 1–3, NBG); 25.1 km east from joining between Montagu Pass and Oudtshoorn-Uniondale road (-DC), *Grobbelaar 2279* (PRE); 33.5 miles (53.6 km) from Uniondale to George (-DC), *Horn SKF 2252* (PRE); Ruigtevlei near Sedgefield (-DD), *Hugo 2010* (NBG, PRE); George, Langkloof (-DD), *Van der Bÿl s.n. sub SAM 52008* (SAM).

—3323 (Willowmore): Keurboomsrivier heights (-CD), *Fourcade 4800* (BOL, NBG); Doucamma uplands, 17 miles (27.2 km) from Keurboomsrivier mouth (-CD), *Gillett 1581* (NBG).

—3324 (Steytlerville): Smitskraal, Kouga mountains, next to track near Graskop (-CB), *Vlok 1196* (PRE); 19 km from Kareedouw to Joubertina (-CC), *Stirton 6359* (PRE); Kareedouw, Humansdorp (-CD), *Compton 4609* (BOL, NBG); Elandsberge, south of Cockscomb above Erasmuskraal (-DB), *Oliver 9363* (NBG).

—3325 (Port Elizabeth): Suurberg National Park, Superbus area (-AD), *Van Wyk & C.M. van Wyk 615* (JRAU); Suurberg National Park, Lot 16, along Brandrug (-BC), *Van Wyk & C.M. van Wyk 1066, 1443, 2044* (JRAU); mountains at Vanstadensrivier (-CC), *Zeyher s.n. sub SAM 15205* (SAM); Adouw, Uitenhage (-CD?), *Ecklon & Zeyher 1187* (SAM); Baakensrivier valley, Fairview (-DC), *Oliver 1263* (NBG, PRE).

—3326 (Grahamstown): Highlands road 10 km from Grahamstown (-AB), *Bayliss 8176* (PRE); Albany, between Boesmansrivier and Assegaairivier (-AC), *Leighton 2613* (BOL); Sidbury, Albany (-AC), *Zeyher & Burke 11* (SAM), *s.n. sub PRE 9510* (PRE); near Coldspring, Albany division (-AD), *Acocks 12100* (PRE), *Britten 5090* (PRE); Lockerbie, about 12 miles (19.2 km) south-west of Grahamstown, Albany division (-AD), *Acocks 23905* (PRE); 10 km from Grahamstown to Highlands and Alicedale (-AD), *Arnold 1133* (PRE); Assegaairivier, Albany (-AD), *Bayliss 3632* (NBG); Coldspring, 6 miles (9.6 km) along Highlands road near railway crossing (-AD), *Bayliss 8188* (PRE), *Brink 306* (PRE); 20 miles (32 km) from Grahamstown to Port Elizabeth (-AD), *Grobbelaar 781* (PRE); Grahamstown, Faraway, portion 3 of

Coldspring Rocky Witteberg quartzite ridge (-AD), *Jacot-Guillarmod 9077* (PRE); Grahamstown (-BC), *Bayliss 3078* (NBG), *Guthrie 3329* (NBG), *MacOwan 1061* (BOL), *Rogers 1351* (PRE), *27467* (J, PRE, SAM), *Tyson 6033* (SAM), *s.n. sub STE 32072* (NBG); Grahamstown, near Hamilton reservoir (-BC), *Britten 411* (PRE); Sandy Drift near Grahamstown (-BC), *Daly & Sole 59* (PRE, 1–3); Waainek, Grahamstown (-BC), *Galpin 341* (PRE); Round Hill, Albany (-BD), *Bolus 32550* (BOL); Albany, 24 miles (38.4 km) east of Grahamstown (-BD), *Maguire 653* (NBG).

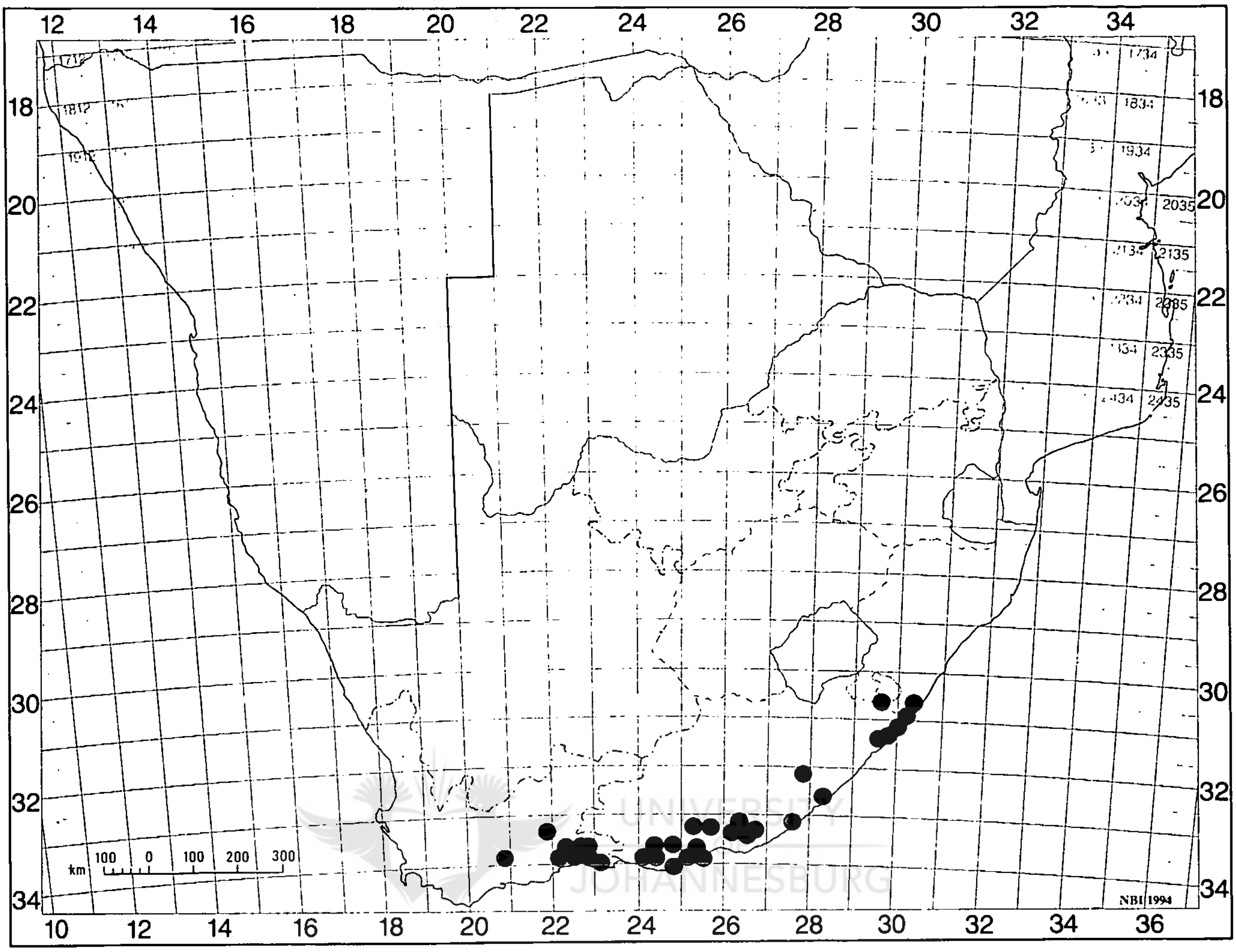
—3327 (East London): Orange Grove, East London (-BB?), *Rattray 1279* (PRE).

—3423 (Knysna): Knysna (-AA), *Zeyher s.n. sub SAM 15206* (SAM).

—3424 (Humansdorp): Hangrivier (-BB?), *Spearman 2* (PRE).

Precise locality unknown: *Anon. s.n. sub STE 31490* (NBG); Malmesbury, *Bolus s.n. sub BOL 32551* (BOL); *De Castelnau & De Laporte 407* (PRE); *Scouler s.n. sub PRE 53105* (PRE); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16430* (UPS) [microfiche only].

Doubtful locality: Piquetberg, *Edwards 242* (BOL).



Map 9.10 The known geographical distribution of *R. elliptica*.

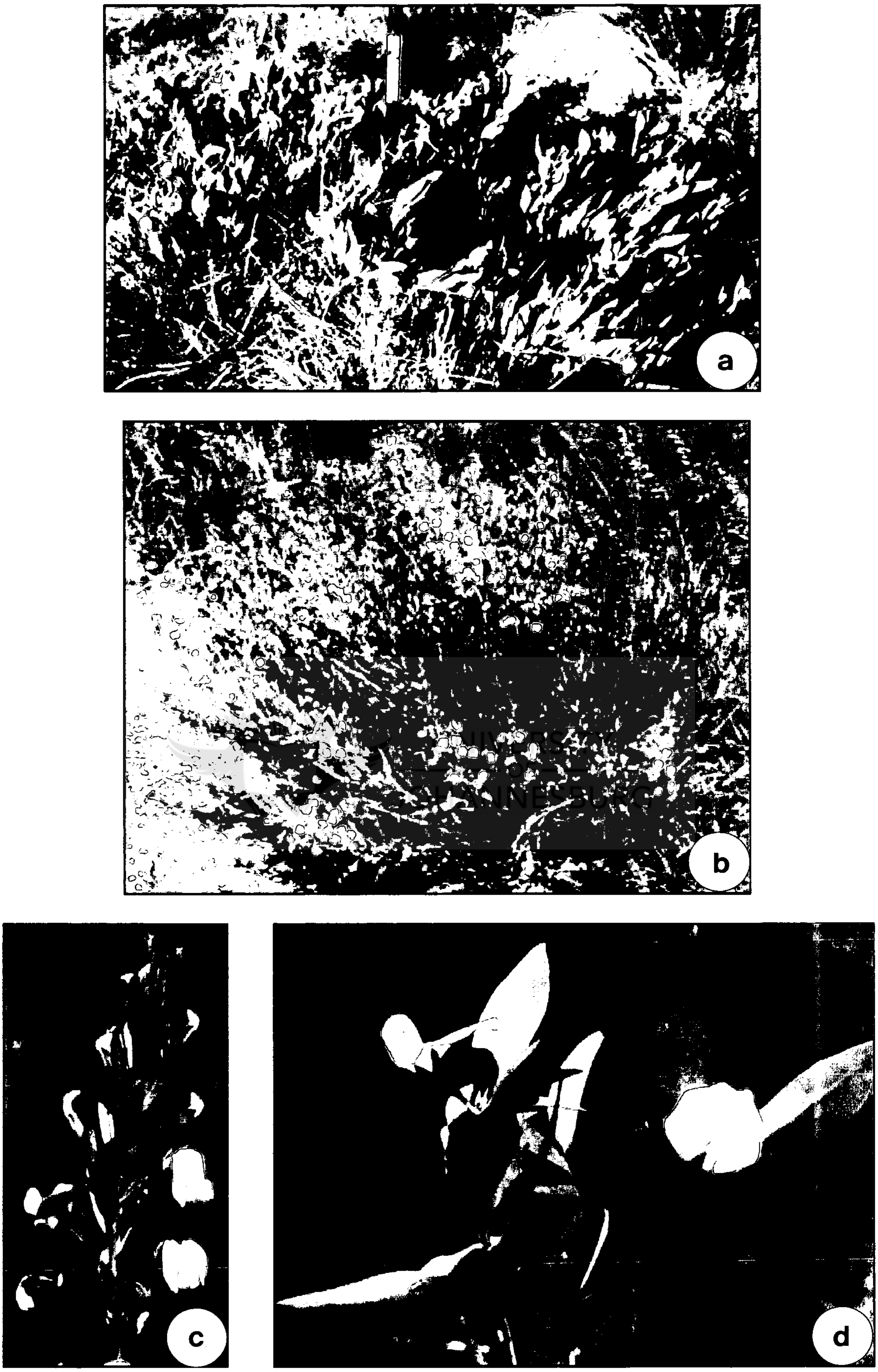


Figure 9.7 Habitat, habit, inflorescences, flowers and pods of *R. elliptica*: **a,** procumbent shrub, growing in grassland; **b,** larger, erect, robust shrub; **c,** elliptic leaves and single-flowered inflorescences; **d,** large flowers and oblanceolate pod.

10. ***Rafnia triflora*** (L.) Thunb., Gen. Nov. Pl.: 145 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 950 (1802); Thunb., Fl. Cap.: 563 (1823); DC., Prodr. 2: 118 (1825); E. Mey. in Linnaea 7: 147 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 159 (1836); E. Mey., Comm. Pl. Afr. Austr. 1(1): 12 (1836); Walp. in Linnaea 13: 463 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 465 (1843); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845); Harv. in Harv. & Sond., Fl. Cap 2: 33 (1862); Schinz in Bull. Herb. Boiss. 2: 200 (1894). Type: South Africa, 'e Cap. b. spei', *LINN 895.16* (LINN, microfiche!, lectotype, designated here).

≡ *Crotalaria triflora* L., Sp. Pl. 2: 1004 (1753), Mant. Pl.: 440 (1767); Berg., Pl. Cap.: 193 (1767).

= *Borbonia cordata* L., Sp. Pl. 2: 994 (1753); Andr., Bot. Rep.: 31, t. 31 (1797). Type: South Africa, 'e Cap. b. spei', *LINN s.n.* (LINN, microfiche!, lectotype, designated here).

≡ *Rafnia cordata* (L.) Mart., Acad. Mun. 6: 189 (1820); DC., Prodr. 2: 118 (1825); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 159 (1836); Walp. in Linnaea 13: 466 (1839), Rep. Bot. Syst. 2: 579 (1843).

= *Rafnia alpina* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 160 (1836); Walp. in Linnaea 13: 466 (1839), Rep. Bot. Syst. 2: 579 (1843). Type: South Africa, Western Cape Province, inter saxa (altit. V) verticis montis "Tafelberg", *Ecklon & Zeyher 1184* (SAM!, lectotype, designated here).

= *Rafnia fastigiata* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 160 (1836); Walp. in

Linnaea 13: 463 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 465 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 33 (1862); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845). Type: South Africa, Western Cape Province, in locis petrosis (altit. V) montium altarum prope "Puspasvalley" (Swellendam), *Ecklon & Zeyher 1182* (SAM!, lectotype, designated here).

Erect woody shrub, up to 2.4 m tall or an erect suffrutex, up to 0.7 m tall. *Leaves* lanceolate, or elliptic to broadly elliptic or obovate or ovate, penninerved; base round or cordate; leaves on flowering branches 23–50 mm long, 10–34 mm wide; basal leaves 43–121 mm long, 16–110 mm wide. *Inflorescences* single-flowered, 1–3 flowers emerging together from axils. *Flowers* 16–21 mm long. *Pedicel* 2–5 mm long. *Bract* triangular, 1–2 mm long. *Bracteoles* triangular, 0.5–1 mm long. *Calyx* lobes ± as long as or longer than tube, 4–11 mm long; upper lobes falcate or broadly falcate, broader or much broader than others; lateral lobes triangular or slightly falcate; carinal lobe shorter than or ± as long as others; upper sinus often deeper or much deeper than others; tube with a ridge between upper lobes, 5–6 mm long. *Standard* ovate or elliptic or suborbicular, 13–18 mm long and wide, often with basal callosities; claw 3–5 mm long. *Wings* oblong or elliptic, 13–16 mm long, 5–8 mm wide, with 5–7 rows of sculpturing; apex narrow or ± obovate; claw 4–6 mm long. *Keel* shortly rostrate, 12–14 mm long, 6–7 mm wide; claw 4–6 mm long. *Pistil* with ovary oblong; style shorter than or ± as long as or longer than ovary, strongly upcurved; ovules 2; stigma usually glabrous, rarely fibrillose. *Pods* obliquely lanceolate, 18–33 mm long, 3–8 mm wide; upper margin proximally slightly convex; lower margin straight.

Diagnostic characters. *R. triflora* (see Figure 9.8) is recognized by its often subtriangular, cordate- or round-based upper leaves which are arranged very close to the stem (see Figure 9.8b), the very large, elliptic to round basal leaves and the inflorescences in which three single-flowered racemes emerge from the leaf axils, giving the appearance of a 3-flowered inflorescence.

Distribution and habitat. *R. triflora* is widespread, occurring from Clanwilliam and the Piquetberg in the north, to the Cape Peninsula and Palmietrivier areas in the south and it continues eastwards to Tsitsikamma and Knysna (see Map 9.11). This species occurs in montane or coastal fynbos and occupies various habitats, from mountain peaks to river mouths, and is typically associated with TMS soil or deep dry reddish soil. Two regional forms are distinguished in *R. triflora*, and they differ in habit, calyx structure and type of substrate which they occupy. The Caledon form is often associated with limestone ridges.

Regional variation. Two regional forms are distinguished, on the basis of differences in habit, calyx structure and distribution.

Typical form. Erect, robust, much-branched woody shrub, up to 2.4 m tall. *Leaves* elliptic to broadly elliptic or obovate; leaves on flowering branches 33–50 mm long, 18–30 (–34) mm wide; basal leaves 57–121 mm long, 28–83 (–110) mm wide. *Bracteoles* ± 1 mm long. *Calyx* lobes ± as long as tube, 4–6 mm long; upper lobes falcate, broader than others; carinal lobe shorter than others; upper sinus often deeper than others. *Wings* oblong; apex narrow. *Pistil* with style shorter than or ± as long as ovary. *Seeds* narrowly to broadly oblong or broadly reniform, 3–5 mm long, 2–4 mm wide; testa smooth.

Diagnostic characters. The typical form of *R. triflora* differs from the Caledon form in that it is a large, robust woody shrub (the Caledon form is a smaller, herbaceous suffrutex) (see Figure 9.8a) and the leaves are larger.

Caledon form. Erect suffrutex, up to 0.7 m tall. *Leaves* lanceolate or elliptic or ovate; leaves on flowering branches 10–15 (–18) mm wide; basal leaves (43–) 50–67 (–93) mm long, 16–23 (–45) mm wide. *Bracteoles* 0.5–2 mm long. *Calyx* lobes longer than tube, 8–11 mm long; carinal lobe sometimes shorter than others; upper sinus often much deeper than others. *Wings* with apex ± obovate. *Pistil* with style long, ± as long as or longer than ovary. *Pods* 27–33 mm long, 7–8 mm wide. *Seeds* unknown.

Diagnostic characters. The Caledon form of *R. triflora* differs from the typical form in the larger calyx lobes which are longer than the tube (lobes are as long as the tube in the typical form), the upper calyx lobes which are usually broadly falcate and much broader than the other lobes (upper lobes falcate and broader than the others in the typical form) and the obovate wing apex (apex narrow in the typical form).

Distribution and habitat. The Caledon form (recorded from Caledon, Palmietrivier, Kleinrivier mountains, Stanford and De Hoop), occurs in montane or coastal fynbos, adjacent streams, or on sand flats, gentle foothills or steep mountain slopes. It is often associated with limestone outcrops, and may occur in rocky, peaty soil, granite-derived soil, TMS-derived soil or clay. Although most of the species of *Rafnia* occur on acidic soils derived from Table Mountain Sandstone (TMS), like most fynbos vegetation, the Caledon form of *R. triflora* occurs on the alkaline soils of limestone outcrops, which are restricted mainly to the Bedasdorp geological formation. The coastal region stretching from Gansbaai in the west to the mouth of the Gouritz River in the east is recognized as the Bredasdorp-Riversdale centre of endemism (Heydenrych, 1994). The area with the highest number of limestone endemics is De Hoop Nature Reserve with 69 species. Many limestone fynbos species are local endemics, with very narrow distribution ranges. Some forms of *R. alata* and *R. diffusa* are also associated with limestone outcrops.

Specimens examined.

—**3218** (Clanwilliam): Piquetberg, 8.6 km along Langeberg division road, western boundary of Rheeboksfontein farm (-DC), *Campbell & Van Wyk 118* (JRAU, 1–3).

—**3219** (Wupperthal): 12.3 km along road from Citrusdal to The Baths (-CA), *Campbell & Van Wyk 123* (JRAU); Clanwilliam division, hills at Keerom (-CC), *Pillans 9202* (BOL).

—**3318** (Cape Town): Table Mountain (-CD), *Alexander-Prior s.n. sub PRE 53109* (PRE), *MacOwan 812* (PRE), *2696* (PRE, 1 & 2, SAM), *Treleaven 142* (NBG); University grounds (-CD), *Cranswick s.n. sub BOL 50571* (BOL), *Levyns 3600* (BOL); Twelve Apostles, 2 km north of Llandudno, Grootkop (-CD), *Ellis 45* (NBG); Kirstenbosch, north of Window Stream (-CD), *Esterhuysen 17657* (PRE); Table Mountain, Oranjekloof (-CD), *Gillett 3496* (NBG, PRE), *Stokoe s.n. sub SAM 59607* (SAM); 3 miles (4.8 km) south of Camp's Bay (-CD), *Grobbelaar 1200* (PRE); above Kirstenbosch, road to Constantianek (-CD), *Grobbelaar 2894* (PRE); Kirstenbosch, entrance to Dell (-CD), *Henderson 1403* (NBG); Newlands (-CD), *Marloth 1622* (PRE); Devil's Peak (-CD), *Penfold 193* (NBG); near Kirstenbosch (-CD), *Pillans 3793* (BOL, PRE), *Salter s.n. sub BOL 42996* (BOL), *Young 209* (PRE); Saddlebosch, Table Mountain (-CD), *Thode 6073* (NBG); Stellenbosch division, Uitkyk (-DD), *Gillett 564* (NBG).

—**3320** (Montagu): Swellendam (-CD), *Mundt s.n. sub SAM 15204* (SAM).

—**3322** (Oudtshoorn): George (-CD), *Guthrie 4301* (NBG).

—**3323** (Willowmore): Flats at Ratelbosch, Tsitsikamma (-DD), *Fourcade 707* (BOL, 1 & 2); Stormsrivier (-DD), *Taylor 3730* (NBG).

—**3418** (Simonstown): Between Hout Bay and Chapman's Peak (-AB), *Barker 3284* (NBG); South Cross Estate, Constantianek road (-AB), *Barker 5345* (NBG); Karbonkelberg (-AB), *Compton 15389* (NBG), *Leighton 668* (BOL); Constantianek, Cape Town (-AB), *Ecklon 674* (PRE), *Ecklon & Zeyher 1181* (SAM), *Grobbelaar 351* (PRE); mountainside above St James' (-AB), *Galpin 12701* (PRE); Wynberg Hill (-AB), *Gillett 3319* (BOL), *Marloth 553* (PRE); Kalk Bay Mountain, Boye's Drive (-AB), *Goldblatt 5101* (PRE), *Salter 7869* (BOL, 1 & 2); Red Hill (-AB), *Grobbelaar 2202* (PRE); Muizenberg (-AB), *Lansdell s.n. sub PRE 53111* (PRE); Firgrove Hill, Bergvliet farm, Constantia (-AB), *Purcell 259* (SAM); Bergvliet farm, Constantia (-AB), *Purcell s.n. sub SAM 89677, s.n. sub SAM 89679* (SAM, 1 & 2); Froggy farm (-AB), *Taylor 6057* (PRE), *7030* (NBG, PRE); Ou Wingerd road, Constantia (-AB), *Walters 1375* (NBG); hillside above Chapman's Peak road (-AB), *Whellan 1784* (PRE); behind Groote Schuur (-AB), *Wolley-Dod 467* (BOL); Wynberg (-AB), *Zeyher s.n. sub SAM 31305* (SAM); Smitswinkel Bay, Partridge Point (-AD), *Van Wyk 3010* (JRAU, 1 & 2); Caledon division, Kogel Bay (-BB), *Boucher 2050* (NBG, PRE), *Leighton 2472* (BOL); Kogelberg, Caledon (-BB), *Compton 18958* (NBG); above Gordon's Bay and near railway line, Stellenbosch district (-BB), *Smith 4792*, 1 & 2, *4808* (PRE); Caledon division, Hottentotsholland mountains (-BB), *Stokoe 6142* (BOL); 3 km from Steenbrasrivier mouth to Hangklip (-BB), *Van Wyk 2885* (JRAU); between Rooiels and Kogel Bay (-BD), *Campbell & Van Wyk 149* (JRAU); Palmietrivier mouth (-BD), *Compton 6082* (NBG); Caledon division, Paardeberg, Palmietrivier (-BD), *Stokoe s.n. sub SAM 61416* (PRE, SAM); Caledon division, Hangklip Estates (-BD), *Stokoe s.n. sub SAM 62242* (SAM).

—3419 (Caledon): Kleinmond (-AC), *De Kock 67* (NBG, PRE, 1 & 2); Palmietrivier mountains (-AC), *Stokoe s.n. sub PRE 53110* (PRE); Kleinmond district, about 3 km from Kleinmond to Hermanus (-AC), *Van Wyk 3501* (JRAU); Stanford (-AD), *Chambers & Chambers s.n. sub NBG 85107* (NBG); 1 km from Stanford turn-off from Hermanus, Gansbaai-Hermanus road (-AD), *Grobbelaar 2773* (PRE); Kleinrivier mountains (-AD), *Stokoe s.n. sub SAM 68746* (SAM); Stanford, Stinkhoutbos (-AD), *C.M. van Wyk 2090* (NBG, PRE); Stanford district, near intersection of main and gravel roads to Bredasdorp (-AD), *Van Wyk 2887* (JRAU); Stanford, Hermanus (-AD), *Walters 1495* (NBG).

—3420 (Bredasdorp): Near Puspas valley, Swellendam (-AB), *Ecklon & Zehyer 1182* (SAM); De Hoop, Potberg Nature Reserve, above Dronkvlei (-AD), *Burgers 1342* (NBG, PRE); De Hoop, veld north-west of reservoir (-AD), *Willemse 19* (NBG).

—3421 (Riversdale): Korinterivier farm, Riversdale district (-AA), *Muir 61* (PRE), Riversdale, Langeberg, Aandevalsrivier farm (-AB), *Vlok 2679* (JRAU, 1 & 2); Rietvlei, near Still Bay (-AD), *Bohnen 8112* (NBG); near Ystervarkfontein, Riversdale division (-BC), *Muir 618* (PRE).

—3423 (Knysna): Springfield plantation (-AA), *Keet 414* (NBG, PRE); Knysna (-AA), *MacOwan 1602* (SAM).

Precise locality unknown: *Alexander-Prior s.n. sub PRE 53094* (PRE); 'e Cap. b. spei', *LINN 895.16* (LINN) [microfiche only]; Flower Show, Cape Town, *Marloth 8864* (PRE, 1 & 2); *Schönland 707* (PRE); Western Cape Peninsula, *Sidey 4121* (PRE); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16437, s.n. sub THUNB-UPS 16442, s.n. sub THUNB-UPS 16443* (UPS) [microfiche only].

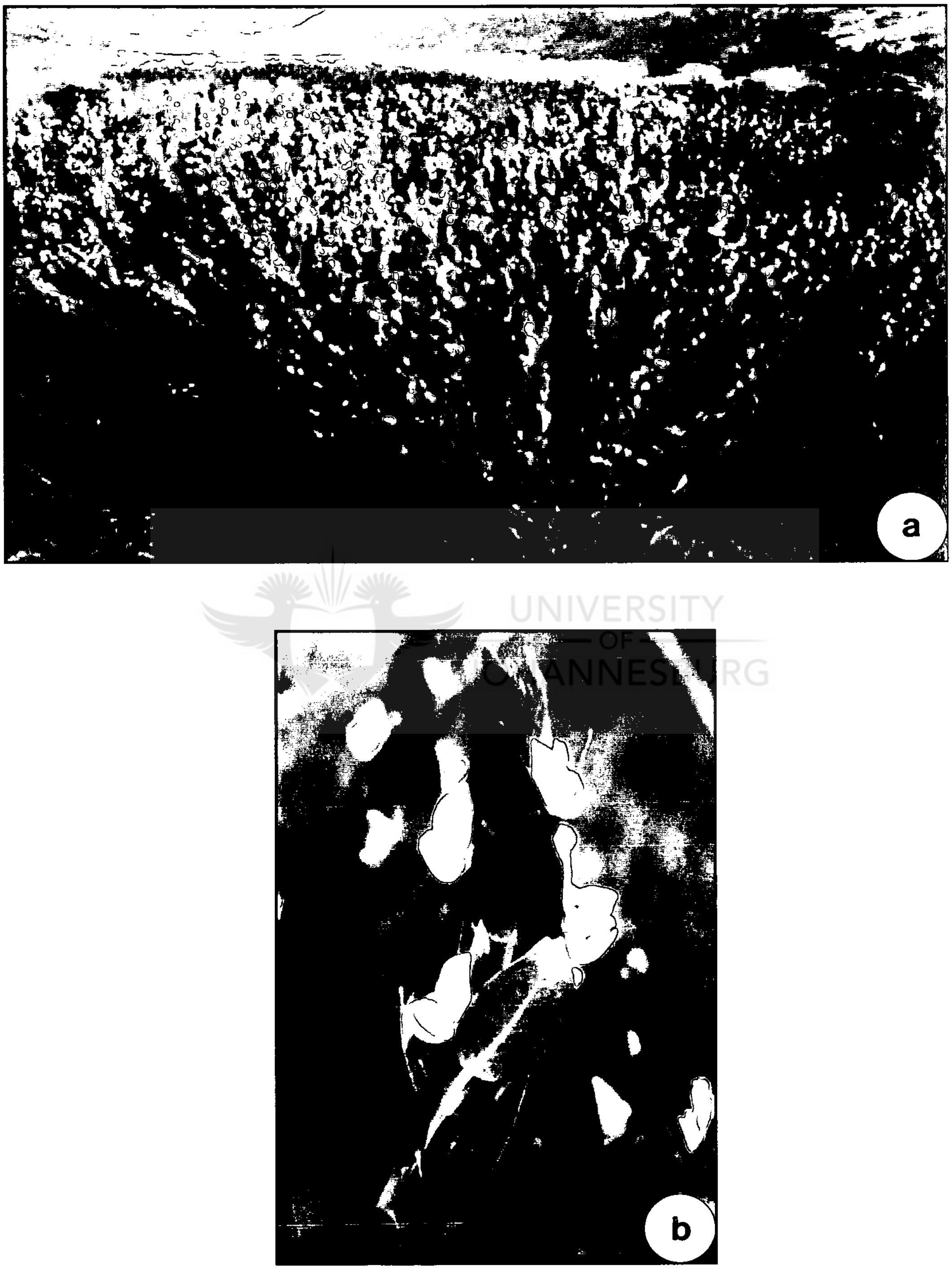
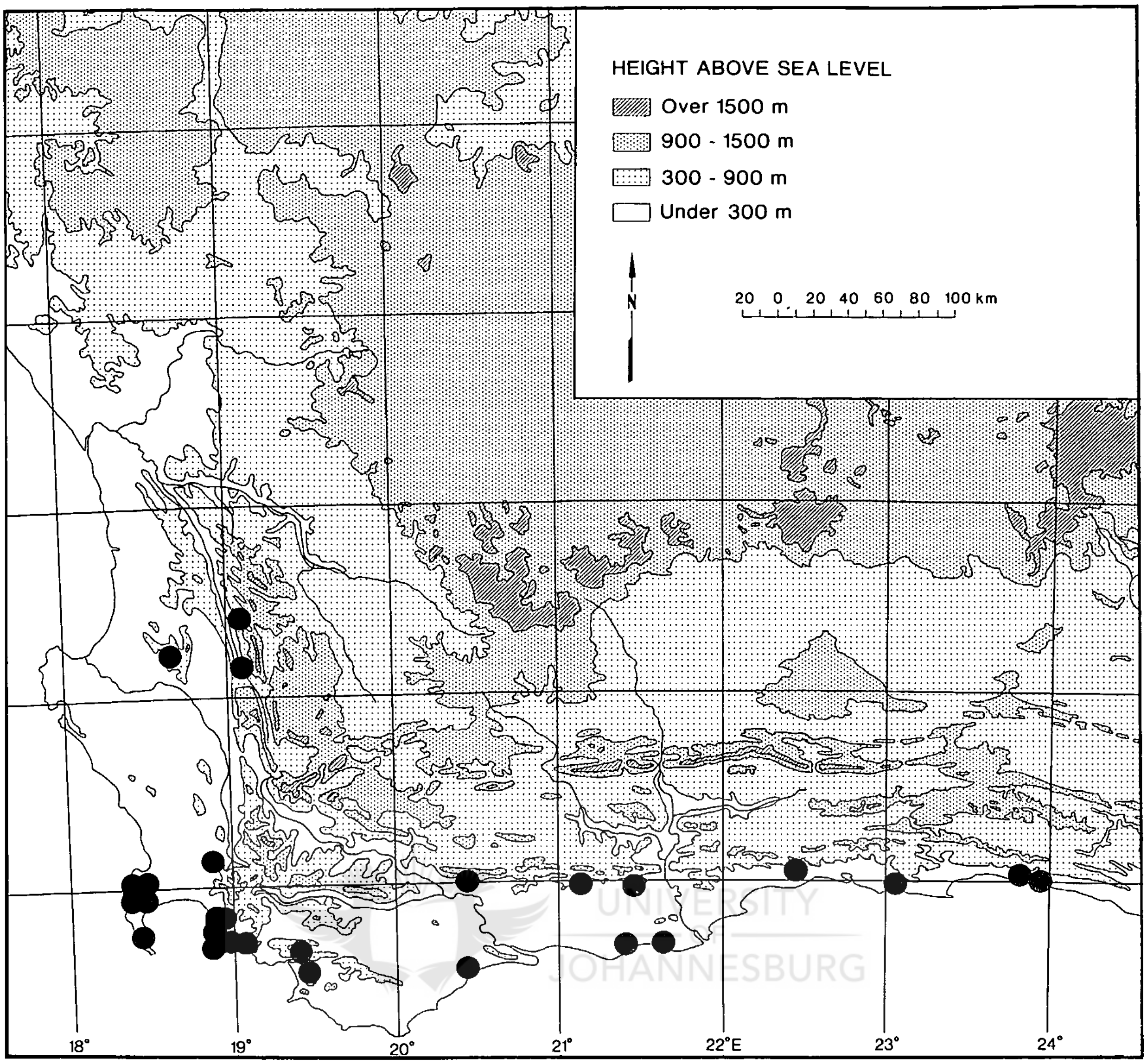


Figure 9.8 Habit, leaves, inflorescences and flowers of *R. triflora*: **a,** erect, woody, much-branched shrub; **b,** upper leaves with round bases and arranged very close to the stem, and single-flowered inflorescences.



Map 9.11 The known geographical distribution of *R. triflora*.

11. ***Rafnia ovata*** E. Mey., Comm. Pl. Afr. Austr. 1(1): 12 (1836); Benth. in Hook., Lond. J. Bot. 2: 465 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 32 (1862). Type: South Africa, Western Cape Province, Cederbergen inter rupes, altit. 2 800–4 600 ped. (III, A, d), *Drège s.n. sub Herb. Benth.* (K!, lectotype, designated here).

= *Rafnia meyeri* Schinz in Bull. Herb. Boiss. 2: 200 (1894). Type: South Africa, Western Cape Province, inter saxa (altit. IV) laterum montium prope "Klapmuts" (Stellenbosch), *Ecklon & Zeyher 1180* (SAM!, lectotype, designated here).

Erect, robust suffrutex, stems not much-branched, up to 1.2 m tall. *Leaves* broadly elliptic or broadly obovate or ovate or round, penninerved; apex acuminate; leaves on flowering branches 35–60 (–63) mm long, (11–) 17–37 mm wide; basal leaves 52–118 mm long, (28–) 40–92 mm wide. *Inflorescence*s single-flowered or rarely few-flowered, 2–4 flowers, sometimes pedunculate. *Flowers* large, 17–22 mm long. *Pedicel* 3–5 mm long. *Bract* ± 1 mm long. *Bracteoles* ± 0.5 mm long. *Calyx* lobes triangular, shorter than tube, 3–5 mm long; upper lobes broader than others; carinal lobe sometimes slightly shorter than others; upper sinus much deeper than others; tube with a ridge between upper lobes, 3–6 mm long. *Standard* ovate or broadly elliptic or suborbicular, 16–20 mm long, (16–) 21–23 mm wide, often with basal callosities; claw 3–4 mm long. *Wings* oblong to oblong-elliptic, 15–19 mm long, 8–10 mm wide, with 7–9 rows of sculpturing; apex obtuse; claw 4–6 mm long. *Keel* sometimes ± strongly upcurved (11–) 14–16 mm long, 7–8 mm wide; claw 5–7 mm long. *Pistil* with ovary oblong to narrowly ovate; style shorter than ovary, strongly upcurved; ovules many (up to 7). *Pods* obliquely lanceolate, 37–44 (–52) mm long, 10–13 mm wide, short-stipitate; stipe 10–16 mm long; upper margin slightly convex, broadly winged; wing ± 2 mm wide; lower margin straight, proximally convex, upcurved into stipe. *Seeds* broadly oblong-reniform, 5–6 mm long, 3–4 mm wide; testa rough.

Diagnostic characters. R. ovata (see Figure 9.9) differs from the other species of *Rafnia* in the herbaceous stems which are not much-branched (see Figure 9.9a), the acuminate leaves (the basal leaves are often very large, comparable in size to those of *R. triflora*) (see Figure 9.9a–d), the inflorescence which is subtended by highly reduced opposite leaves which may also be absent, the large flowers (see Figure 9.9c), the calyx lobes which are shorter than the calyx tube and the large, stipitate pods which are broadly winged on the upper suture (see Figure 9.9d).

Distribution and habitat. R. ovata occurs as far north as Nieuwoudtville and continues southwards through the Cedarberg to Stellenbosch and eastwards to Tweedside in the Laingsburg area (Map 9.12). This species grows in montane fynbos, often in disturbed areas, in foothills or high mountain slopes or sandy flats and near rivers, often in TMS-derived soil.

Specimens examined.

—**3119** (Calvinia): Glenridge, Nieuwoudtville (-AC), *Barker 9212*, *9568*, 1 & 2 (NBG); Vanrhynsdorp, top of Vanrhyn's Pass (-AC), *Van Bredá 1401* (PRE).

—**3218** (Clanwilliam): Skimmelberg (-BD), *Pillans 9093* (BOL); Piquetberg, Waboom farm, Zebrakop (-DB), *Taylor 5347* (PRE); Piquetberg, 2.1 km along New Caledonia road (-DC), *Campbell & Van Wyk 34*, 1 & 2, *122*, 1 & 2 (JRAU); Piquetberg (-DC?), *Levyns 2184* (BOL), *Loubser 1027* (BOL).

—**3219** (Wupperthal): Cedarberg State Forest, Heuningvlei, Groot Koupoort (-AA), *Esterhuysen 12130* (BOL), *Kruger 1691* (PRE, 1 & 2); Clanwilliam division, Cedarberg, Heuningvlei (-AA), *Stokoe s.n. sub SAM 55791* (SAM), *Taylor 11254* (NBG); Clanwilliam division, Cedarberg, Krakadouw Peak (-AA), *Stokoe s.n. sub SAM 55792* (SAM), *Thorne s.n. sub SAM 52514* (SAM); 2 miles (3.2 km) south of Wupperthal (-AC), *Rycroft 2253* (NBG); Clanwilliam division, Cedarberg, Sneeuberg to Maltese Cross (-AC), *Schelpe 285* (BOL); Clanwilliam, heights above Wupperthal (-AC), *Taylor 5931*

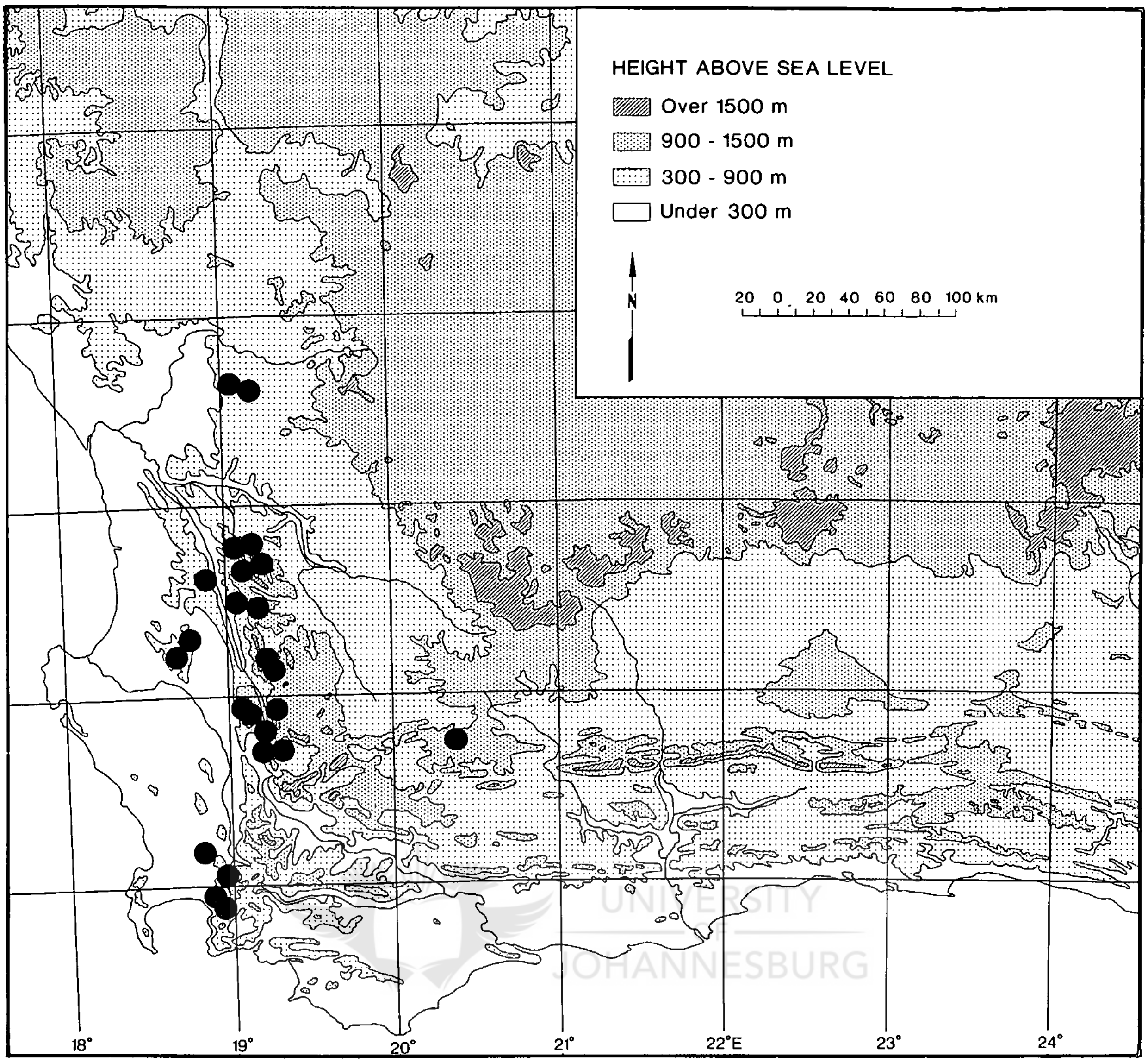
(NBG, PRE); Sneeuberg, Cedarberg (-CA), *Barnard s.n. sub SAM 44109* (SAM); Middelberg plateau, Cedarberg (-CA), *Compton 12726* (NBG); Kromrivier, Clanwilliam division (-CA), *Leighton 21597* (BOL); Clanwilliam division, Cedarberg, Duiwelskop (-CA), *Stokoe s.n. sub SAM 55791* (PRE); Ceres, Wydekloof, opposite turn-off to Donkerbos (-CD), *Campbell & Van Wyk 128* (JRAU, 1–5 NBG, PRE); Disselfontein, Koue Bokkeveld mountains, Ceres (-CD), *Hanekom 988* (PRE).

—**3318** (Cape Town): Duiwelsvurk, Jonkershoek (-DD), *Borchardt 233* (PRE), *Wicht 155* (PRE); Klapmuts, Stellenbosch (-DD), *Ecklon & Zeyher 1180* (SAM).

—**3319** (Worcester): Witsenberg (-AA), *Andreae 146* (NBG), *Zeyher 356* (PRE, SAM, 1 & 2); Tulbagh, Groot Winterhoek mountains (-AA), *Anon. 8593* (NBG), *Marloth 1639* (PRE, 1 & 2), *Phillips s.n. sub PRE 53104* (PRE); Sneeugat valley, Groot Winterhoek, Tulbagh (-AA), *Phillips 1735* (SAM); Voorberg, Groot Winterhoek mountains (-AA), *Van Wyk 3135* (JRAU); Groenfontein, Swartruggens near Winkelhaakrivier (-AB), *Levyns 1914* (BOL); Agter-Witsenberg, Ceres district (-AB), *Walters 528* (NBG); Witsenberg flats, Ceres (-AD), *Compton 18813* (NBG).

—**3320** (Montagu): Tweedside, Laingsburg division (-AB), *Compton 3038* (BOL); Tweedside, Matjiesfontein district (-AB), *Marloth 12067* (PRE).

—**3418** (Simonstown): Knorhoek, Sir Lowry's Pass (-BB), *Gray s.n.* (NBG); Somerset West, Stellenbosch (-BB), *Over s.n. sub NBG 14211* (NBG); Waterkloof, Somerset West, Stellenbosch division (-BB), *Parker 3868* (NBG); Helderberg, Stellenbosch (-BB), *Stokoe 887* (PRE); Vergelegen, Somerset West (-BB), *Valpy s.n. sub NBG 14208* (NBG); Hottentotsholland mountains (-BB), *Zeyher s.n. sub SAM 15202* (SAM).



Map 9.12 The known geographical distribution of *R. ovata*.

Figure 9.9 Habit, leaves, branches, inflorescences, flowers and pods of *R. ovata*: **a,** robust suffrutex with the stems not much-branched; **b,** flowering stem (left) and stem from the previous season (right), and note the strongly glaucous, acuminate leaves; **c,** single-flowered inflorescences with large flowers and calyx lobes that are shorter than the calyx tube; **d,** large stipitate pods broadly winged on the upper suture.

12. *Rafnia inaequalis* G.J. Campbell & B-E. van Wyk sp. nov., *R. acuminatae* et *R. amplexicauli* similis sed foliis juvenes revolitis (in *R. acuminata* et *R. amplexicauli* plano vel leviter cupulari), nervatura foliorum penninervi (in *R. acuminata* et *R. amplexicauli* reticulata), lobo carinali calycis perpusillo filiformi (in *R. acuminata* et *R. amplexicauli* triangulari), extensione aliformi inter lobos superos calycis (absunt in *R. acuminata* et *R. amplexicauli*), et legumine parvo stipitato (in *R. acuminata* et *R. amplexicauli* sessili) differt. Type: South Africa, Western Cape Province, Piquetberg, 7.5 km along Langeberg Division Road, western boundary of Rheeboksfontein farm, *Campbell & Van Wyk 119* (NBG!, holotype; BOL!, JRAU!, K!, MO!, NBG!, PRE!, UPS!, isotypes).

Erect shrublet, up to 0.4 m tall. *Leaves* broadly elliptic or obovate-elliptic or oblong or round, penninerved, revolute when young; base cordate; leaves on flowering branches opposite, 22–37 mm long, 14–25 mm wide; basal leaves (26–) 30–50 mm long, 15–36 mm wide; coppice leaves ovate to round, 23–33 mm long, 19–26 mm wide. *Inflorescences* single-flowered. *Flowers* 12–15 mm long. *Pedicel* 7–9 mm long. *Bract* 1–2 mm long. *Bracteoles* shortly triangular, ± 0.5 mm long. *Calyx* relatively long; lobes much longer than tube, 7–10 mm long; upper lobes broadly falcate, much broader than others; lateral lobes falcate; carinal lobe very narrow, shorter than others; upper sinus deeper than others; tube with a wing-like extension between upper lobes, ± 4 mm long. *Standard* ovate to broadly ovate or broadly elliptic, 12–14 mm long and wide; apex acute; claw ± 3 mm long. *Wings* oblong, shorter than keel, 7–9 mm long, 3–4 mm wide, with 6–7 rows of sculpturing; apex obtuse, base gradually tapering into claw; claw ± 3 mm long. *Keel* 10–11 mm long, 4–6 mm wide; claw 3–4 mm long. *Stamens* usually monadelphous or rarely diadelphous. *Pistil* long-stipitate; ovary ± oblong; style long, longer than ovary, strongly upcurved; ovules 2. *Pods* oblong, 16–17 mm long, ± 4 mm wide, stipitate; stipe 8–9 mm long, often curved; upper and lower margins slightly convex. *Seeds* narrowly to broadly reniform or oblong, 3–4 mm long, 2–3 mm wide; testa smooth.

Diagnostic characters. *R. inaequalis* (Figure 9.10) is similar to *R. acuminata* and *R. amplexicaulis* but differs in the revolute young leaves (the young leaves are flat or slightly cupular in *R. acuminata* and *R. amplexicaulis*) (Figure 9.10b–d), the penninerved leaf venation (venation is reticulate in *R. acuminata* and *R. amplexicaulis*), the minute, filiform carinal calyx lobe (the lobe is larger and triangular in *R. acuminata* and *R. amplexicaulis*), the wing-like extension on the tube between the upper lobes (such a wing is absent in *R. acuminata* and *R. amplexicaulis*) and the small, stipitate pod (the pod is sessile in *R. acuminata* and *R. amplexicaulis*).

Distribution and habitat. *R. inaequalis* is known only from the Piquetberg (see Map 9.13), where it co-occurs with its presumably closely related species, *R. acuminata* and *R. amplexicaulis.* The species occurs in montane fynbos, in disturbed areas in deep sand.

Specimens examined.

—**3218** (Clanwilliam): Piquetberg, Rheeboksfontein farm (-DC), *Campbell & Van Wyk 119* (BOL, JRAU, K, MO, NBG, 1–3, PRE, 1 & 2, UPS); Piquetberg (-DC?), *Compton 23005* (NBG).

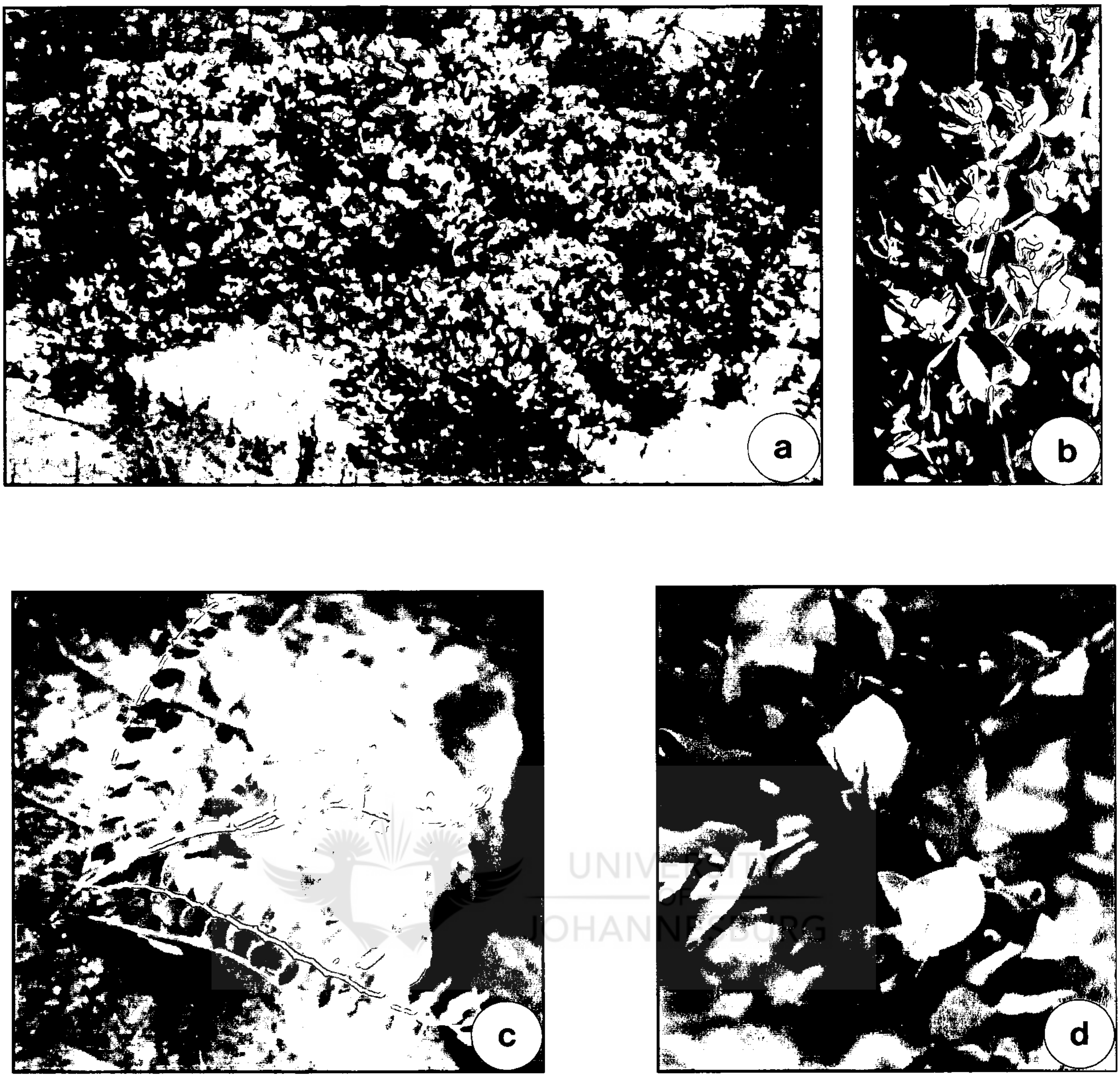


Figure 9.10 Habit, inflorescences, flowers and seedling of *R. inaequalis*: **a,** erect, spreading shrublet; **b,** cordate leaves, revolute young leaves and single-flowered inflorescences; **c,** seedling with subopposite coppice leaves; **d,** revolute young leaves, and flowers.

13. *Rafnia acuminata* (E. Mey.) G.J. Campbell & B-E. van Wyk comb. nov. Type: South Africa, 'e Cap. b. spei', *Drège s.n.* (P?, to be chosen as lectotype); *Drège s.n sub Herb. Benth.* (K!).

≡ *Vascoa acuminata* E. Mey. in Linnaea 7: 148 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836).

≡ *Vascoa perfoliata* (Thunb.) DC. var. *acuminata* (E. Mey.) Walp. in Linnaea 13: 462 (1839).

= *Borbonia perfoliata* Thunb., Prodr. Pl. Cap.: 122 (1800), nom. illeg. Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16330* (UPS, specimen marked α, microfiche!).

≡ *Vascoa perfoliata* (Thunb.) DC., Prodr. 2: 119 (1825), Mém. Lég.: 187 (1826); E. Mey. in Linnaea 7: 148 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836), nom. illeg.

≡ *Rafnia perfoliata* auctt. non (L.) Willd., Sp. Pl. 3: 949 (1802): E. Mey., Comm. Pl. Afr. Austr. 1(1): 12 (1836); Walp. in Linnaea 13: 462 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 464 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 32 (1862); Schinz in Bull. Herb. Boiss. 2: 201 (1894).

[Note: *Borbonia perfoliata* Thunb. was apparently described as new without reference to *Crotalaria perfoliata* of Linnaeus (1753) or *B. perfoliata* of Lamarck (1785). *C. perfoliata* L. is the basionym of *Baptisia perfoliata* (L.) R. Br., and was lectotypified in this sense, on the Dillenius plate [Dill., Hort. Elth.: 122, t. 102. f. 122 (1732)] by Reveal in Turland & Jarvis (1997).

If *B. perfoliata* Thunb. (1800b) was perhaps not intended as a new name but merely the use of the earlier *B. perfoliata* Lam. (1785) by Thunberg, then "*B. perfoliata* Thunb." does not exist as a name. If "*B. perfoliata* Thunb." is a newly described species, then it is a later homonym of *B. perfoliata* Lam. and consequently illegitimate. *B. perfoliata* Lam. is a species of *Aspalathus* (see Dahlgren, 1988). However, whatever the case, *B. perfoliata* Lam./Thunb. cannot now be transferred to *Rafnia* because the transfer is blocked by the existence of *R. perfoliata* (L.) Willd. for a North American species of *Baptisia* (see Turland & Jarvis (1997). The correct name of the plant should therefore be based on *Vascoa acuminata* E. Mey., the earliest available basionym.

Prostrate, much-branched trailing shrublet, up to 0.3 m tall, 1 m wide. *Leaves* cordate to oblong-cordate, reticulately veined, often embracing the stem; leaves on flowering branches opposite, 20–30 (–40) mm long, 18–25 (-36) mm wide; basal leaves 20–40 mm long, 15–30 (–36) mm wide. *Inflorescences* single-flowered. *Flowers* 9–14 mm long. *Pedicel* 2–4 mm long. *Bract* 0.5–2 mm long. *Bracteoles* minute, 0.1–0.2 mm long. *Calyx* lobes relatively long or not relatively long; lobes ± as long as or much longer than tube, 2–9 mm long; upper lobes falcate or broadly falcate, broader or much broader than others; lateral lobes narrowly triangular or slightly falcate; carinal lobe sometimes slightly shorter than others; lateral sinus sometimes deeper than lower sinus; tube often with a ridge between upper lobes, 2–3 mm long. *Standard* elliptic or suborbicular, 8–14 mm long, 6–14 mm wide, often with basal callosities; claw 2–3 mm long. *Wings* oblong, 8–13 mm long, 3–6 mm wide, with 5–7 rows of sculpturing; apex narrow; lower margin sometimes convex; claw 2–3 mm long. *Keel* rostrate to ± long-rostrate, sometimes ± strongly upcurved, 7–11 mm long, 4–6 mm wide; apex narrow to slightly obtuse; claw 2–4 mm long. *Pistil* with ovary ± narrowly ovate to oblong; style ± as long as or longer than ovary, strongly upcurved; ovules 2–3. *Pods* narrowly lanceolate, 20–28 mm long, 6–9 mm wide; upper margin slightly convex; lower margin ± straight to proximally convex. *Seeds* broadly reniform to oblong, ± 5 mm long, ± 3 mm wide; testa smooth.

Diagnostic characters. R. acuminata (see Figure 9.11) is similar to *R. amplexicaulis* but differs in the prostrate, trailing habit (*R. amplexicaulis* is a large, erect, robust woody shrub) (see Figure 9.11a) and the proximally narrow pod (the pod is proximally broad and the upper margin convex in *R. amplexicaulis*). *R. acuminata* is distinguished from the remaining species by its cordate, reticulately veined leaves (see Figure 9.11b).

Regional variation. Two regional forms are distinguished in *R. acuminata*, and they differ in calyx structure and distribution.

Typical form. *Bract* 0.5–0.7 mm long. *Calyx* not relatively long, lobes ± as long as the tube, 2–5 mm long; upper lobes falcate, broader than the others; lateral lobes narrowly triangular. *Standard* 8–10 mm long, (6–) 9–11 mm wide. *Wings* 8–9 mm long, 3–4 mm wide. *Keel* rostrate, 7–9 mm long.

Northern form. *Bract* 1.5–2 mm long. *Calyx* relatively long; lobes much longer than the tube, 6–9 mm long; upper lobes broadly falcate, much broader than the others. *Standard* 13–14 mm long and wide. *Wings* 12–13 mm long, 5–6 mm wide. *Keel* ± long-rostrate, 10–11 mm long.

Diagnostic characters. The northern form of *R. acuminata* differs from the typical form in the larger bracts, the calyx lobes which are much longer than the tube (lobes about as long as the tube in the typical form) and the broadly falcate upper calyx lobes which are much broader than the other lobes (upper lobes falcate and not as much broader than the other lobes in the typical form). The standard, wing and keel petals of the northern form are larger than those of the typical form and the keel is long-rostrate (rostrate in the typical form).

Distribution and habitat. The typical form of *R. acuminata* occurs from the Cedarberg in the north to the Bredasdorp area in the south (see Map 9.13). The northern form is restricted to the Piquetberg and Algeria in the Cedarberg. *R. acuminata* occurs in coastal, montane and grassy fynbos and grows on gentle or steep, dry, rocky slopes. It is often associated with stony shale, dry, sandy TMS soil or clay or granitic soil.

Specimens examined.

—**3218** (Clanwilliam): Piquetberg, Versveld Pass (-DC), *Campbell & Van Wyk 36* (JRAU); *Maguire 1154* (NBG, 1 & 2); Moutonsvlei, Piquetberg (-DC), *Pillans 7355* (BOL).

—**3219** (Wupperthal): Algeria, Cedarberg (-AC), *Compton 4786* (NBG); boundary between Breekkrans and Kromrivier (-CB), *Taylor 11432* (NBG, PRE, 1 & 2); Clanwilliam division, Keerom, above Olifantsrivier valley (-CC), *Esterhuysen 17909* (BOL).

—**3318** (Cape Town): Piquetberg division, Porterville (-BB), *Loubser 799* (BOL); Jonkershoek, Stellenbosch (-DD), *Compton 15309* (NBG, PRE); Jonkershoek State Forest, Swartboskloof (-DD), *Floyd s.n. sub PRE 60902* (PRE); Jonkershoek State Forest, The Valley (-DD), *Kruger 11* (NBG, PRE); Biesievlei, Jonkershoek (-DD), *Rycroft 1074* (PRE).

—**3319** (Worcester): Tulbagh division, Witsenberg, Sneeugat valley (-AA), *Stokoe 7408* (BOL); Tulbagh, Groot Winterhoek mountains, near Saron (-AA), *Stokoe 8401* (BOL); Winterhoek mountains, Tulbagh (-AA), *Zeyher s.n. sub SAM 15201* (SAM, 1 & 2); Skurweberge, near Gydo (-AB), *Bolus 7570* (BOL); Roodesandsberg, Tulbagh (-AC), *Compton 6498* (NBG); Paarl division, Elandskloof mountains, north of Wellington (-AC), *Stokoe s.n. sub SAM 69768* (SAM); Eendracht farm, Waaihoek (-AD), *Pica Survey 6 sub PRE 871* (PRE); near De Doorns, about 3 miles (4.8 km) north of Worcester (-BC), *Schlieben & Van Bredá 9935* (NBG, PRE); national road, Hex River valley (-BC), *Walters 1335* (NBG); Paarl, Drakenstein mountains, Du Toitskloof (-CA), *Campbell & Van Wyk 22* (JRAU), *Compton 22309* (NBG, 1 & 2), *Lewis 3584* (SAM), *Pillans 8419* (BOL, PRE), *Wilman s.n. sub BOL 26049* (BOL); Paarl division, Seven Sisters Mountain (-CA), *Esterhuysen 13730* (BOL); Du Toitskloof, mountain to Baineskloof trail, Limietberg hike (-CA), *Hartley 609* (J); near Wellington (-CA?), *Thompson 40* (PRE); Sneeukop, Wellington (-CA), *Thorne s.n. sub SAM 46497* (SAM); Lategan farm, Breederivier (-CA), *Walters 896* (NBG); 5 km west of Worcester (-CB), *Bayer 3360*

(NBG); Botha (-CB), *Compton 18690* (NBG); Franschhoek, Paarl (-CC), *Barker 4164* (NBG), *Marloth 8107* (PRE), *Phillips 1100* (SAM, 1 & 2), *Thode A2192* (PRE, 1 & 2); Franschhoek Pass, Paarl (-CC), *Boucher 2362* (NBG, PRE), *Compton 8171, 20204* (NBG), *Gillett 754* (NBG), *Grobbelaar 1079* (PRE), *Rodin 3087* (BOL, PRE); Paarl division, Wemmershoek (-CC), *Esterhuysen 4034* (BOL), *17674* (BOL, PRE); Tierkloof, Wemmershoek (-CC), *Gray s.n. sub BOL 26048* (BOL); Franschhoek, Klein Drakenstein mountains, Zachariashoek catchment (-CC), *Haynes H295* (NBG, PRE), *Kruger KR761* (NBG, PRE); Middagkrans mountains (-CC), *Stirton 10097* (NBG); Drakenstein mountains near Wellington (-CC), *Tupou s.n. sub BOL 32553* (BOL), *Tyson 764* (PRE); Zachariashoek State Forest, Kasteelkloof catchment (-CC), *Van Wilgen 142* (NBG, PRE); Onklaarberg, isolated mountain 20 miles (32 km) south of Worcester (-CD), *Stokoe 1152a* (PRE, 1 & 2); Jonaskop, Villiersdorp (-DC), *Bayliss 1396* (PRE), *Campbell & De Castro 97* (JRAU), *Greuter 22039* (PRE), *Negin 5* (NBG), *Schutte 444* (JRAU), *Van Wyk 2067* (JRAU, 1–3); McGregor, Robertson (-DD), *Compton 11894* (NBG).

—**3320** (Montagu): Montagu Baths (-CA), *Page s.n. sub PRE 53093* (PRE).

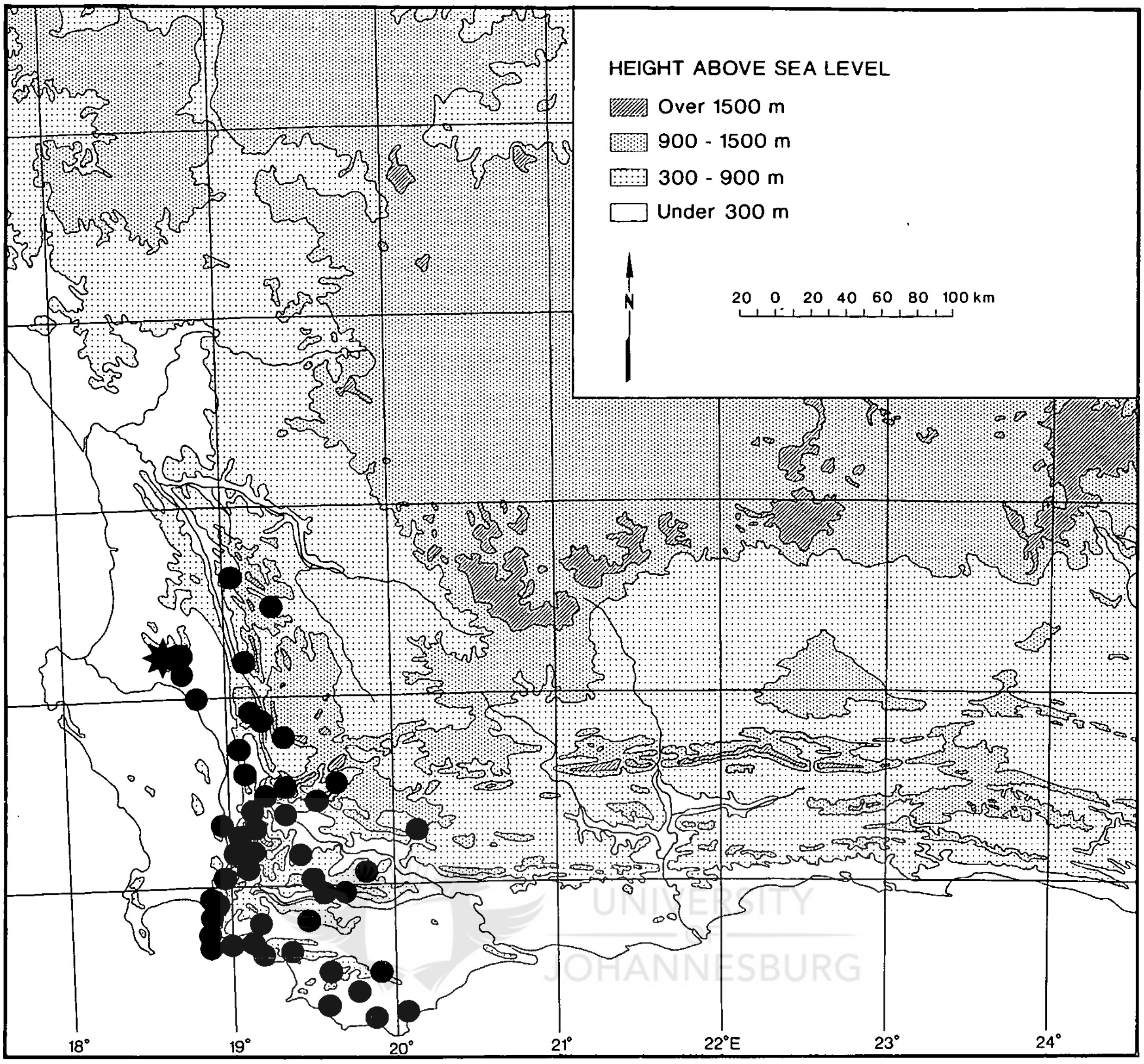
—**3418** (Simonstown): Stellenbosch, Hottentotsholland mountains (-BB), *Alexander-Prior s.n. sub PRE 53087, s.n. sub PRE 53095* (PRE); Strand, about 1 km from Gordon's Bay to Rooiels (-BB), *Campbell & Van Wyk 129* (JRAU), Sir Lowry's Pass, Stellenbosch (-BB), *Compton 14224* (NBG), *Grobbelaar 225* (PRE), *Guthrie 2210* (NBG), *Levyns 2539* (BOL), *Rogers 26650* (PRE), *Schlechter 7288* (BOL, PRE), *s.n. sub TM 403* (PRE), *Stirton 8359* (PRE); Stellenbosch district, Vergelegen, Somerset West (-BB), *Esterhuysen 34015* (BOL); Gordon's Bay (-BB), *Goldblatt 2975* (NBG), *Marloth 10112* (NBG, PRE, 1 & 2), *Stirton 8397* (PRE); Helderberg, Stellenbosch division (-BB), *Parker 3741* (BOL, NBG); Stellenbosch, between Vanderstel and Sir Lowry's Pass station (-BB), *Smith 4780* (PRE, 1 & 2); Stellenbosch, Vanderstel, near Dennegeur (-BB), *Smith 4885* (PRE); 8 km from Gordon's Bay to Hangklip (-BB), *Stirton 8401* (PRE); between Kogel Bay and Gordon's Bay (-BB), *Van Wyk 2994* (JRAU); Steenbras road (-BB), *Walsh 6* (PRE); Groot Hangklip (-BD), *Boucher 759* (NBG, PRE), *Taylor 5868* (NBG); Palmietrivier mouth (-BD), *Compton 3453* (BOL), *12354* (NBG), *Levyns 8919* (BOL); Pringle Bay (-BD), *Compton 6091* (NBG), *Levyns 10642* (BOL); 4 km from Rooielsrivier to Gordon's Bay (-BD), *Grobbelaar 2826* (PRE); Rooiels (-BD), *Stirton 8407* (PRE).

—**3419** (Caledon): Houhoek mountains (-AA), *Bolus 5007, s.n. sub BOL 43042* (BOL), *Guthrie 2241* (NBG); 18.4 km south-of Greyton (-AB), *Acocks 24423* (PRE); Hermanus (-AC), *Barker 1628* (NBG), *A.E. van Wyk 2090* (PRE); Hemel-en-Aarde (-AC), *Barker 7619* (NBG, 1 & 2); Hawston Mountain (-AC), *Compton 10185* (NBG); Kleinmond (-AC), *De Vos 358* (NBG, 1 & 2), *Stokoe s.n. sub PRE 53097* (PRE); Hermanus Mountain (-AC), *Leighton 332* (BOL); Fernkloof Nature Reserve, Hermanus (-AC), *Orchard 292* (NBG), *Schutte 437* (JRAU); Palmietrivier mountains (-AC), *Stokoe s.n. sub SAM 61413* (PRE, SAM); Heuningklip, Botrivier (-AC), *Taylor 4082*, *5860*, 1 & 2 (NBG); McGregor, Riviersonderend mountains on road to Skilpadkop (-BA), *Campbell & Van Wyk 17* (JRAU); Genadendal (-BA), *Galpin 3918* (PRE); Greyton Nature Reserve, Platkloof, Riviersonderend mountains (-BA), *Goldblatt 8670* (PRE), *Rycroft 3355* (NBG); 20 km from McGregor on road over mountains to Greyton (-BA), *Grobbelaar 2211* (PRE); Appelskraal, Riviersonderend mountains (-BA), *Stokoe s.n. sub SAM 61414* (SAM); Salmonsdam Nature Reserve (-BC), *Matthews 102* (PRE); Bredasdorp, Napier (-BD), *Jordaan 510* (NBG); Hagelkraal (-DA), *Stirton & Zantovska 11321* (NBG, PRE); Elim (-DB), *Bolus s.n. sub NH 13620* (PRE), *Frowein 1035* (PRE); Bredasdorp, Brandfontein, Soetanysberg, near Wolwekloof (-DB), *Smith 5007* (PRE).

—**3420** (Bredasdorp): Heuningberg Nature Reserve (-CA), *Schutte 537* (JRAU).

Precise locality unknown: Cedarberg, *Andrag 2* (NBG); 'Tulbagh, Kleinrivier and Hottentotsholland mountains', *Ecklon & Zeyher 1201* (PRE, SAM); 'Hottentotshollandskloof and Houhoek, Stellenbosch', *Ecklon & Zeyher 1202*, 1 & 2 (SAM); 'Nuweberg, Palmietrivier, Swartberg, Caledon, Riviersonderend mountains', *Ecklon & Zeyher 2283* (SAM); *Ecklon & Zeyher s.n. sub PRE 9954* (PRE); *Rycroft 1074* (NBG); *Thode 5288* (NBG); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16330 (∝)* (UPS) [microfiche only].

Figure 9.11 Habit, leaves, inflorescences and flowers of *R. acuminata*: **a,** prostrate, trailing shrublet; **b,** cordate, reticulately veined leaves and single-flowered inflorescences.



Map 9.13 The known geographical distributions of *R. inaequalis* (star) and *R. acuminata* (dots).

14. ***Rafnia amplexicaulis*** (L.) Thunb., Gen. Nov. Pl.: 144 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 949 (1802); Thunb., Fl. Cap.: 563 (1823); E. Mey., Comm. Pl. Afr. Austr. 1(1): 11 (1836); Walp. in Linnaea 13: 462 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 464 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 32 (1862); Schinz in Bull. Herb. Boiss. 2: 200 (1894). Type: South Africa, 'e Cap. b. spei', *LINN 895.5* (LINN, microfiche!, lectotype, designated here).

≡ *Crotalaria amplexicaulis* L., Sp. Pl. 2: 1003 (1753), Pl. Rar. Afr.: 16 (1760); Lam. Encycl. 2: 194 (1785).

≡ *Vascoa amplexicaulis* (L.) DC., Prodr. 2: 119 (1825), Mém. Lég.: 187 (1826); E. Mey. in Linnaea 7: 148 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836).

= *Crotalaria reniformis* Lam., Encycl. 2: 194 (1785); DC., Prodr. 2: 118 (1825) [as a synonym of *R. amplexicaulis*]. Type not seen.

= *Rafnia virens* E. Mey., Comm. Pl. Afr. Austr. 1(1): 11 (1836); Walp. in Linnaea 13: 462 (1839), Rep. Bot. Syst. 2: 578 (1843); Benth. in Hook., Lond. J. Bot. 2: 464 (1843); Harv. In Harv. & Sond., Fl. Cap. 2: 32 (1862). Type: South Africa, Western Cape Province, Dutoitskloof in montibus inter saxa altit. 1 500 ped. (III, A, 2), *Drège s.n.* (P, photo.!, lectotype, designated here; K!, isotype).

[Note: The protologue of *Crotalaria amplexicaulis* clearly shows that the plant currently known as *Rafnia amplexicaulis* is referred to. Since there are no original specimens in LINN or elsewhere, we are left with no option but to choose a neotype. Linnaeus referred to the plate in Seba [Locupl. Rer. Nat. Thes. 1: t. 24, f. 5 (1734)]. This figure clearly depicts *R. acuminata* (E. Mey.) G.J. Campbell & B-E. van Wyk, previously erroneously known as *Rafnia perfoliata* auctt. non (L.) Willd. We thus prefer to choose a neotype which agrees taxonomically with the rather unambiguous diagnosis given in the protologue (see International Code of Botanical Nomenclature (ICBN), Recommendation 7B.4). This choice will fix the current application of the name to *R. amplexicaulis*, as is recommended by the ICBN (Recommendation 7B.5). We thus choose *LINN 895.5* as neotype instead of the Seba plate ['Genista, africana, perfoliata, flore luteo'] because the latter does not clearly reflect the statement of intent in the protologue "foliis ... oppositis reniformibus".]

Erect, robust, much-branched woody shrub, up to 2.5 m tall, 3 m wide. *Leaves* reniform to cordate, reticulately veined, embracing the stem; leaves on flowering branches opposite, 22–37 (–42) mm long, 24–44 mm wide; basal leaves 27–77 mm long, 31–68 (–88) mm wide. *Inflorescences* single-flowered. *Flowers* 12–17 mm long. *Pedicel* 4–6 mm long. *Bract* 0.2–0.7 mm long. *Bracteoles* absent. *Calyx* lobes short, broadly triangular, shorter than or as long as tube, 2–4 mm long; upper lobes falcate, broader than others; carinal lobe broadly triangular, sometimes slightly longer than others; tube 3–6 mm long. *Standard* broadly ovate or broadly elliptic, (10–) 13–16 mm long, (13–) 16–17 (–21) mm wide, often with basal callosities; claw 3–6 mm long. *Wings* oblong-elliptic, 10–13 mm long, 5–8 mm wide, with 6–7 rows of sculpturing; apex obtuse to broadly oblong; claw 4–6 mm long. *Keel* long-rostrate, strongly upcurved towards apex, 9–11 mm long, 5–7 mm wide; claw 4–6 mm long. *Pistil* with ovary ± ovate, oblong; style shorter than or ± as long as ovary, strongly upcurved; ovules 2–4. *Pods* obliquely lanceolate, 22–27 mm long, 7–10 mm wide; upper margin proximally convex; lower margin straight. *Seeds* narrowly oblong to reniform, 4–6 mm long, 2–4 mm wide; testa rough.

Diagnostic characters. *R. amplexicaulis* (see Figure 9.12) differs from *R. acuminata* in that the leaves may also be reniform (not only cordate, as in *R.* acuminata) (see Figure 9.12c & d) and are often a pale green colour (dark green to glaucous in *R. acuminata*). *R. amplexicaulis* differs from the remaining species in the reticulate, cordate to reniform leaves and the pod shape, as well as the absence of bracteoles.

Distribution and habitat. *R. amplexicaulis* has a similar distribution to that of *R. acuminata* but is more concentrated in the north. It reaches from Nieuwoudtville in the north to Worcester in the south and includes Elim, near Bredasdorp (see Map 9.14). This species grows in coastal fynbos, sandveld or resnosterveld, on sand flats, foothills, gentle or steep, rocky mountain slopes and is associated with deep or shallow, dry TMS sand or granitic soil.

Specimens examined.

—**3118** (Vanrhynsdorp): Matsikamma mountains (-DB), *Stirton 5954* (PRE); Gifberg (-DC), *Esterhuysen 21952* (BOL), *Van Wyk 3030* (JRAU, 1 & 2); Syferfontein, above Bo-Trekpoort, north-east of Rietvleiberg (-DC), *Oliver 3814* (PRE).

—**3119** (Calvinia): Lokenburg, 21 miles (33.6 km) south of Nieuwoudtville (-CA), *Story 4353* (PRE).

—**3218** (Clanwilliam): 24 km from Eland's Bay to Redelinghuys (-AD), *Stirton 6119* (PRE); between Bloufonteinkop and Platberg, north-east of Graafwater (-BA), *Boucher 3635* (NBG, PRE); 11 km from Clanwilliam on Pakhuis Pass (-BB), *Grobbelaar 2810* (PRE); Klein Kliphuis farm, Pakhuis Pass (-BB), *Schlieben & Van Bredá 9907* (NBG, PRE); Pakhuis Pass, near Leipoldt's grave (-BB), *Van Wyk 3125* (JRAU); Boekenberg (-BC), *Leighton 21599* (BOL); Skimmelberg (-BD), *Pillans 9162* (BOL); half way between Clanwilliam and Citrusdal (-BD), *Van Wyk 2440* (JRAU, 1 & 2); Piquetberg, 2.1 km along New Caledonia road (-DC), *Campbell & Van Wyk 39* (JRAU), *Campbell, Van Wyk & De Castro 120* (JRAU, NBG, PRE); Piquetberg, road to Gryskop, near T-junction at Moutonsvlei (-DC), *Goldblatt 7498* (PRE); top of Piquetberg (-DC), *Jones s.n. sub NBG 28505* (NBG).

—**3219** (Wupperthal): Pakhuis Pass (-AA), *Acocks 15033* (PRE), *Compton 4758, 9632* (NBG), *Galpin*

11092 (PRE), *Grobbelaar 2182* (PRE), *Levyns 3963* (BOL), *Salter 2760* (BOL), *Stirton 6406* (PRE); Pakhuis Pass, below Faith, Hope and Charity Peaks, below top of pass (-AA), *Campbell & Van Wyk 40* (JRAU); Pakhuis flats, northern Cedarberg (-AA), *Taylor 11097* (NBG); Heuningvlei extension (-AA), *Taylor 11258* (NBG); 13.6 km from Citrusdal-Clanwilliam road to Algeria (-AC), *Grobbelaar 2674* (PRE); 3 miles (4.8 km) south-east of Citrusdal (-AC), *Hanekom 1320* (PRE); Nieuwoudt's Pass (-AC), *Perry 3246* (NBG); Krokodam (-AC), *Stirton 6394* (PRE); Wupperthal (-AC), *Thode A1983* (PRE, 1 & 2); Cedarberg, plateau on Wolfberg (-AD), *C.M. van Wyk 1502* (NBG, PRE); Middelberg, Cedarberg (-CA), *Hubbard 354* (NBG); Porterville, half way up Dasklip Pass to Zuurvlakte, Groot Winterhoek State Forest (-CC), *Campbell & Van Wyk 111* (JRAU).

—3318 (Cape Town): Malmesbury district, commonage (-BC), *Goldblatt 3132* (PRE); Paarlberg (-DB), *Bolus 2749* (BOL), *Campbell & Van Wyk 26* (JRAU), *Compton 22943* (NBG), *Drège s.n. sub SAM 24381* (SAM), *Jordaan J1275* (NBG, PRE), *Kruger M180* (NBG, PRE), *MacOwan 53* (SAM); Wellington, Paradise (-DB?), *Britten 3152* (PRE, 1 & 2); Banghoek, Stellenbosch (-DD), *Compton 10351* (NBG), *Ihlenfeldt & Meyer 1741* (PRE), *Stokoe s.n. sub SAM 56856* (PRE, SAM); Brian Rycroft Nature Reserve, Dwarsriviershoek, Banghoek, Stellenbosch (-DD), *Rycroft 3307* (NBG); first waterfall, Jonkershoek (-DD), *Wicht 140* (PRE).

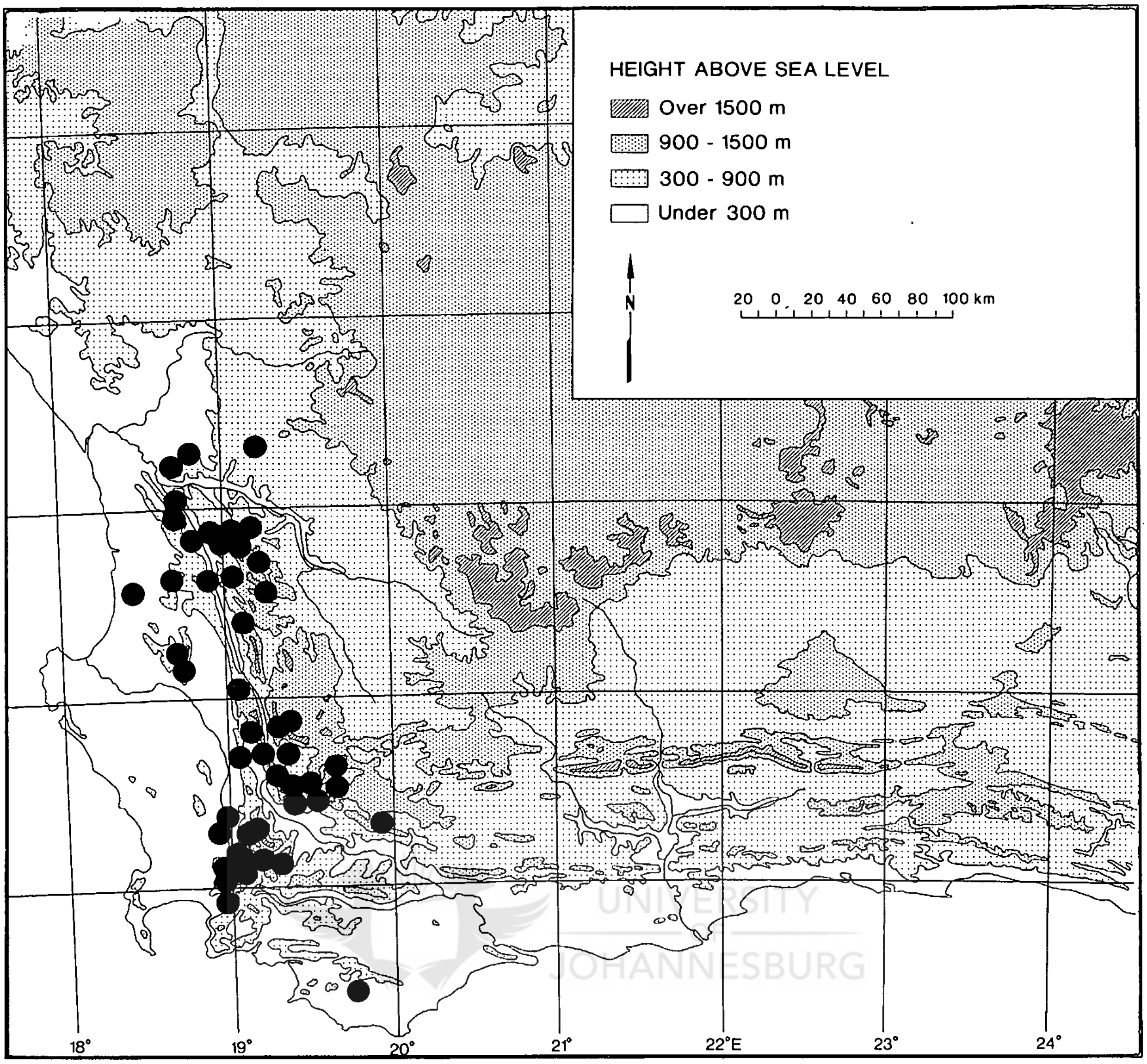
—3319 (Worcester): Tulbaghkloof (-AA), *Bolus 2749* (PRE, 1 & 2), *Davis s.n. sub SAM 65704* (SAM), *Ecklon & Zeyher 1200* (BOL, PRE, SAM); Gauwskloof, Koue Bokkeveld mountains, Ceres division (-AB), *Adamson D45* (PRE); Elandsfontein (-AB), *Van Bredá 341* (PRE) [atypical specimen]; Tulbagh waterfall (-AC), *Compton 12433* (NBG), *Herre 8914* (NBG), *Isaac s.n. sub BOL 32555* (BOL); Witsenberg, Tulbagh (-AC), *Ecklon & Zeyher 361* (SAM, 1 & 2); Tulbagh (-AC), *Marloth 2855, 4239* (PRE); Ceres, Mitchell's Pass (-AD), *Bolus s.n. sub BOL 32554, s.n. sub BOL 42836* (BOL), *Grobbelaar 1187* (PRE), *Walters 1064, s.n. sub NBG 70457* (NBG); Ceres upper valley (-AD), *Guthrie 2141* (NBG); Bokkerivier farm, Ceres (-AD), *Horrocks 122* (NBG); Witelskloof, Hex River mountains (-AD), *Stirton 8323* (PRE), *Walters 198* (NBG), *Watmough 844* (PRE); Ceres, Matroosberg, near Lakenvlei (-BC), *Bolus 4400* (NBG), *Marloth 4502a* (PRE), *Phillips 1928* (SAM); Hex River valley near de Dooms (-BC), *Bolus 11860, s.n. sub PRE 53084* (PRE), *Van Wyk 2907* (JRAU), *Walters 1339* (NBG); Hex River valley (-BC), *Tyson 677* (SAM), *764* (PRE, 1 & 2); national road, Orchard (-BC), *Walters 562, 1869* (NBG); Du Toitskloof, Paarl (-CA), *Johnson 263* (BOL, NBG), *Stokoe s.n. sub SAM 61417* (SAM); Baineskloof, Paarl district (-CA), *Schlechter s.n. sub TM*

1630 (PRE), *9194* (BOL); Sneeukop mountains, Wellington (-CA), *Thorne s.n. sub SAM 46496* (SAM); Brandwag (-CB), *Van Bredá 270* (PRE); Franschhoek, Paarl (-CC), *Compton 5808* (BOL), *MacOwan 2903* (PRE, SAM, 1 & 2), *Phillips 1101* (SAM); Bergrivierhoek, Paarl (-CC), *Compton 8330* (BOL, NBG); Franschhoek Pass, Paarl (-CC), *Compton 21906* (NBG); Paarl division, Wemmershoek Peak (-CC), *Esterhuysen 11273* (BOL); Stettynsberg (-CD), *Esterhuysen 11113* (BOL) [atypical specimen]; Louwshoek mountains (-CD), *Stokoe s.n. sub SAM 59609* (PRE, SAM); 17 km along national road from Worcester to De Doorns (-DA), *Campbell & Van Wyk 105* (JRAU); Haudesberg, Koo, Montagu (-DB), *Lewis 5700* (NBG).

—3418 (Simonstown): Caledon division, Somerset, Sneeukop (-BB), *Stokoe 6143* (BOL, 1 & 2).

—3419 (Caledon): Elim (-DB), *Bolus s.n. sub PRE 53089* (PRE).

Precise locality unknown: *Drège s.n. sub PRE 9400* (PRE); *Ecklon & Zeyher s.n. sub PRE 9952* (PRE); *Ecklon & Zeyher s.n. sub BOL 42845* (BOL); *Lehmann s.n. sub PRE 24280* (PRE); Clanwilliam district, *Liebenberg 4269* (NBG) [atypical specimen]; 'e Cap. b. spei', *LINN 895.4* (LINN) [microfiche only]; Cedarberg, *Pocock 313* (NBG); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16330 (ß), s.n. sub THUNB-UPS 16424* (UPS) [microfiche only]; Elandsfontein, *Van Bredá 341* (PRE); *Zeyher s.n. sub PRE 53082* (PRE).



Map 9.14 The known geographical distribution of *R. amplexicaulis.*

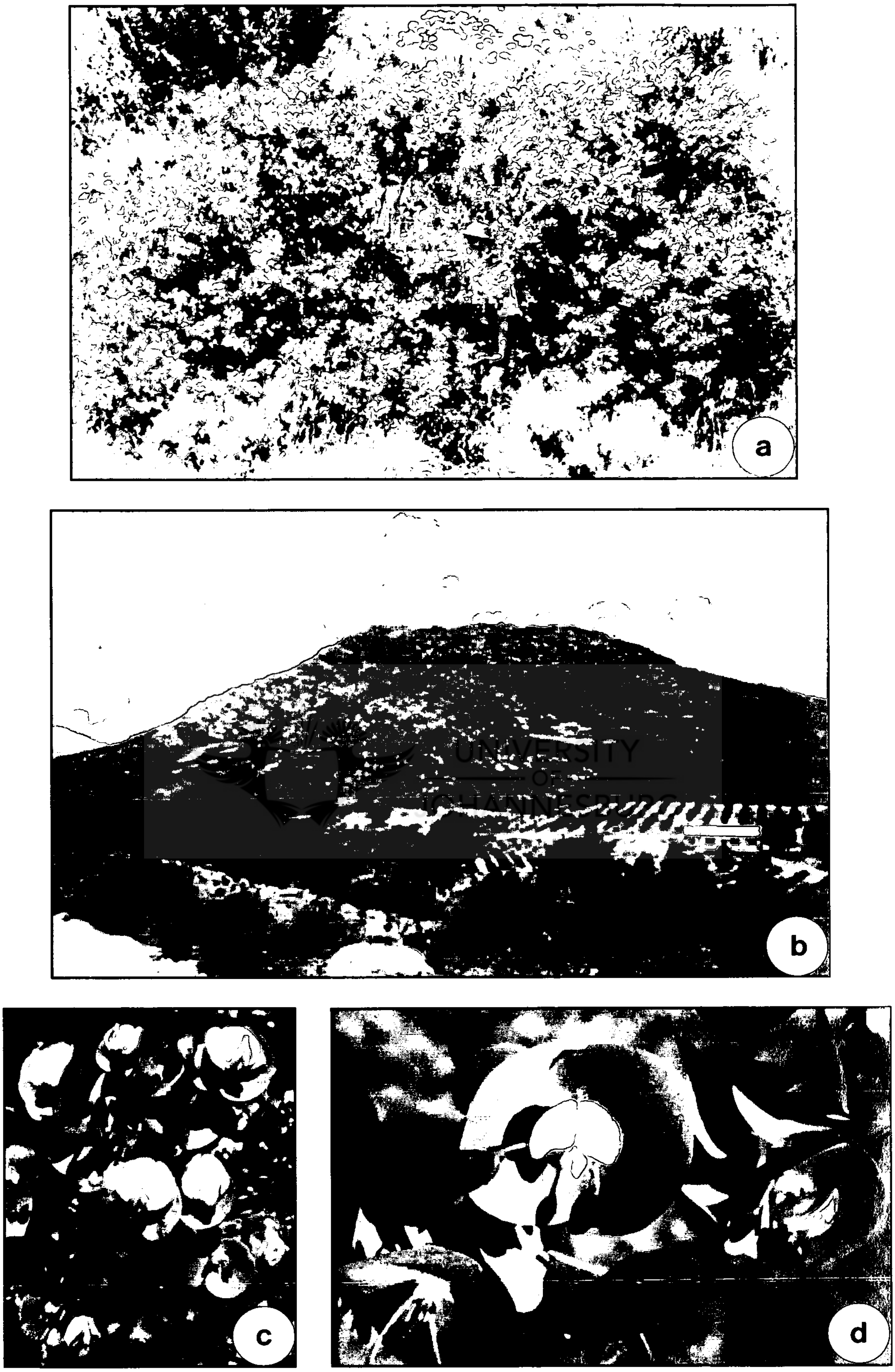


Figure 9.12 Habit, habitat, leaves, inflorescences and flowers of *R. amplexicaulis*: **a,** large, woody, much-branched shrub; **b,** the yellow shrubs on the hillside are *R. amplexicaulis*; **c,** cordate to reniform leaves subtending single-flowered inflorescences; **d,** lateral, dichotomously branching shoots, and flowers.

Section 2: Colobotropis E. Mey., Comm. Pl. Afr. Austr. 1(1): 13 (1836); Walp. in Linnaea 13: 464 (1839), Rep. Bot. Syst. 2: 579 (1843). Type species: *Pelecynthis rhomboidea* E. Mey. [now *Rafnia capensis* (L.) Schinz].

= Section *Hybotropis* E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (1836); Walp. in Linnaea 13: 465 (1839); E. Mey. ex Steud., Nom. Bot. 2: 780 (1841); Walp., Rep. Bot. Syst. 2: 580 (1843). Type species: *Pelecynthis gibba* E. Mey. [now *R. capensis* (L.) Schinz].

= Section *Caminotropis* E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (1836); Walp. in Linnaea 13: 465 (1839), Rep. Bot. Syst. 2: 580 (1843); Benth. in Hook., Lond. J. Bot. 2: 469 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 31 (1862); Schinz in Bull. Herb. Boiss. 2: 198 (1894). Type species: *Pelecynthis retroflexa* (Thunb.) E. Mey. [now *Rafnia capensis* (L.) Schinz].

= Section *Pelecynthis* (E. Mey.) Walp. in Linnaea 13: 464 (1839); Benth. in Hook., Lond. J. Bot. 2: 467 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 31 (1862); Schinz in Bull. Herb. Boiss. 2: 198 (1894). Type species: *Rafnia rhomboidea* Walp. [now *Rafnia capensis* (L.) Schinz].

Diagnostic characters. Section *Colobotropis* differs from section *Rafnia* in the lower lobes of the calyx which are fused slightly higher up to form a trifid lip, with the carinal lobe longer than the other lobes, the incurved edges of the standard petal, the absence of petal sculpturing on the wing petals (all except *R. diffusa* and sometimes *R. spicata*), which have a broad longitudinal central pocket, the obtuse to truncate or emarginate keel petals, which have a distinct basal, lateral, usually calloused pocket (spur), the staminal sheath widening towards the base, the shorter free parts of the stamens (fused higher up than in section *Rafnia*), the style which is strongly upcurved and shorter than the ovary and the pods which are stipitate except in *R. schlechteriana*, in which they are sessile.

Common to all taxa of section *Colobotropis* are the narrowly triangular to ± linear bracts and bracteoles, the latter of which are often minute or absent. The calyx lobes are triangular to narrowly triangular, ± as long as or shorter than the tube and the upper lobes are triangular, symmetrical (non-falcate) and usually broader than the others. The carinal anther is usually similar to the small, dorsifixed anthers, and sometimes even identical in size and shape. The pistil is stipitate, the ovary oblong and the stigma fibrillose and mostly capitate, or less often small. The seeds are broadly oblong to cordate-reniform and the seed sinus is mostly deep or less often shallow.

15. *Rafnia diffusa* Thunb., Gen. Nov. Pl.: 149 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 952 (1802); Thunb., Fl. Cap.: 565 (1823); DC., Prodr. 2: 119 (1825); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 160 (1836); Walp. in Linnaea 13: 465 (1839); Benth. in Hook., Lond. J. Bot. 2: 470 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 38 (1862); Schinz in Bull. Herb. Boiss. 2: 200 (1894). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16432* (UPS, microfiche!, lectotype, designated here). [Note: There is only a single specimen in the Thunberg herbarium.]

≡ *Pelecynthis diffusa* (Thunb.) E. Mey., Comm. Pl. Afr. Austr. 1(1): 15 (1836); Walp., Rep. Bot. Syst. 2: 580 (1843).

= *Pelecynthis retroflexa* sensu E. Mey., Comm. Pl. Afr. Austr. 1(1): 15 (1836); Walp., Rep. Bot. Syst. 2: 580 (1843).

= *Rafnia retroflexa* sensu Benth. in Hook., Lond. J. Bot. 2: 469 (1843).

Prostrate or decumbent, much-branched shrublet, up to 0.6 m tall. *Leaves* often penninerved; leaves on flowering branches variable, linear to narrowly lanceolate or elliptic or obovate, subopposite to opposite, 9–24 mm long, 4–15 mm wide, sometimes bright green, remaining so when dry; basal leaves obovate or ovate, to round, 13–35 mm long, ± 20 mm wide; coppice leaves broadly obovate or round, 20–47 mm long, 14–50 mm wide. *Inflorescences* single-flowered. *Flowers* small, 6–9 mm long. *Pedicel* 1–4 mm long. *Bract* narrowly triangular to linear, 0.3–0.8 (–1.2) mm long. *Bracteoles* subulate to minute, 0.1–0.3 mm long. *Calyx* lobes triangular to narrowly triangular, ± as long as or shorter than the tube, 0.5–2 mm long; upper lobes often broader than others; carinal lobe ± as long as or longer than others; tube 0.8–2 mm long. *Standard* suborbicular, round or rarely ovate, sometimes folded in along lower half of edges, 6–9 mm long, 5–10 mm wide, with or without an apical cusp; claw 1–3 mm long. *Wings* oblong to narrowly oblong, ± as long as keel, 5–8 mm long, 2–3 mm wide, with 4–6 rows of sculpturing invariably present; apex obtuse; claw minute, not broadly attached to blade, 1–2 mm long [form 3: 3–4 mm long]. *Keel* variable, rostrate or obtuse or truncate [form 3: keel rostrate, with upper margin concave, apex upcurved; form 6: ± obtuse, upcurved and ± sqaure, 5–7 mm long, 3–4 mm wide]; upper margin straight; claw ± 2 mm long [form 3: 3–5 mm long]. *Stamens* usually monadelphous or rarely diadelphous; staminal sheath straight, not widened towards base. *Pistil* with style sometimes incurved towards apex; ovules 2–4; stigma small, fibrillose. *Pods* oblong, 9–12 mm long, 3–4 mm wide; stipe 5–10 mm long; upper margin ± straight; lower margin proximally convex, upcurved towards stipe. *Seeds* broadly reniform to narrowly oblong, 2–4 mm long, 1–3 mm wide; sinus shallow; testa rough.

Diagnostic characters. *R. diffusa* (see Figure 9.13) is distinguished from the other species of section *Colobotropis* by the coppice leaves which are different in size and shape from the upper leaves (see Figure 9.13c), the very small flowers (similar in size to *R. spicata* and some forms of *R. capensis* subsp. *capensis*) and round standard blade (see Figure 9.13b) and the invariable presence of wing sculpturing. It also differs from *R. capensis* in the softer-textured flowers (the flowers are usually tougher-textured in *R. capensis*), the keel shape which is usually obtuse or rarely ± truncate (distinctly truncate in *R. capensis*), the very small calyx which is usually much shorter than the corolla (calyx larger in *R. capensis* and not as much shorter than the corolla) and the very variable leaf shape (more variable than in *R. capensis*).

Distribution and habitat. *R. diffusa* occurs from Vanrhynsdorp in the north to the Malmesbury district in the south. Only *R. diffusa* and *R. angulata* subsp. *angulata* occur in the Malmesbury area (see Maps 9.2 & 9.15). *R. diffusa* occurs in montane fynbos or sandveld and grows on deep, dry sand flats or low or high mountain slopes and is associated with limestone outcrops, loamy soil, TMS soil or hard karoo soil.

Regional variation. *R. diffusa* is rather variable, and six geographical forms are distinguished. The northern, Wupperthal and Pakhuis Pass forms are typical forms and relatively similar, but separated geographically. The Citrusdal form differs from the other forms in the narrower leaves, the usually broader, triangular calyx lobes which are often shorter than the tube (lobes mostly narrower, longer and about as long as or slightly shorter than the tube in the other forms), the smaller, distinctly rostrate keel (the keel is obtuse to truncate in the other forms) and the longer wing and keel claws. This form occurs in Citrusdal and in the Clanwilliam area, including Keerom, Grasruggens and Elandskloof. The Piquetberg form has narrower leaves which are elliptic or lanceolate or linear, not obovate or round as in the typical forms. The Malmesbury form differs from the other forms in the often densely leafy appearance and the shape of the keel petal, in which the raised, truncate apex appears square.

Specimens examined.

—3118 (Vanrhynsdorp): Sandkraal (-DA), *Compton 20815* (NBG); 25 miles (40 km) from Clanwilliam to Klawer (-DC), *Grobbelaar 1128* (PRE); Gifberg (-DC), *Hugo 709* (NBG, PRE), *Phillips 7483* (NBG, PRE), *7490* (SAM), *Stirton 5962* (PRE), *Van Wyk 2881* (JRAU, 1 & 2), *Zietsman & Zietsman 1204* (PRE); Clanwilliam division, Nardouw Pass (-DC), *Stokoe s.n. sub SAM 61409* (SAM, 1 & 2).

—3119 (Calvinia): Arendskraal farm, near Nieuwoudtville (-AC), *Barker 9776* (NBG); between Nieuwoudtville and escarpment, along Arendskraal road (-AC), *Campbell & Van Wyk 44* (JRAU); Watermeyer farm, near Nieuwoudtville (-AC), *Theiler 76* (PRE); Vanrhynsdorp, Glenridge farm, 3 miles (4.8 km) from Nieuwoudtville (-AC), *Van Bredá 1012* (PRE); Lokenburg, 21 miles (33.6 km) south of Nieuwoudtville (-CA), *Acocks 17080, 17276, 17453* (PRE), *Story 4333, 4379, 4407*, 1 & 2 (PRE); Lokenburg, ridges west of *Themeda* valley (-CA), *Leistner 426* (PRE).

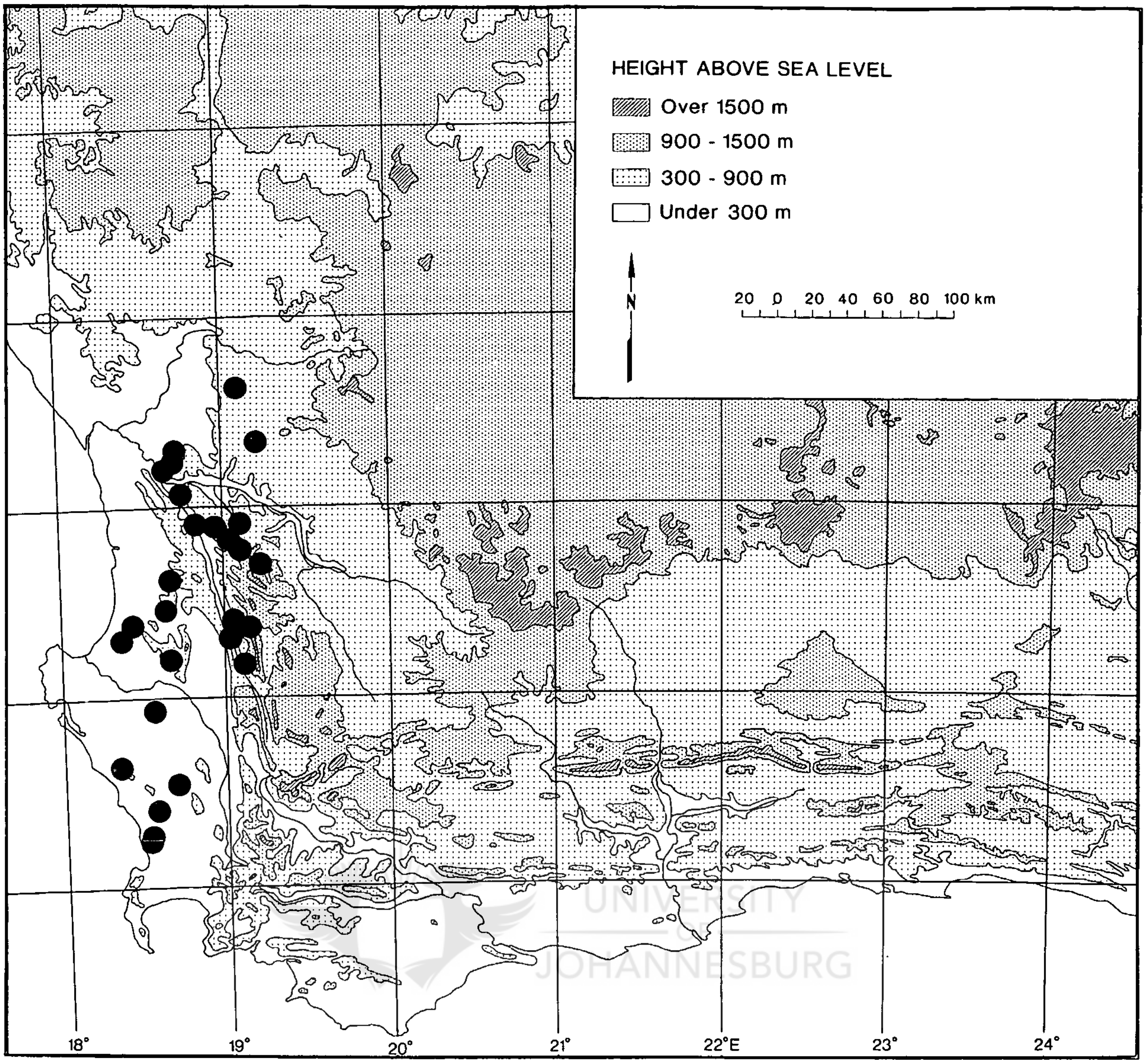
—3218 (Clanwilliam): Olifantsrivier valley, national road north of Clanwilliam (-BB), *Barker 10332* (NBG, 1 & 2); Pakhuis Pass, 1 km below Picnic Rocks (-BB), *Campbell & Van Wyk 41* (JRAU, 1 & 2); Bodwater, west of Clanwilliam (-BB?), *Acocks 15170* (PRE); Olifantsrivier valley (-BB?), *Leipoldt 17113* (BOL); Cedarberg, Pakhuis mountains near Pilaarsberg (-BB), *Taylor 10754* (NBG); Boekenberg (-BC), *Leighton 21600* (BOL); Piquetberg, 8 miles (12.8 km) north-west of Aurora turning (-CB), *Acocks 19805* (PRE); Papkuilsfontein farm, north of Kapteinskloof (-CB), *Stirton & Zantovska 11412* (NBG, 1 & 2); Piquetberg district, 11.7 km south of Redelinghuys (-DA), *Acocks 24444* (PRE); Piquetberg, eastern foot of mountain near northern end (-DA), *Van Wyk 3508* (JRAU, 1 & 2); Piquetberg (-DC?), *Maguire 1151, 1194*, 1 & 2 (NBG).

—3219 (Wupperthal): Clanwilliam division, Cedarberg, Krakadouw (-AA), *Bodkin s.n. sub NBG 14325* (NBG), *Stokoe s.n. sub SAM 55913* (SAM); Clanwilliam division, Pakhuis Pass (-AA), *Bolus 3269* (SAM), *Bond 606* (NBG), *Compton 9608* (NBG), *Goldblatt 3081* (NBG), *Leipoldt s.n. sub BOL 32560* (BOL), *Levyns 7210* (BOL), *Lewis s.n. sub BOL 50548* (BOL), *Stirton 10181* (NBG); Clanwilliam, Pakhuis Pass, below Faith, Hope and Charity Peaks (-AA), *Campbell & Van Wyk 43* (JRAU), *124* (BOL, JRAU, K, MO, NBG, PRE); Clanwilliam, Heuningvlei (-AA), *Leipoldt 537* (BOL, NBG, PRE), *Pocock 585* (NBG); Pakhuis flats, northern Cedarberg (-AA), *Taylor 11098* (NBG); Wupperthal (-AC), *Taylor 11145* (NBG, PRE); Citrusdal, 12.3 km along road from Citrusdal to The Baths (-CA), *Campbell & Van Wyk 140* (NBG); Clanwilliam division, Elandskloof (-CA), *Compton 16152* (NBG), *Stokoe s.n. sub SAM 55790* (NBG, PRE, SAM); Cedarberg, north-east of Citrusdal (-CA), *Goldblatt 7263* (NBG); Clanwilliam, near waterfall, between Citrusdal and Elandskloof (-CA), *Stokoe 7830* (NBG, PRE); Clanwilliam, Keerom flats (-CC), *Esterhuysen 17940* (BOL, PRE); Clanwilliam division, roadside between Keerom and Citrusdal (-CC), *Esterhuysen 17945* (BOL); Clanwilliam division, Grasruggens mountains (-CC), *Pillans 8726* (BOL, 1 & 2, PRE).

—3318 (Cape Town): Koperfontein, near Hopefield (-AB), *Bachmann 5976* (BOL); Malmesbury, Darling Flora Reserve (-AD), *Winkler 169* (NBG, 1 & 2); Malmesbury, opposite Abbotsdale (-BC), *Goldblatt 5111* (PRE); 5–7 miles (8–11.2 km) from Malmesbury on Moorreesburg road (-BC), *Van Rensburg 171* (NBG); 45 km from Cape Town to Malmesbury (-DA), *Grobbelaar 2889* (PRE); Malmesbury, beyond Vissershok (-DA), *Leighton 698* (BOL); Koeberg (-DA), *Pillans s.n. sub BOL 18797* (BOL); near Vissershok (-DC), *Compton 16367* (NBG).

Precise locality unknown: Swartland, *Pappe 357* (SAM, 1 & 2); Caledon division, Riversonderend mountains, *Stokoe 7371* (BOL); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16432* (UPS) [microfiche only]; *Zeyher 357* (PRE).

Doubtful locality: Laingsburg division, Koudeberg *Thode A1985* (PRE, 1 & 2).



Map 9.15 The known geographical distribution of *R. diffusa*.

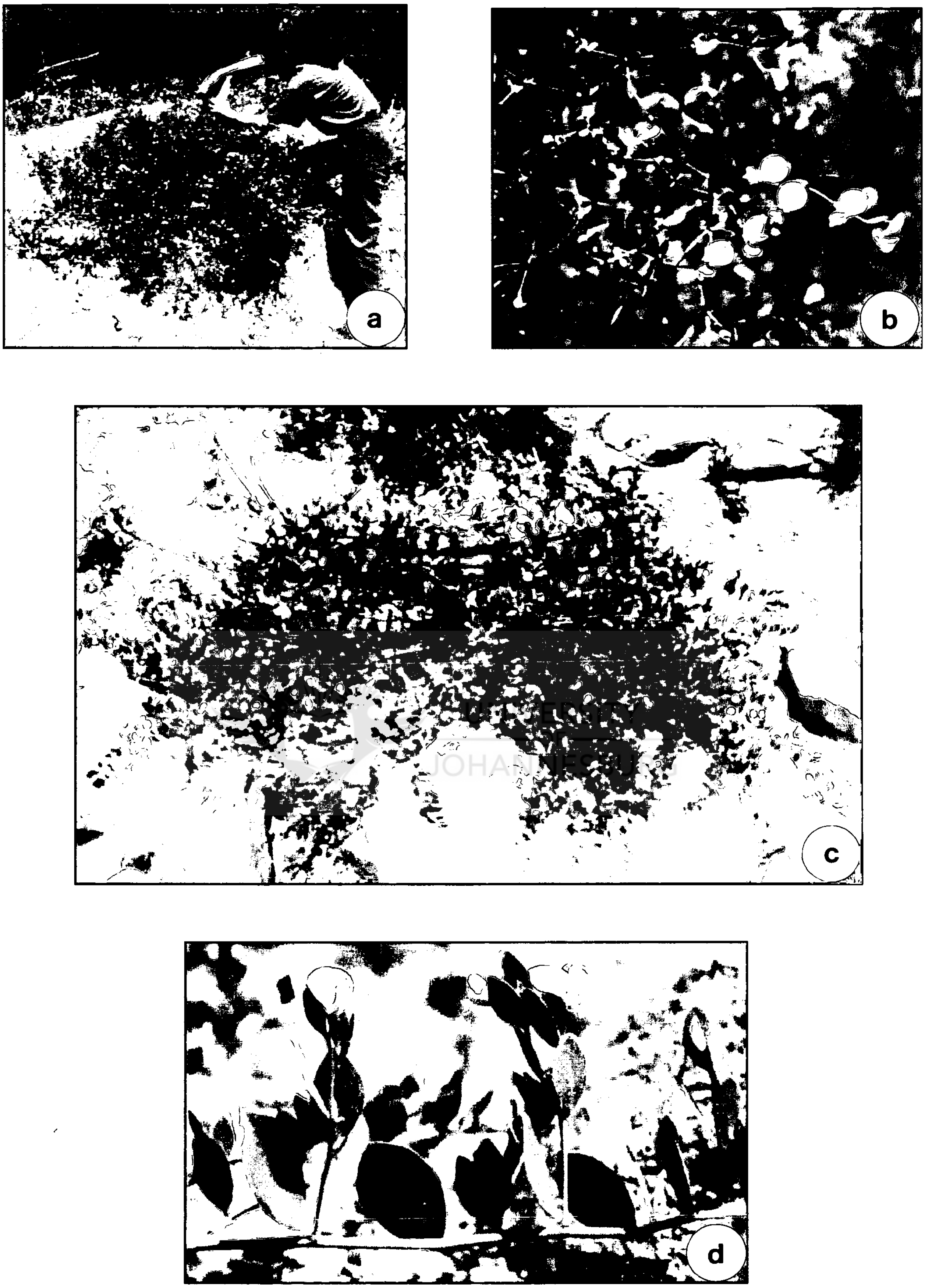


Figure 9.13 Habit, leaves, inflorescences, flowers and pods of *R. diffusa*: **a,** diffuse, much-branched shrublet (Citrusdal form); **b,** single-flowered inflorescences, small flowers with round standard petals and small, stipitate pods (Citrusdal form); **c,** typical form of *R. diffusa*, and note the larger basal leaves and smaller upper leaves; **d,** glaucous leaves and small flowers.

16. ***Rafnia spicata*** Thunb., Gen. Nov. Pl.: 147 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 564 (1823); DC., Prodr. 2: 119 (1825); E. Mey. in Linnaea 7: 148 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (1836); Harv. in Harv. & Sond., Fl. Cap. 2: 38 (1862). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16441* (UPS, microfiche!, lectotype, designated here).

Procumbent, clump-forming shrublet, much-branched from base, up to 0.3 m tall, 1.5 m wide. *Leaves* narrowly lanceolate to lanceolate, narrowly obovate to ovate, bright green, often remaining so when dry; leaves on flowering branches subopposite to opposite, (11–) 17–26 mm long, 2–6 (–10) mm wide; basal leaves 18–40 mm long, 4–18 mm wide. *Inflorescences* single-flowered, aggregated into spike-like pseudoracemes. *Flowers* very small, 6–8 mm long. *Pedicel* 2–3 mm long. *Bract* linear to narrowly triangular, 0.4–0.6 (–0.9) mm long. *Bracteoles* minute to subulate, 0.2–0.3 mm long. *Calyx* lobes triangular to narrowly triangular, ± as long as or shorter than tube, 1–2 mm long; upper lobes broader than others; tube 1–2 mm long. *Standard* broadly elliptic to suborbicular, lower half of edges often foled in, 5–7 mm long and wide, without an apical cusp; claw 2–3 mm long. *Wings* oblong, 5–7 mm long, 2–3 mm wide, sometimes with 2–4 rows of sculpturing; apex obtuse; claw not broadly attached to blade, 2–3 mm long. *Keel* variable, ± acute to almost rostrate or obtuse or sometimes slightly asymmetrically truncate or emarginate, 5–6 mm long, 2–3 mm wide; claw 2–3 mm long. *Stamens* monadelphous, with sheath straight, not widened towards base. *Pistil* with the stigma small, fibrillose; ovules 2. *Pods* ± narrowly oblong, 10–15 mm long, 3–4 mm wide; stipe 4–6 mm long; upper margin straight; lower margin straight, proximally sharply tapering into the stipe. *Seeds* oblong to broadly reniform, almost oblique-cordiform, 2–3 mm long, 1–2 mm wide; sinus shallow; testa rough.

Diagnostic characters. *R. spicata* (Figure 9.14) is similar to *R. capensis* subsp. *capensis* (particularly the Ceres form, from which it is often difficult to distinguish), but differs in the inflorescences which are often aggregated into spike-like pseudoracemes (inflorescences not aggregated in subsp. *capensis*)(Figure 9.14b), the smaller, softer-textured flowers and the wing petals which may or may not be sculptured (sculpturing invariably absent in subsp. *capensis*). It also differs from *R. diffusa* in the smaller, procumbent, clump-forming habit (diffuse and much-branched in *R. diffusa*) (Figure 9.14a).

Distribution and habitat. *R. spicata* is limited to the Cedarberg area (Map 9.16), where it occurs in dry fynbos on sand dunes, sand flats or mountain slopes and is often associated with TMS-derived soils, shale soils or shallow, rocky sand.

Specimens examined.

—**3218** (Clanwilliam): Clanwilliam (-BB), *Leipoldt s.n. sub SAM 31329* (SAM); Piquetberg (-DC?), *Esterhuysen 16105* (BOL).

—**3219** (Wupperthal): Clanwilliam, Heuningvlei (-AA), *Stokoe s.n. sub SAM 55788* (SAM); Cedarberg Forest Reserve, Rondeheuwel, near Driehoek (-AC), *Emdon 203* (NBG); Cedarberg Forest Reserve, Sneeuberg (-AC), *Kruger KR971* (NBG, PRE), *Pocock 350* (NBG), *Taylor 6136, 11295* (NBG); Cedarberg, Nieuwoudt's Pass (-AC), *Pocock 794* (NBG); between Hartseer and Crystal Pool, Cedarberg (-AC), *Taylor 7451* (PRE); Wupperthal, Clanwilliam (-AC), *Thode A1984* (PRE, 1 & 2); Cedarberg Forest Station, Hoogvertoon, Algeria (-AC), *Viviers 13* (PRE); Wolfberg (-AD), *Esterhuysen 22458* (BOL); Middelberg plateau (-CA), *Compton 12729* (NBG), *Esterhuysen 7197* (BOL); Middelberg, Ceres (-CA), *Hanekom 1259* (PRE), *Van Wyk 2308* (JRAU, 1 & 2); neck between Apollo and Murraysberg (-CA), *Taylor 11405* (NBG); Gideonskop, north-western border of Ceres division (-CB), *Oliver 9042* (NBG); Hondverbrand ridge (-CB), *Taylor 11627* (NBG, PRE); Die Possie, Waboomsrivier, Koue Bokkeveld mountains (-CC), *Hanekom 2541* (PRE); Skurweberge, Ceres road, 18.2 km from Donkerbos turn-off at Wydekloof to Ceres (-CD), *Campbell & Van Wyk 127, 141* (JRAU, K, NBG, PRE); Rietrivier (-DC), *Bean & Viviers 1961*

(BOL); Swartruggens, 21 km along Swartrug division road to Ceres-Karoo (-DC), *Campbell & Van Wyk 142* (JRAU, K, NBG, PRE); Swartruggens, Ceres district, 5.4 miles (8.6 km) along farm road north from summit of Katbakkies Pass (-DC), *Taylor 6087* (NBG).

—**3319** (Worcester): Groot Winterhoek, path ot Perdevlei (-AA), *Low 1254* (NBG); Visgat, between Skurweberge and Groot Winterhoek mountains (-AA), *Stokoe s.n. sub SAM 63834* (SAM); Skurweberge, near Ceres (-AB), *Bolus 7337* (BOL, PRE, 1 & 2), *Hutchinson 634* (BOL, PRE), *Kolbe s.n. sub BOL 43069* (BOL), *Levyns 1079* (BOL), *s.n. sub SAM 31650* (SAM); Baviaansberg, Ceres (-BA), *Stokoe s.n. sub SAM 52723* (SAM).

Precise locality unknown: Ceres Flower Show, *Compton 4406* (BOL); *Marloth 6263* (PRE); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16441* (UPS) [microfiche only].

Doubtful locality: Heuningklip, Botrivier, Caledon, *Taylor 4068a* (NBG).

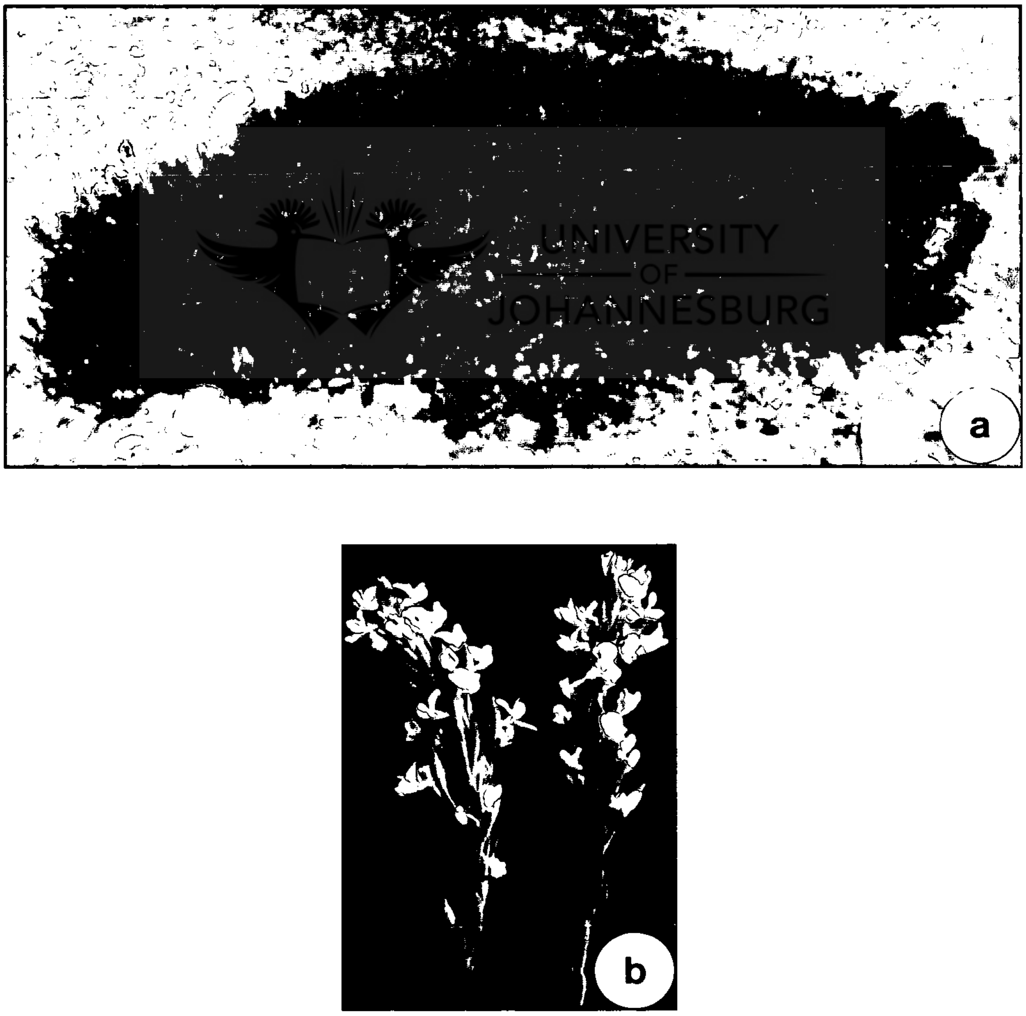
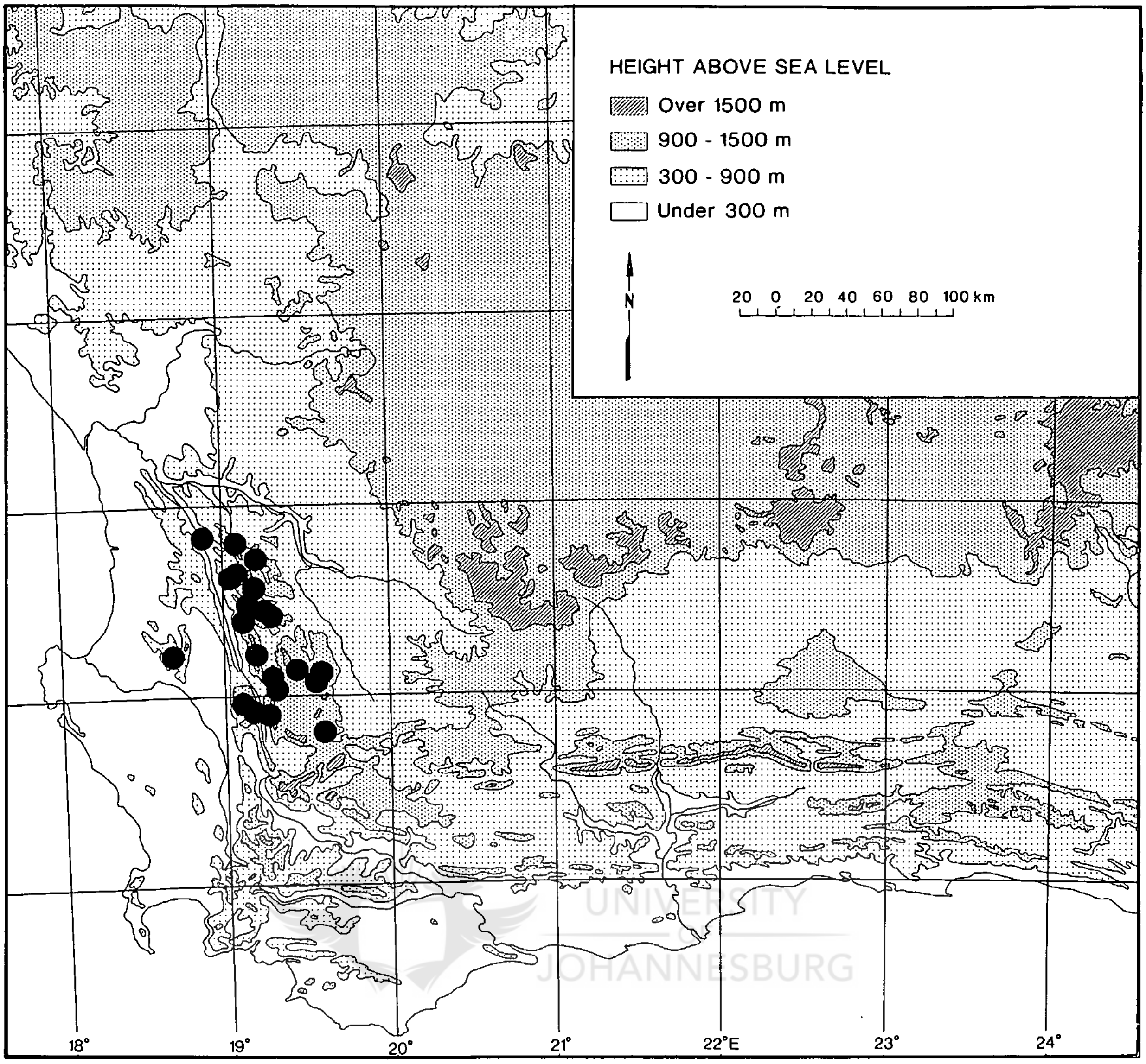


Figure 9.14 Habit, inflorescences and flowers of *R. spicata*: **a,** procumbent, clump-forming shrublet; **b,** single-flowered inflorescences (flowers small) are aggregated into spike-like pseudoracemes.



Map 9.16 The known geographical distribution of *R. spicata*.

17. *Rafnia schlechteriana* Schinz in Bull. Herb. Boiss. 2: 197 (1894). Type: South Africa, Western Cape Province, Cape Town, Table Mountain, *Schlechter 73* (P, photo!).

Erect, much-branched, virgate suffrutex or shrublet, up to 0.6 m tall. *Leaves* ovate or round or obovate or broadly elliptic, sometimes acuminate, often penninerved; base often round; leaves on flowering branches invariably opposite, 31–45 mm long, (12–) 16–34 mm wide; basal leaves 46–76 mm long, 29–60 mm wide. *Inflorescences* single-flowered, aggregated into large, conical pseudoracemes. *Flowers* 11–14 (–17) mm long. *Pedicel* 5–7 mm long. *Bract* linear to narrowly triangular, 1–2 mm long. *Bracteoles* ± 0.5 mm long. *Calyx* lobes triangular to narrowly triangular, ± as long as or shorter than tube, 3–6 mm long; upper lobes broader than others; tube 3–4 mm long. *Standard* oblong, 8–12 mm long and wide, with or without an apical cusp; claw 3–5 mm long. *Wings* oblong, 8–11 mm long, 5–6 mm wide; apex obtuse; claw broadly attached to blade, 4–5 mm long. *Keel* symmetrically truncate, without a broad lobe below apex, 7–10 mm long, 4–6 mm wide; claw 4–5 mm long. *Stamens* monadelphous. *Pistil* short-stipitate; ovary ± oblong to narrowly ovate; style not incurved towards apex; stigma small, fibrillose; ovules 2. *Pods* sessile, broadly obliquely lanceolate, 30–40 mm long, 14–18 mm wide; upper margin slightly asymmetrically convex, broadly winged; wing 4–5 mm wide; lower margin straight, proximally convex, very broad. *Seeds* cordate-reniform or broadly oblong to oblique-cordiform, 4–5 mm long and wide; sinus shallow; testa rough.

Diagnostic characters. R. schlechteriana (see Figure 9.15) is distinguished from the other species of *Rafnia* by the leaves on the flowering branches which are invariably opposite, the large basal leaves which are distinctly cartilaginous and much larger than the upper leaves (see Figure 9.15a), which may be acuminate, the inflorescences which are secondarily aggregated into large, conical pseudoracemes (see Figure 9.15a & b), the symmetrically truncate keel petal (as in *R. capensis* subsp. *pedicellata*) and the broad, obliquely triangular, sessile pod which is broadly winged on the upper suture. *R. schlechteriana* and *R. ovata* are easily confused on herbarium sheets, but the flowers differ markedly.

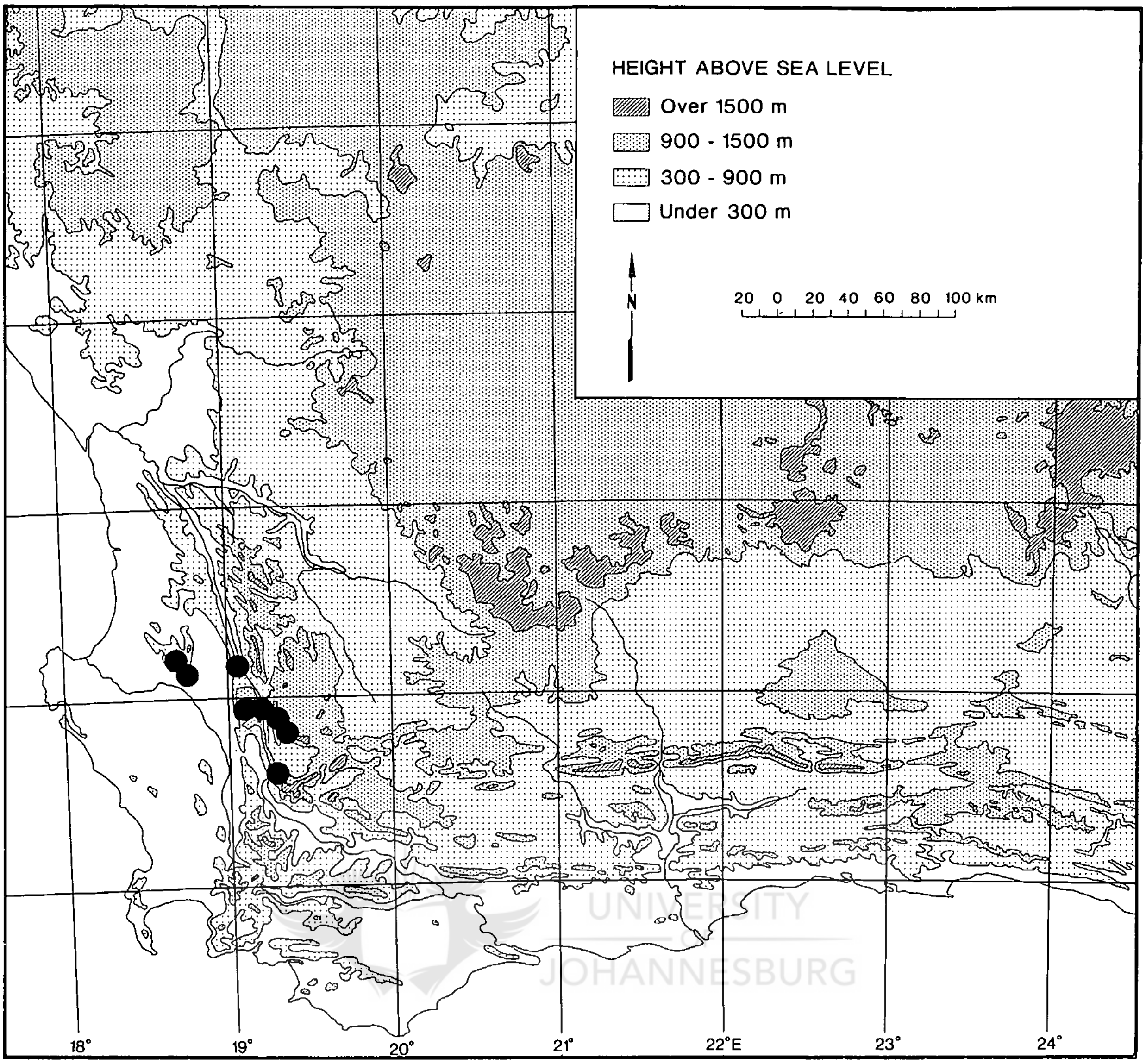
Distribution and habitat. *R. schlechteriana* occurs on the Piquetberg and in the Olifantsrivier mountains, south of the Cedarberg (Map 9.17), where it grows in montane fynbos, on foothills or high slopes, in TMS soil.

Specimens examined.

—3218 (Clanwilliam): Piquetberg (-DC?), *Bolus 13535* (BOL), *Compton 22961* (NBG), *Goldblatt s.n. sub NBG 97432* (NBG), *Guthrie 2577* (NBG); Versveld Pass, Piquetberg (-DC), *Campbell & Van Wyk 33* (JRAU, NBG), *117* (BOL, JRAU, K, NBG, PRE), *Grobbelaar 2803* (PRE), *Van Wyk 3228* (JRAU); Moutonsvlei, Piquetberg (-DC), *Pillans 7225* (BOL).

—3219 (Wupperthal): Cardouw Pass, Clanwilliam (-CC), *Barker 8125* (NBG), *Lewis 3585* (SAM); Clanwilliam, Keerom hills at eastern foot of Vier-en-Twintigriviers mountains (-CC), *Esterhuysen 17875* (BOL, NBG); Grasruggens, Olifantsrivier mountains, Porterville (-CC), *Van Zyl 3095* (NBG, PRE).

—3319 (Worcester): Ceres division, Olifantsrivier mountains, ridge south of Groen (-AA), *Esterhuysen 13421* (BOL); Ceres division, between Rosendalfontein and Visgat (-AA), *Pillans 9651* (BOL, PRE); Ceres division, Visgat, between Skurweberge and Groot Winterhoek mountains (-AA), *Stokoe s.n. sub SAM 63835* (SAM); Skurweberge near Gydo (-AB), *Bolus 7569* (BOL); Hansiesberg, Ceres (-AB), *Compton 16672* (NBG), *Oliver 6042* (NBG); Ceres division, Skurweberge (-AB), *Lewis 906* (SAM); Ceres district, Mitchell's Pass (-AD), *Schutte & Van Wyk 555* (JRAU), *Thorne s.n. sub SAM 51227* (SAM).



Map 9.17 The known geographical distribution of *R. schlechteriana*.

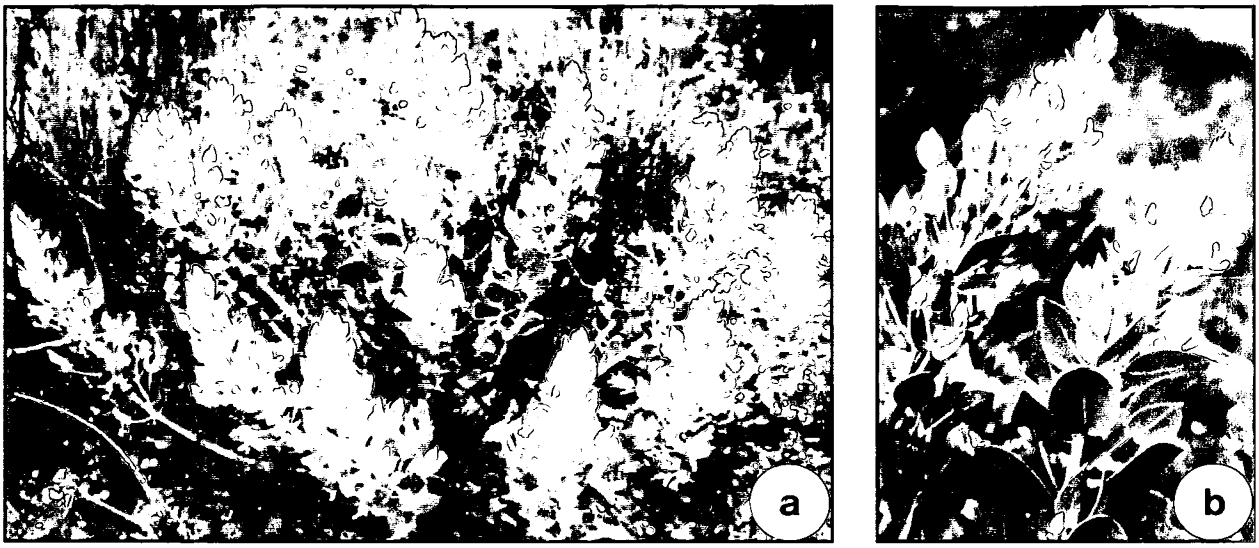


Figure 9.15 Habit, leaves, inflorescences and flowers of *R. schlechteriana*: **a,** erect, virgate suffrutex, with large basal leaves which are much larger than the upper leaves; **b,** single-flowered inflorescences which are secondarily aggregated into large, conical pseudoracemes, and note the flowers fading orange.

18. *Rafnia capensis* (L.) Schinz in Bull. Herb Boiss. 2: 199 (1894); Druce in Rep. Bot. Exch. Cl. Brit. Isles, 1913: 422 (1914), nom. superfl. Type: South Africa, Western Cape Province, Cape Peninsula, Cape of Good Hope Nature Reserve, *c.* 0.9 km from entrance gate on gravel slope along roadside near resting place, *Campbell & Van Wyk 151* (K!, MO!, NBG!, PRE!, neotype, designated here).

≡ *Spartium capense* L., Sp. Pl. 2: 995 (1753), Pl. Rar. Afr.: 14 (1760) ('*Spatium*').

= *Liparia opposita* L., Mant. Pl. Alt.: 269 (1771) nom. illeg. superfl. [Note: Linnaeus illegitimately renamed *S. capense* to *Liparia opposita* in Mant. Pl. Alt. in 1771.]

≡ *Rafnia opposita* (L.) Thunb., Gen. Nov. Pl.: 146 (1800a) nom. illeg., Prodr. Pl. Cap.: 123 (1800b) excluding synonyms; Willd., Sp. Pl. 3: 950 (1802); Thunb., Fl. Cap.: 564 (1823); DC., Prodr. 2: 119 (1825) excluding synonyms; E. Mey. in Linnaea 7: 148 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (1836); Walp. in Linnaea 13: 465 (1839); Benth. in Hook., Lond. J. Bot. 2: 467 (1843); Harv. in Harv. & Sond., Fl. Cap. 2: 36 (1862).

≡ *Pelecynthis opposita* (L.) E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (1836); Walp., Rep. Bot. Syst. 2: 579 (1843); Schinz in Bull. Herb. Boiss. 2: 200 (1894).

= *Crotalaria opposita* sensu L. f., Suppl. Pl. Syst. Veg.: 322 (1782).

[Note: The original material of *Spartium capense* is the plant currently known as *Rafnia angulata* (*LINN 895.22*, right hand specimen), *LINN 895.23* (LINN), *LINN 297.19* (S) and *Anon. s.n. sub Herb. Burman* (G). We have proposed the conservation of the current use of the name *R. capensis* by also proposing the conservation of a type chosen to fix the current application of the name (Campbell *et al.*, submitted for publication in Taxon).]

= *Cytisus capense* Berg., Pl. Cap.: 217 (1767). Type: South Africa, 'e Cap. b. spei', *Grubb s.n. sub SBT* (SBT!, lectotype, designated here). [Note: Bergius annotated the only available specimen "*Cytisus mihi capensis*" in his own hand.]

= *Rafnia retroflexa* Thunb., Gen. Nov. Pl.: 148 (1800a) nom. nov., Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 951 (1802); Thunb., Fl. Cap.: 565 (1823); DC., Prodr. 2: 119 (1825); Walp. in Linnaea 13: 465 (1839); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845); Harv. in Harv. & Sond., Fl. Cap. 2: 37 (1862); Schinz in Bull. Herb. Boiss. 2: 199 (1894). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16439* (UPS, microfiche!, lectotype, designated here). [Note: We choose this specimen because it is the only one available in the Thunberg Herbarium.]

= *Rafnia pauciflora* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 162 (1836); Walp. in Linnaea 13: 465 (1839); Benth. in Hook., Lond. J. Bot. 2: 470 (1843); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845). Type: South Africa, Western Cape Province, in lapidosis (altit. III) laterum montium vallis "Tulbagh" prope "Waterfall" (Worcester), *Ecklon & Zeyher 1195* (SAM!, specimen on far right, lectotype, designated here).

= *Pelecynthis corymbosa* E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (1836); Walp., Rep. Bot. Syst. 2: 579 (1843). Type not seen.

= *Rafnia corymbosa* (E. Mey.) Walp. in Linnaea 13: 464 (1839); Benth. in Hook., Lond. J. Bot. 2: 468 (1843). Type not seen.

Much-branched woody shrub, up to 1 m tall or an erect or procumbent shrublet, up to 0.4 m tall or a prostrate, decumbent shrublet, up to 0.3 m tall. *Leaves* variable, linear or lanceolate or elliptic to broadly elliptic to transverse-elliptic, or narrowly to broadly obovate to transverse obovate or ± angular-obovate or ovate or round, often penninerved; leaves on flowering branches invariably alternate or subopposite to opposite or invariably opposite, 9–42 mm long, 1–19 mm wide; basal leaves 9–60 mm long, 1–34 mm wide. *Inflorescences* single-, few- or multi-flowered, 2–45 flowers. *Flowers* 7–14 mm long. *Pedicel* 2–18 mm long . *Bract* narrowly triangular to linear, 0.3–3 mm long. *Bracteoles* subulate or linear to narrowly triangular or minute or absent, 0.1–0.7 mm long. *Calyx* lobes triangular to narrowly triangular or upper and lateral lobes sometimes slightly falcate, shorter than or ± as long as or longer than or much longer than tube, 1–9 mm long; upper lobes broader than others; tube 1–4 mm long. *Standard* oblong or elliptic to broadly elliptic or ovate to broadly ovate, 5–13 mm long, 5–12 mm wide, with or without an apical cusp; claw 1–4 mm long. *Wings* oblong or obovate or oblong-obovate or oblong-elliptic or suborbicular, shorter than, ± as long as or longer than keel, 4–11 mm long, 2–5 mm wide; apex obtuse to obovate; claw often broadly attached to blade, 2–6 mm long. *Keel* obtuse or almost rostrate, slightly lobed below apex or symmetrically truncate without a broad lobe below apex or asymmetrically truncate to emarginate with a broad lobe below apex, 5–9 mm long, 3–5 mm wide; claw 2–5 mm long. *Stamens* usually monadelphous or rarely diadelphous. *Pistil* with style incurved or not incurved towards apex; ovules 2–4; stigma small or capitate, fibrillose. *Pods* oblong to broadly oblong or ± obliquely lanceolate, 12–40 mm long, 4–12 mm wide; stipe 2–16 mm long; upper margin straight or slightly convex; lower margin straight, proximally convex, upcurved towards stipe. *Seeds* oblong or oblong-cordiform or reniform to broadly reniform or oblong-reniform or cordate-reniform or suborbicular, 3–5 mm long, 2–4 mm wide; sinus deep; testa rough.

Key to the subspecies of *R. capensis*

1a. Inflorescences single-flowered 2
1b. Inflorescences few- or multi-flowered 3
2a. Calyx lobes shorter than that part of the corolla exceeding the calyx............. 4
2b. Calyx lobes much longer than that part of the corolla exceeding the calyx, calyx lobes long, thin and greatly reflexed .... **subsp. *calycina***
3a. Inflorescences 1–9-flowered 5
3b. Inflorescences 20–45-flowered, in dense, terminal racemes, pedicels elongate .... **subsp. *pedicellata***
4a. Keel truncate to emarginate 6
4b. Keel slightly lobed below the apex .... **subsp. *carinata***
5a. Small, prostrate shrublet, leaves sometimes cuneate, inflorescences 4–8-

flowered .... **subsp. *elsieae***

5b. Erect or woody shrub, or procumbent perennial, inflorescences mostly 2–4-flowered .... **subsp. *ovata***

6a. Stigma mostly small, robust shrub or clump-forming perennial, leaves on flowering branches subopposite to opposite, often linear or lanceolate, wing claws not broadly attached to wing blade .... **subsp. *capensis***

6b. Stigma capitate, coppice leaves round or broadly obovate, leaves on flowering branches opposite, wing claws broadly attached to wing blade .... **subsp. *dichotoma***

18a. ***R. capensis*** (L.) Schinz subsp. ***capensis***

Erect, robust shrub, up to 1.2 m tall or a procumbent shrublet, up to 0.4 m tall. *Leaves* linear to lanceolate or elliptic or narrowly obovate to obovate; leaves on flowering branches subopposite to opposite, (9–) 12–34 mm long, 1–10 mm wide; basal leaves 12–48 (–53) mm long, 1–12 (–22) mm wide. *Inflorescences* single-flowered. *Flowers* often very small, 7–11 mm long. *Pedicel* 2–5 mm long. *Bract* 0.3–0.9 mm long. *Bracteoles* minute, 0.1–0.3 mm long, or absent. *Calyx* lobes triangular to narrowly triangular, ± as long as tube, 1–2 mm long; tube 1–2 mm. *Standard* elliptic or ovate, 5–9 mm long and wide. *Wings* oblong-elliptic to suborbicular, shorter than keel, 4–8 mm long; apex obtuse; claw 2–4 mm long, not broadly attached to blade. *Keel* obtuse or symmetrically truncate without a broad lobe below apex or asymmetrically truncate or emarginate with a broad lobe below apex. *Pistil* with style not incurved towards the apex. *Pods* ± oblong, 13–19 (–22) mm long, 4–7 mm wide; stipe 3–12 mm long. *Seeds* oblong to reniform.

Diagnostic characters. *R. capensis* subsp. *capensis* (see Figure 9.16a & b) is very similar to subsp. *dichotoma* and subsp. *ovata*, with which it merges in numerous geographical forms, but it differs from these subspecies in the narrower leaves (Figure 9.16b), which are often linear (elliptic or obovate but never linear in the other two subspecies), the generally smaller bracts and calyx lobes, the wings which are shorter than the keel (wings as long as the keel in subsp. *dichotoma* and as long as or longer than the keel in subsp. *ovata*), the wing claws not broadly attached to the blade (claws broadly attached to the blade in the other two subspecies), the style which is not incurved towards the apex (style incurved in subsp. *dichotoma* and slightly incurved in subsp. *ovata*), and the generally longer pod stipe.

Distribution and habitat. This subspecies is widespread from the Cape Peninsula in the south-west to the Oudtshoorn district in the east (see Map 9.18). It occurs in dry, grassy fynbos or renosterveld and grows on sand flats, foothills and gentle or steep rocky, stony or sandy slopes. *R. capensis* subsp. *capensis* is associated with deep or shallow TMS, quartzitic, shale or limestone-derived soils.

Regional variation. *R. capensis* subsp. *capensis* is widespread and variable and has many regional forms. The forms merge with each other, and there is every possible intermediate form. Forms of subsp. *capensis* also merge with *R. spicata* and forms of subsp. *dichotoma* and subsp. *ovata* so that it is often difficult to distinguish between the species and subspecies. The typical form of subsp. *capensis* occurs eastwards as far as Oudtshoorn and George and in the Laingsburg area, Rooiberg and Swartberg. This form may be a large, densely leafy shrub up to 1 m tall, with very small, obovate leaves. These plants are distinctly glaucous and dry totally black. The Bredasdorp and broad-leaf Peninsula forms are smaller shrublets, but have larger, lanceolate leaves which may be bright green and remain so when dry, and are very similar to the Hermanus form of subsp. *ovata*. The Hex River valley form has sparse, often linear leaves, as does the Ceres form which is very similar to *R. spicata*.

Specimens examined.

—3318 (Cape Town): Table Mountain (-CD), *Andreae s.n. sub BOL 50542* (BOL); Camp's Bay, lower Blinkwater (-CD), *Cassidy 97* (BOL, NBG); Wynberg Hill (-CD), *Compton s.n. sub BOL 61276* (BOL); Table Mountain, slopes around Twelve Apostles (-CD), *Froembling 345* (NBG); Camp's Bay (-CD), *Michell s.n. sub BOL 50543* (BOL), *Young 398* (PRE), *s.n. sub TM 26463* (PRE); Malmesbury district, Burger's Post farm near Pella (-DA), *Boucher & Shepherd 4908* (NBG, PRE); Paarl district, 6.4 km west-north-west of Windmill (-DB), *Acocks 24518* (PRE); Kraaifontein, Stellenbosch (-DC), *Compton 4847* (NBG); Modderdam (-DC), *Compton 17456* (NBG); Klapmuts, Paarl (-DD), *Bolus s.n. sub BOL 32549* (BOL).

—3319 (Worcester): Winterhoek mountains near Tulbagh (-AA), *Bolus 5010* (BOL); Witsenberg flats, Ceres (-AA), *Compton 18807* (NBG); Olifantsrivier mountains, ridge south of Groen (-AA), *Esterhuysen 13468* (BOL); Tulbagh, Groot Winterhoek mountains, Sneeugat Peak (-AA), *Esterhuysen 19819* (BOL); Witsenberg, Tulbagh (-AA), *Phillips 1736* (SAM), *Zeyher s.n. sub SAM 15203* (SAM); valley between Skruweberge and Witsenberge (-AA), *Thorne s.n. sub SAM 53130* (SAM); about 3 km from top of Gydo Pass to Agter-Witsenberg (-AB), *Grobbelaar 2682* (PRE); 24 km from turn-off from Gydo Pass road to Agter-Witsenberg (-AB), *Grobbelaar 2866* (PRE); Rocklands farm, about 30 km north of Ceres, highest peak of Skurweberge west of homestead (-AB), *Hugo 2522* (NBG, PRE); Koue Bokkeveld mountains, Skurweberge behind Gydo (-AB), *Schlechter 10005* (BOL, PRE, 1–3); Tulbagh, near waterfall (-AC), *Ecklon & Zeyher 1195* (SAM); Ceres (-AD), *Anon. s.n. sub STE 31489* (NBG), *Bolus 8371* (BOL, NBG, 1 & 2, PRE, 1 & 2), *s.n. sub BOL 61275* (BOL); Hex River valley, Buffelshoekkloof (-AD), *Esterhuysen 14273* (BOL); Bokkerivier farm, Ceres (-AD), *Horrocks 117* (NBG); Baviaansberg, Ceres (-BA), *Compton 12882* (NBG); Hex River valley near De Doorns (-BC), *Acocks 15518* (PRE), *Bolus 13079* (PRE, 1 & 2), *13089* (BOL), *Walters 1337* (NBG); Matroosberg, Ceres division (-BC), *Bolus 3961* (NBG), *s.n. sub BOL 42887* (BOL), *Schutte & Van Wyk 563* (JRAU); 7.2 km from Sandhills turn-off to De Doorns (-BC), *Campbell, Van Wyk & De Castro 131* (JRAU); Roodeberg (-BC), *Compton 8409* (NBG); Ceres division, Valsgatkloof below Roodeberg (-BC), *Esterhuysen 1555* (BOL, PRE); Matroosberg, near Lakenvlei (-BC), *Phillips 1930* (SAM); Ceres district, about 20 m inside entrance gate to Lakenvleidam (-BC), *Van Wyk 2287* (JRAU, 1 & 2, NBG); De Doorns, between Worcester and Touwsrivier (-BC), *Van Wyk 3014* (JRAU); national road, Orchard (-BC), *Walters 1044* (NBG); Bonteberg (-BD), *Compton 10000* (NBG); Breederivier valley near Darling bridge (-CA), *Bolus 2751* (BOL, 1–3), *Compton 9907* (NBG); Du Toitskloof (-CA), *Levyns 1120* (BOL); Baineskloof (-CA), *Schlechter 9135* (PRE, 1 & 2); Lategan farm, Breederivier (-CA), *Walters 887, 898* (NBG); about 1 km along national road from Jan du Toit bridge to Worcester (-CB), *Campbell & Van Wyk 104*, *Campbell, Van Wyk & De Castro 133* (JRAU, NBG, PRE); Hex River kloof (-CB), *Sidey 1882* (PRE); 12 miles (19.2 km) from Worcester on Ceres road (-CB), *Story 3590* (PRE); Louwshoekkloof (-CD), *Esterhuysen 17650* (BOL, PRE); Hex River Pass (-DA), *Compton 22839* (BOL, NBG); Hex River valley, Orchard, sand at foot of Karadouw (-DA), *Esterhuysen 10936* (BOL); Vreesniet farm, Sandhills (-DA), *Walters 1378* (NBG); Haudesberg, Koo, Montagu (-DB), *Lewis 5707* (NBG); Villiersdorp, Jonaskop (-DC), *Campbell 99* (JRAU); 20 km from McGregor on road over mountains to Greyton (-DC), *Grobbelaar 2210* (PRE).

—3320 (Montagu): Poort north of Pienaarskloof (-AA), *Acocks 23706* (PRE); Cabidu, Laingsburg (-AB), *Barker 6778, 6779* (NBG); Fisantekraal, Laingsburg (-BC), *Compton 21106* (NBG); plantation below Tienuurkop, Swellendam (-CD), *Wurts 547* (NBG); Anysberg (-DA), *C.M. van Wyk 1018* (NBG, PRE).

—3321 (Ladismith): Witteberg, Laingsburg (-AC), *Compton 21143* (NBG); Bo- Buffelsfontein, north of Ladismith, Laingsburg (-AC), *Stirton 10289* (NBG); Swartberge, below Towerkop (-AD), *Esterhuysen 18546* (PRE); Seweweekspoort mountains (-AD), *Primos 45* (BOL), *Stokoe 1833* (PRE); Klein Swartberg, Seweweekspoort Peak (-AD), *Vlok 154* (NBG, PRE); Gamkasberg Nature Reserve, Calitzdorp district (-BC), *Boshoff P128* (NBG), *Vlok & Schutte 406* (BOL, JRAU, K, MO, NBG, PRE); Swartberg, north-west of Waboomsberg (-BD), *Oliver 5551* (NBG); ridge between Rooiberg and Bailey Peak (-CB), *Oliver 5426* (NBG, PRE); Rooiberg (-CB), *Taylor 9801* (NBG), *Thompson 3381* (NBG); Riversdale district, Muiskraal (-CC), *Oliver & Fellingham 9142* (NBG); Garcia's Pass, Riversdale (-CC), *Thorne s.n. sub SAM 43130* (SAM); Klein Karoo, Gamkasberg Reserve, road south of Keurkloof (-DB), *Allardice 1706* (NBG); Kruispad, Oudtshoorn (-DB), *Compton 21765* (NBG, 1 & 2); Klein Karoo, Langkloof farm against Langeberg (-DC), *Bohnen 8370* (PRE); Bergkloof, Langeberg, Mossel Bay (-DC), *Lewis 5413* (NBG, 1 & 2); Attaquaskloof, footpath east of Fouriesberg, Paardevleiberg (-DD), *Bond 1637* (NBG, PRE); Mossel Bay, Cloetesberg, above Bergkloof (-DD), *Linder 4155* (BOL); Riet Valley farm, Klipheuwel, west of junction of Kammarivier and Spitskoprivier (-DD), *Matthews 1110* (NBG); Cloete's Pass, Mossel Bay division (-DD), *Muir 2150* (BOL, PRE).

—3322 (Oudtshoorn): Swartberg Pass, Prince Albert district (-AC), *Bolus 11463* (BOL, PRE, 1 & 2), *Campbell & Van Wyk 11* (JRAU, 1 & 2), *Campbell, Van Wyk & Vlok 153* (JRAU, 1 & 2, NBG, PRE); *Compton 10421* (NBG), *Pocock S94* (NBG, PRE), *Stokoe s.n. sub SAM 55813, s.n. sub SAM 61415* (SAM); Swartberg Pass, Gamkaskloof road (-AC), *Campbell & Van Wyk 9, 10*, 1 & 2 (JRAU), *Vlok 37* (NBG, PRE); Swartberg (-AC), *Esterhuysen 28819* (BOL), *Stokoe s.n. sub SAM 62241* (SAM); near Voortrekker memorial sign, Swartberg Pass (-AC), *Stirton 9525* (PRE); Prince Albert division, 8 miles (12.8 km) west from top of Swartberg Pass (-AC), *Stokoe s.n. sub SAM 68750* (PRE, SAM); Swartberg Pass, Teeberg (-AC), *Van Wyk 2972* (JRAU); Groot Swartberg, next to Botha's track (-AC), *Vlok 1160* (PRE); Kleinmoerasrivier spruit (-CC), *Barker 7711* (NBG, 1 & 2); Outeniqua mountains near Moerasrivier (-CC), *Esterhuysen 19472* (BOL, 1 & 2); Montagu Pass (-CD), *Schlechter 5825* (BOL, PRE); Waboomskraal, 4 miles (6.4 km) from top of Outeniqua Pass (-CD), *Stokoe s.n. sub SAM 68745* (SAM); George (-CD), *Vlok 4* (NBG, PRE); Kamanassie mountains (-DA), *Vlok 371* (NBG); Buffelsrivier, west of Kamanassie mountains (-DB), *Thompson 1389* (NBG, PRE).

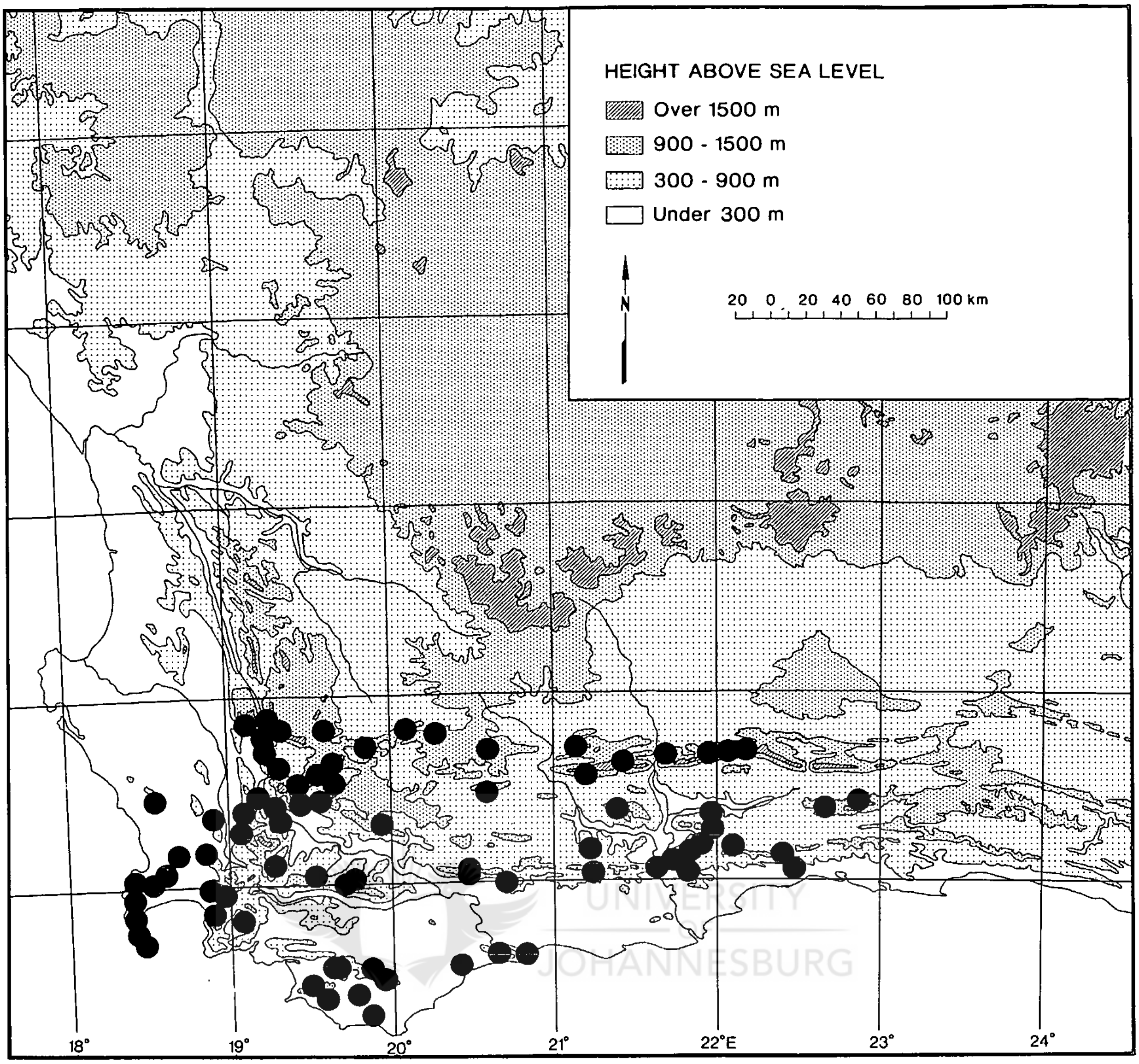
—3418 (Simonstown): Fishhoek mountains (-AB), *Barker 3260* (NBG); Steenberg (-AB), *Compton 13800, 17874* (NBG); Vlakkenberg (-AB), *Compton 20169* (NBG); west of Red Hill, Cape Point road (-AB), *Goldblatt 5169* (PRE); Hout Bay (-AB), *Guthrie 142* (BOL); Tokay, Wynberg (-AB), *Levyns 5262* (PRE), *Wolley-Dod 1921* (BOL); Constantia, Bergvliet farm, hill at Smuts (-AB), *Purcell s.n. sub SAM 89671* (SAM); Constantia, Bergvliet farm, Ladies' Mile Hill (-AB), *Purcell s.n. sub SAM 89674, s.n. sub SAM 89676* (SAM); Constantiaberg (-AB), *Salter 2913* (BOL); Fishhoek flats (-AB), *Salter 7790* (BOL); between Buffelsfontein and Cape Point (-AD), *Bolus s.n. sub BOL 50529* (BOL); Cape of Good Hope Nature Reserve (-AD), *Campbell & Van Wyk 30* (JRAU), *108, 151* (K, MO, NBG, PRE), *Whellan 1767* (PRE); Smitswinkel (-AD), *Compton 16658* (NBG); Lourensford Estate, Stellenbosch division (-BB), *Parker 3949* (BOL, NBG); Stellenbosch, Vanderstel (-BB), *Smith 5151* (PRE).

—3419 (Caledon): Haasvlakte, near Lebanon plantation (-AA), *Grobbelaar 1025* (PRE); Appelskraal, Riviersonderend mountains (-BA), *Stokoe s.n. sub SAM 61412* (SAM); Paardeberg, Papiesvlei, 8.1 miles (13 km) east of Stanford (-BC), *Taylor 4295* (PRE); Jan Swartskraal farm, Napier, Bredasdorp mountains (-BD), *Stirton 8222* (PRE); Havenga farm near Strandkloof, Bredasdorp (-CB), *Martin 354* (NBG); Hagelkraal, between Danger Point and Quoin Point (-DA), *Lewis 3588* (SAM); Bredasdorp district, 10 miles (16 km) west of Elim (-DA), *Salter 4075* (BOL); Rietfonteinpoort near Elim (-DB), *Bolus s.n. sub BOL 42890* (BOL), *Schlechter 9695* (BOL); Bredasdorp mountains (-DB), *Galpin 10488* (PRE); Elim (-DB), *Schlechter 9709* (PRE); Brandfontein, Soetanysberg, near Wolwekloof, Bredasdorp (-DB), *Smith*

4976 (PRE, 1 & 2).

—3420 (Bredasdorp): De Hoop, Oulande (-AD), *Fellingham 812* (NBG); Suurbraak (-BA), *Schlechter 5688* (BOL); 1.7 miles (2.7 km) west of Hamerkop (-BC), *Acocks 23163* (PRE); De Hoop, Potberg Nature Reserve, 3 km south-south-east of Potberg residence (-BC), *Burgers 1434* (NBG, PRE); Potberg, above Melkhoutrivier farm (-BC), *Burgers 2666* (NBG, 1 & 2, PRE); Potberg (-BC), *Compton 20409* (NBG), *Lewis 2461* (SAM); Hamerkop, De Hoop (-BC), *C.M. van Wyk 2001* (NBG, PRE); De Hoop, 1 km west of Potberg Educational Centre (-BC), *C.M. van Wyk 2022* (NBG, PRE); Swellendam district, hillside near Cape Infanta, Frans Rietfontein (-BD), *Esterhuysen 29361* (BOL); 2.5 miles (4 km) west of San Sebastian Point (-BD), *Taylor 7181* (NBG, PRE).

Precise locality unknown: 'Table Mountain, Constantia, Caledon, Swellendam', *Ecklon & Zeyher 1191* (SAM); 'Hottentotsholland mountains, Stellenbosch, near Fishhoek', *Ecklon & Zeyher 1193* (SAM); 'e Cap. b. spei', *LINN 895.17*, *LINN 895.22* [left hand specimen] (LINN) [microfiche only]; 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16438*, *s.n. sub THUNB-UPS 16439* (UPS) [microfiche only].



Map 9.18 The known geographical distribution of *R. capensis* subsp. *capensis.*

18b. ***Rafnia capensis*** (L.) Schinz subsp. ***carinata*** G.J. Campbell & B-E. van Wyk subsp. nov. a subspeciebus ceteris petalo carinali paene rostrato, infra apicem cum lobo exiguo (in subspeciebus ceteris truncato, infra apicem cum lobo magno) differt. Type: South Africa, Western Cape Province, between "Op-die-Berg" and Citrusdal, *Van Wyk 2304* (NBG!, holotype; PRE!, isotype).

Erect or procumbent, much-branched shrublet, up to 0.4 m tall. *Leaves* lanceolate or elliptic or obovate to broadly obovate; leaves on flowering branches subopposite to opposite, 14–25 (–35) mm long, 6–15 mm wide; basal leaves 15–38 mm long, 6–17 (–23) mm wide. *Inflorescences* single-flowered. *Flowers* 9–12 mm long. *Pedicel* 4–7 mm long. *Bract* 0.7–1.4 mm long. *Bracteoles* linear to narrowly triangular, 0.3–0.4 mm long. *Calyx* lobes ± as long as or longer than tube, 3–5 mm long; upper and lateral lobes sometimes slightly falcate; tube 2–3 mm long. *Standard* elliptic or ovate, 8–10 (–13) mm long, 7–9 (–12) mm wide, without an apical cusp; claw 2–3 mm long. *Wings* oblong-elliptic, ± as long as or longer than keel, 7–11 mm long; apex obtuse; claw 3–5 mm long. *Keel* almost rostrate with a slight lobe below apex, 6–8 mm long. *Stamens* monadelphous. *Pistil* with style incurved towards apex. *Pods* ± oblong, 16–20 mm long, 7–10 mm wide; stipe 7–10 mm long; upper margin slightly convex. *Seeds* unknown.

Diagnostic characters. R. capensis subsp. *carinata* (see Figure 9.16c) differs from the other subspecies in the almost rostrate keel petal, which has a slight lobe below the apex (truncate to emarginate with a large lobe below the apex in other subspecies). This subspecies often appears identical to subsp. *dichotoma* (see Figure 9.16e & f) but is distinguished by keel shape.

Distribution and habitat. This subspecies is limited to the Cedarberg, and has a distribution (see Map 9.19) similar to that of *R. spicata* (see Map 9.16). It grows on dry fynbos, on sand flats or steep, rocky mountain slopes and is associated with shale, TMS and sandy loam and is occasionally found in deep sand.

Specimens examined.

—3219 (Wupperthal): Citadelkop, Clanwilliam (-AA), *Compton 24283* (NBG, 1 & 2); Cedarberg wilderness area, Groot Koupoort (-AA), *Haynes 1325* (NBG, PRE); 90 km from Berg-en-dal to Cedarberg (-AA?), *Stirton 9182* (PRE); Heuningvlei extension (-AA), *Taylor 11257* (NBG, PRE); Cedarberg, near Wupperthal (-AC), *Bolus s.n. sub BOL 32561* (BOL), *Thode A1986* (PRE, 1 & 2); Cedarberg Forest Reserve, Hoogvertoon (-AC), *Kruger KR956* (NBG, PRE); Cedarberg, Rocky Pass between Sneeuberg hut and Maltese Cross (-AC), *Taylor 10516* (PRE); beyond Die Rif, central Cedarberg (-AC), *Taylor 11917* (NBG, PRE); Cedarberg, plateau after Uitkyk Pass, road to Algeria (-AC), *C.M. van Wyk 2549* (MO, PRE); Cedarberg, between Wupperthal and Eselbank (-AC), *Van Wyk 3680* (BOL, K); Algeria Forest Station, Sneeuberg (-AC), *Viviers 124* (PRE); Cedarberg, Elandskloof Pass (-CA), *Campbell & Van Wyk 126* (JRAU); Clanwilliam division, Sneeuberg, Cedarberg (-CA), *Esterhuysen 18035* (BOL); Cedarberg State Forest, Sneeuberg Peak (-CA), *Forsyth 157* (NBG, PRE); Cedarberg, Kromrivier (-CA), *Shaw s.n. sub BOL 32561* (BOL); Bokkeveld, Sneeukop (-CD), *Bean & Viviers 1975* (BOL); between Op-die-Berg and Citrusdal (-CD), *Van Wyk 2304* (NBG, PRE).

18c. ***Rafnia capensis*** (L.) Schinz subsp. ***calycina*** G.J. Campbell & B-E. van Wyk subsp. nov. a subspeciebus ceteris lobis calycis longis, valde reflexis (in subsp. *calycina* corollam aequantibus; in subspeciebus ceteris dimidio longitundine corollae, recte), differt. Type: South Africa, Western Cape Province, Piquetberg, 2.1 km along New Caledonia Road, *Campbell & Van Wyk 121* (NBG!, holotype; BOL!, JRAU!, K!, MO!, NBG!, PRE!, isotypes).

Erect or procumbent shrublet, up to 0.5 m tall. *Leaves* lanceolate or broadly elliptic or obovate or ovate or round; leaves on flowering branches invariably opposite, 14–22 mm long, 6–15 mm wide; basal leaves 21–29 mm long, 17–25 mm wide. *Inflorescences* single-flowered. *Flowers* 10–13 mm long. *Pedicel* 3–7 mm long. *Bract* 1–2 mm long. *Bracteoles* linear to narrowly triangular, ± 0.7 mm long. *Calyx* long; lobes triangular to narrowly triangular, much longer than tube, 7–9 mm long; lateral and lower lobes reflexed at anthesis; tube 3–4 mm long. *Standard* oblong, 9–11 mm long, 7–10 mm wide; claw 3–4 mm long. *Wings* oblong, shorter than keel, 6–7 mm long; claw 4–5 mm long. *Keel* asymmetrically truncate to emarginate with a broad lobe below the apex, 7–8 mm long; claw ± 4 mm long. *Stamens* monadelphous. *Pistil* with style incurved towards apex. *Pods* oblong, 12–17 mm long, 4–7 mm wide; stipe (10–) 13–16 mm long; upper margin slightly convex. *Seeds* oblong-reniform.

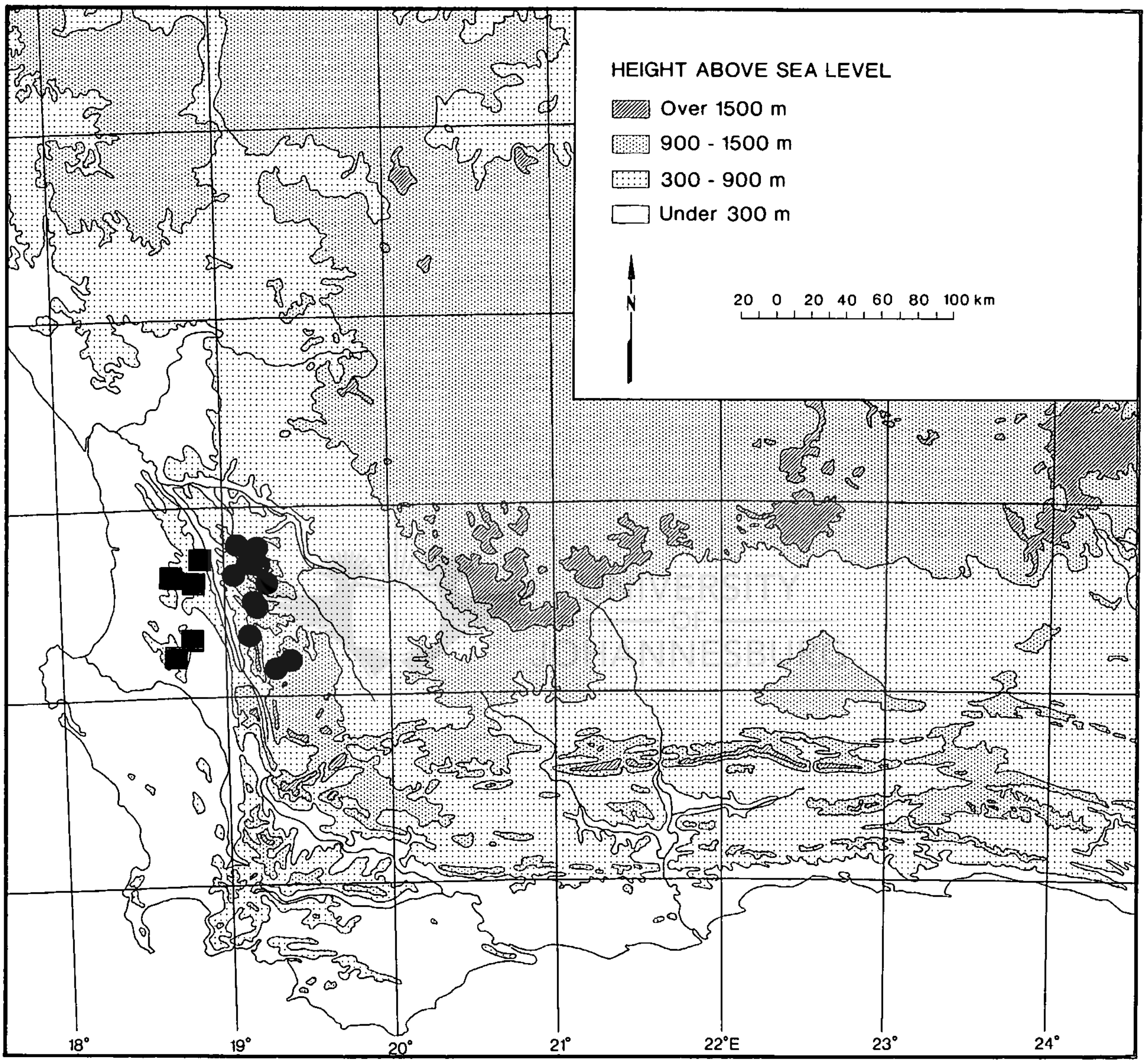
Diagnostic characters. R. capensis subsp. *calycina* (Figure 9.16d) differs from other subspecies in the long, strongly reflexed calyx lobes (lobes as long as the corolla in subsp. *calycina* and up to half as long as the corolla and less reflexed in the other subspecies).

Distribution and habitat. This subspecies occurs on the Piquetberg and Olifantsrivier mountains (Map 9.19). It may be found in montane fynbos or disturbed places on gentle or steep stony slopes and is associated with TMS-derived soils and deep sand.

Specimens examined.

—**3218** (Clanwilliam): Boekenberg (-BC), *Leighton s.n. sub BOL 32557* (BOL); Olifantsrivier mountains, adjacent Swartboskraal, south of Bo-Swartberg (-BD), *Bean & Viviers 1500* (BOL); between Kransvlei and Elandsfontein (-BD), *Bolus s.n. sub BOL 23841* (BOL); Elandskloof (-BD), *Rabinowitz s.n. sub SAM 68749* (PRE), *Stokoe s.n. sub SAM 68749* (SAM); Piquetberg division, plateau between Avontuurberg and Zebrakop (-DB), *Pillans 7508* (BOL, NBG); Piquetberg (-DC?), *Bolus 8428* (BOL, PRE, 1 & 2), *Compton 22963*, 1 & 2, *22968* (NBG), *Maguire 1178* (NBG, 1 & 2), *Martin 782*, 1 & 2, *857* (NBG);

Piquetberg, 2.1 km along New Caledonia road (-DC), *Campbell & Van Wyk 38*, 1 & 2 (JRAU), *121* (BOL, JRAU, K, MO, NBG, PRE); Piquetberg district, Levant Hill (-DC), *Esterhuysen 35798* (BOL, PRE); Piquetberg, dam east of Levant Peak (-DC), *Goldblatt 6515* (PRE); Piquetberg district, turn-off to New Caledonia (-DC), *Van Wyk 3225* (JRAU).



Map 9.19 The known geographical distributions of *R. capensis* subsp. *carinata* (dots) and *R. capensis* subsp. *calycina* (squares).

18d. ***Rafnia capensis*** (L.) Schinz subsp. ***dichotoma*** (Eckl. & Zeyh.) G.J. Campbell & B-E. van Wyk stat. nov. Type: South Africa, Western Cape Province, in montibus prope "Gnadenthal" (Caledon), *Ecklon & Zeyher 1190* (SAM!, lectotype, designated here).

≡ *Rafnia dichotoma* Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (Jan., 1836); Walp. in Linnaea 13: 465 (1839); Benth. in Hook., Lond. J. Bot. 2: 469 (1843); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845); Harv. in Harv. & Sond., Fl. Cap. 2: 37 (1862); Schinz in Bull. Herb. Boiss. 2: 199 (1894).

= *Pelecynthis dichotoma* E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (Feb., 1836); Walp., Rep. Bot. Syst. 2: 580 (1843). Type: South Africa, Western Cape Province, Draakensteen in montosis (III, A, e), *Drège s.n.*, not seen.

= *Pelecynthis gibba* E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (1836); Walp., Rep. Bot. Syst. 2: 580 (1843). Type: South Africa, Western Cape Province, Cedarbergen, (III, A, d) *Drège s.n.* (P!).

≡ *Rafnia gibba* (E. Mey.) Druce in Rep. Bot. Exch. Cl. Brit. Isles, 1916: 643 (1917).

Erect, much-branched shrub, up to 1 m tall or a prostrate, decumbent shrublet, up to 0.2 m tall, 0.5 m wide. *Leaves* broadly elliptic to transverse elliptic or obovate to transverse-obovate or round; leaves on flowering branches invariably opposite, 14–23 mm long, 11–19 mm wide; basal leaves 16–25 mm long, 10–18 (–23) mm wide; coppice leaves broadly ovate or round or oblate, 29–40 mm long, 25–42 mm wide. *Inflorescences* single- or rarely few-flowered, 2–3 flowers. *Flowers* 8–11 mm long.

Pedicel 2–5 mm long. *Bract* 0.5–0.8 mm long. *Bracteoles* linear to narrowly triangular, 0.3–0.4 mm long. *Calyx* lobes usually triangular or sometimes short and broadly triangular, 2–4 mm long. *Standard* broadly elliptic or broadly ovate, 6–10 mm long; claw 2–3 mm long. *Wings* obovate or oblong-elliptic to suborbicular, 6–8 mm long, 3–4 mm wide; claw 3–5 mm long. *Keel* symmetrically truncate without a broad lobe below apex or asymmetrically truncate to emarginate with a broad lobe below apex, 6–8 mm long. *Stamens* monadelphous. *Pistil* with style incurved towards apex; ovules 2. *Pods* broadly oblong, 14–23 mm long, 6–10 mm wide; stipe 4–10 mm long; upper margin slightly convex. *Seeds* cordate-reniform or suborbicular, ± 4 mm wide.

Diagnostic characters. R. capensis subsp. *dichotoma* (see Figure 9.16e & f) differs from the typical subspecies in the invariably opposite leaves on the flowering branches (leaves subopposite to opposite in subsp. *capensis*), the very large coppice leaves which differ from the basal and upper leaves (coppice leaves not as distinctly different from the other leaves in subsp. *capensis*), the longer bracteoles and calyx lobes, the wing claw which is broadly attached to the wing blade (not broadly attached in subsp. *capensis*), the incurved style (not incurved in subsp. *capensis*) and the cordate-reniform or suborbicular seeds (the seeds are oblong to reniform in subsp. *capensis*).

Distribution and habitat. This subspecies is fairly widespread, and seems to have a distribution (see Map 9.20), which overlaps with both subsp. *capensis* (see Map 9.18) and subsp. *ovata* (see Map 9.21). *R. capensis* subsp. *dichotoma* reaches from the Cedarberg in the north, southwards to Caledon and eastwards to Ladismith. It grows in grassy fynbos, in foothills or high mountain slopes or sand flats and on gentle or steep dry, rocky, stony, sandy (TMS) slopes.

Regional variation. R. capensis subsp. *dichotoma* is divided into five regional forms. The northern form occurs in the Olifantsrivier valley and near Ceres and has longer, narrower calyx lobes. The forms occurring in Caledon, Jonaskop, Genadendal, Montagu and Riversdale are more or less typical forms, with slight variations according to locality. An atypical form occurs on Prospect Peak near Worcester. It is a prostrate, diffuse shrublet with very small, cordate leaves (similar to those of *R. acuminata*) but with flowers typical of subsp. *dichotoma*.

Specimens examined.

—**3219** (Wupperthal): Cedarberg, Heuningvlei (-AA), *Pocock 584* (NBG, PRE); 2 miles (3.2 km) east of Citrusdal (-CA), *Hanekom 1251* (NBG, PRE); Apollo, up Kromrivier valley (-CA), *Taylor 11483* (NBG); Porterville, Piquetberg division (-CC), *Edwards 254* (PRE); Ceres division, Onderboskloof, Olifantsrivier valley (-CC), *Esterhuysen 14297* (BOL); Clanwilliam division, Keerom, Olifantsrivier (-CC), *Esterhuysen 17867* (BOL); Ceres, Skoongesig, Koue Bokkeveld mountains (-CC), *Hanekom 1274* (PRE).

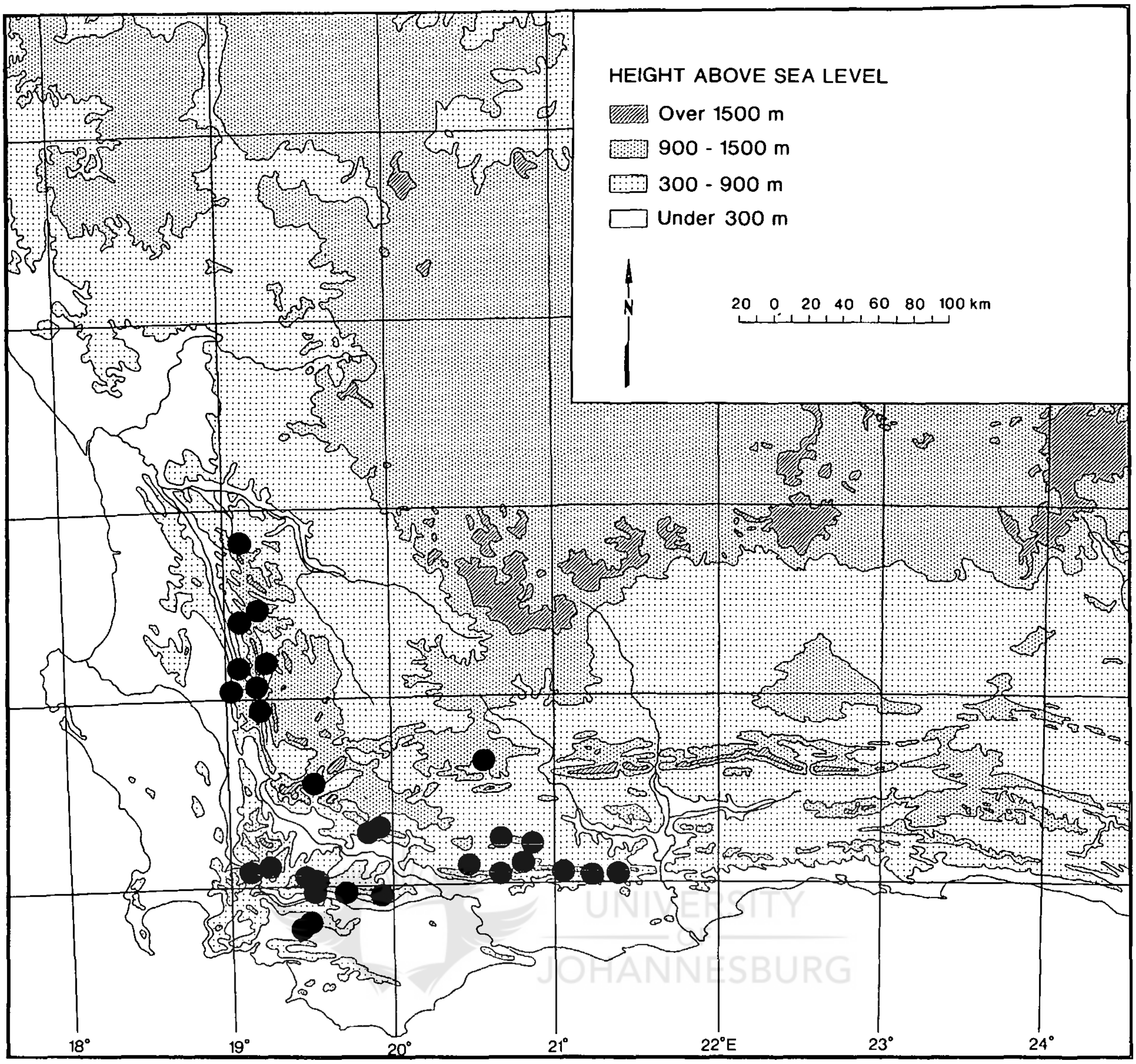
—**3319** (Worcester): Ceres division, Olifantsrivier mountains, ridge south of Groen (-AA), *Esterhuysen 13467* (BOL); Matroosberg (-BC), *Bolus 3961* (NBG); lower eastern slopes of Prospect Peak, Hex River mountains (-BC), *Esterhuysen 15960* (BOL, 1 & 2, NBG, PRE, SAM) [atypical specimens]; Franschhoek Pass, Paarl (-CC), *Compton 12969* (NBG), *Van Wyk 2999* (JRAU, 1 & 2); Hawequas State Forest, Zachariashoek experimental catchment, Kasteelkloof catchment (-CC), *Le Maitre 48* (NBG, PRE); Kroonland Peak, outside High Noon property, Villiersdorp (-CD), *Hugo 2454* (NBG); Onklaarberg, 20 miles (32 km) south of Worcester (-CD), *Stokoe 1152b* (NBG, PRE); Caledon division, Riviersonderend mountains (-CD?), *Stokoe s.n. sub SAM 57819* (NBG, SAM); Dassieshoek Peak, Langeberge, near Robertson (-DB), *Esterhuysen 29061, 29129* (BOL); Haudesberg, Koo, Montagu (-DB), *Lewis 5699* (NBG), *Rycroft 2200* (NBG); Riviersonderend mountains, Villiersdorp, Jonaskop (-DC), *Boucher 4261* (NBG, PRE), *Campbell 98*, 1 & 2 (JRAU), *Campbell & Van Wyk 160* (BOL, 1 & 2, JRAU, 1 & 2, K, 1 & 2, NBG, PRE, 1 & 2), *Oliver 9077* (NBG, PRE), *Walters 2359* (NBG); Riviersonderend mountains, Boschkloof, overlooking Retreat farm and Poesjenelsrivier valley (-DC), *McDonald 1732a* (NBG, PRE); Jonaskop, near Horlosiekloof (-DC), *Rourke 1751* (NBG, 1 & 2, PRE).

—**3320** (Montagu): Keurkloof (-BC), *Compton 5817* (BOL), *Lewis s.n. sub BOL 32558* (BOL); Langeberg near Goedgeloof hut, Swellendam State Forest (-CD), *McDonald 1449* (NBG, PRE); Tradouw's Pass (-DC), *Adamson s.n. sub SAM 38999* (SAM), *Levyns & Levyns 635, 636* (BOL, NBG); Barrydale mountains (-DD), *Barnard s.n. sub SAM 28982* (SAM); Langeberg, Warmwaterberg (-DD), *Van der Merwe 190* (NBG).

—3321 (Ladismith): Garcia's Pass, Riversdale division (-CC), *Esterhuysen 28791* (BOL), *Galpin 3917* (PRE), *Muir 2959* (PRE), *Phillips 325* (PRE, SAM), *Thorne s.n. sub SAM 38932* (SAM), *Van Wyk 2798* (JRAU, 1 & 2); Gymanshoek Pass, Riversdale (-CC), *Hugo 2736* (NBG, PRE); Kareekop, Garcia's Pass (-CC), *Stirton 10280* (PRE); east of toll house, Garcia's Pass, Riversdale (-CC), *C.M. van Wyk 686* (NBG, PRE), Langeberg, Riversdale (-CD?), *Muir 2958* (PRE).

—3419 (Caledon): Caledon (-AB?), *Bolus 8428* (BOL); Swartberg (-AB), *Zeyher s.n. sub SAM 15211* (SAM); Genadendal (-BA), *Bolus 372* (BOL, PRE, 1 & 2, SAM), *Ecklon & Zeyher 1190* (PRE, SAM); Appelskraal, Riviersonderend mountains (-BA), *Ecklon & Zeyher 2280* (PRE, SAM), Greyton, Boesman's Pass, Riviersonderend mountains (-BA), *Rycroft 3221* (NBG); Dasberg near Stormsvlei, Riviersonderend mountains (-BB), *Stokoe s.n. sub SAM 62240* (PRE, SAM).

Precise locality unknown: Cedarberg, *Drège sub Herb. Benth.* (P); Riversdale division, Forestry Department, *Stokoe s.n. sub SAM 61408* (SAM).



Map 9.20 The known geographical distribution of *R. capensis* subsp. *dichotoma*.

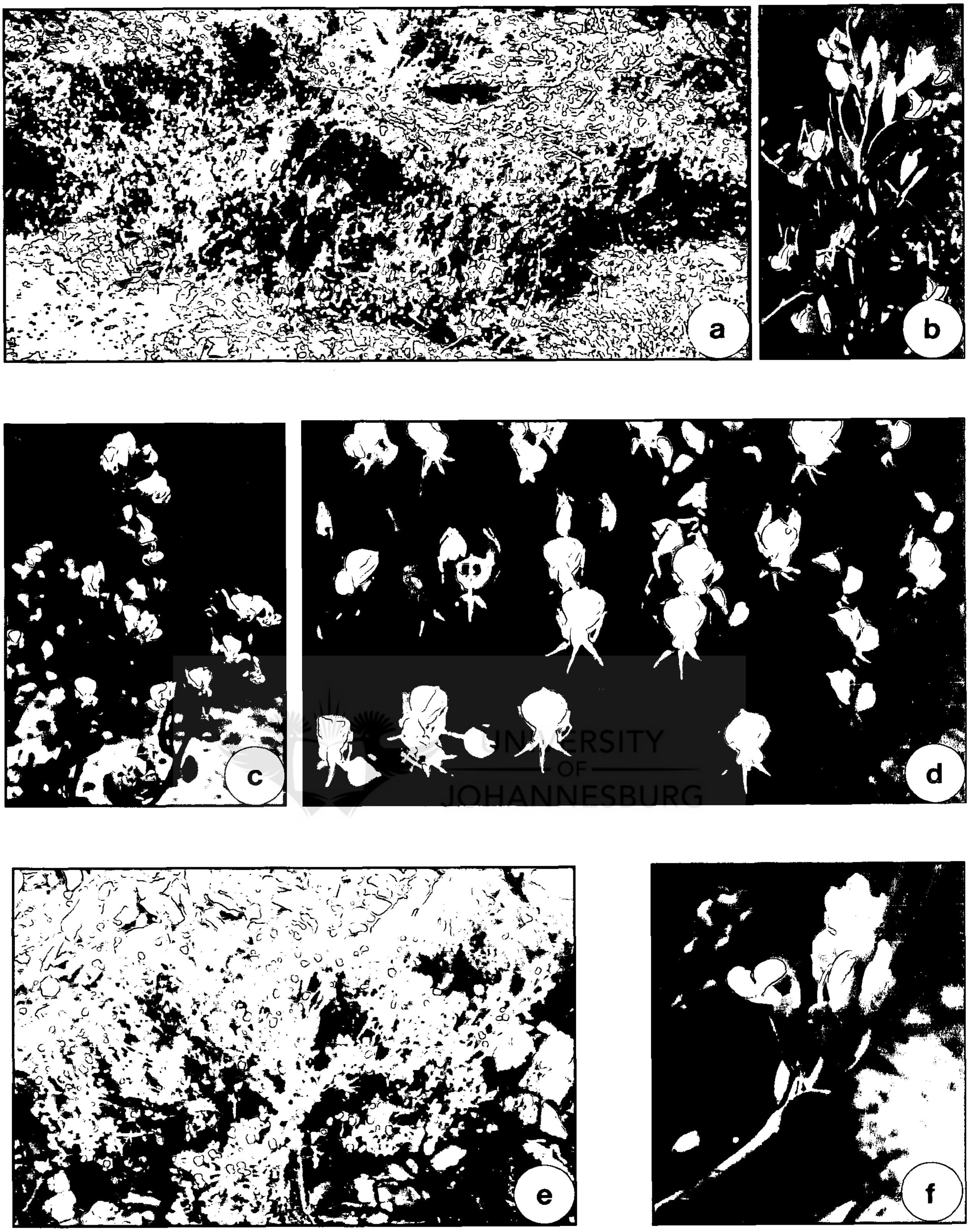


Figure 9.16 Habit, leaves, inflorescences and flowers of *R. capensis* subsp. *capensis* (a & b), *R. capensis* subsp. *carinata* (c), *R. capensis* subsp. *calycina* (d) and *R. capensis* subsp. *dichotoma* (e & f): **a,** procumbent shrublet; **b,** obovate leaves and single-flowered inflorescences, and note the edges of the standard petals which are folded in; **c,** erect shrublet with broadly obovate leaves, single-flowered inflorescences and standard petals which are slightly folded in along the edges; **d,** single-flowered inflorescences and flowers with long, strongly reflexed lower calyx lobes; **e,** erect shrublet, and note the difference between flowering shoots and branches from the previous season; **f,** single-flowered inflorescence and note the folded edges of the standard petal and the truncate keel.

18e. ***Rafnia capensis*** (L.) Schinz subsp. ***ovata*** (Berg.) G.J. Campbell & B-E. van Wyk stat. nov. Type: South Africa, 'e Cap. b. spei', *Grubb s.n.* (SBT, photo!, lectotype, designated here). [Note: see *Cytisus capensis* Berg.]

≡ *Spartium ovatum* Berg., Pl. Cap.: 197 (1767).

≡ *Rafnia ovata* (Berg.) Schinz in Bull. Herb. Boiss. 2: 199 (1894).

= *Crotalaria cuneiformis* Lam., Encycl. 2: 195 (1785). Type not seen.

= *Rafnia cuneifolia* Thunb., Gen. Nov. Pl.: 145 (1800a), Prodr. Pl. Cap.: 123 (1800b); Willd., Sp. Pl. 3: 950 (1802); Thunb., Fl. Cap.: 563 (1823); DC., Prodr. 2: 118 (1825); E. Mey. in Linnaea 7: 147 (1832); Eckl. & Zeyh., Enum. Pl. Afr. Austr.: 161 (1836); E. Mey., Comm. Pl. Afr. Austr. 1(1): 12 (1836); Walp. in Linnaea 13: 463 (1839), Rep. Bot. Syst. 2: 579 (1843); Benth. in Hook., Lond. J. Bot. 2: 468 (1843); Presl in Abh. k. Böhm. Ges. Wiss. Ser. 5.3: 474 (1845); Harv. in Harv. & Sond., Fl. Cap. 2: 37 (1862). Type: South Africa, 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16431* (UPS, microfiche!, right hand specimen, lectotype, designated here).

≡ *Rafnia cuneifolia* var. *cuneifolia* as '*R. cuneifolia* Thunb. var. *obovata* Harv.' in Harv. & Sond., Fl. Cap. 2: 37 (1862).

= *Rafnia cuneifolia* var. *lanceolata* Harv. in Harv. & Sond., Fl. Cap. 2: 37 (1862). Type as for *Pelecynthis corymbosa* E. Mey.

= *Pelecynthis rhomboidea* E. Mey., Comm. Pl. Afr. Austr. 1(1): 14 (1836); Walp., Rep. Bot. Syst. 2: 579 (1843). Type: South Africa, Western Cape Province, Piquetberg in apricis, altit. 2 800 ped. (III, A, d) *Drège s.n. sub Herb. Benth.* (K!); *sub Herb. Hook.* (K!).

≡ *Rafnia rhomboidea* (E. Mey.) Walp. in Linnaea 13: 464 (1839); Benth. in Hook., Lond. J. Bot. 2: 499 (1843).

≡ *Rafnia cuneifolia* var. *rhomboidea* (E. Mey.) Harv. in Harv. & Sond., Fl. Cap. 2: 37 (1862).

Much-branched woody shrub, up to 1 m tall or a procumbent shrublet, up to 0.4 m tall. *Leaves* lanceolate or broadly elliptic or obovate to broadly obovate or transverse-obovate or ovate or round; leaves on flowering branches subopposite to opposite, 15–39 mm long, (4–) 8–17 mm wide; basal leaves 21–48 mm long, (7–) 13–26 mm wide. *Inflorescences* single- or more often few-flowered, 2–9 flowers. *Flowers* 9–12 mm long. *Pedicel* 3–7 mm long. *Bracteoles* narrowly triangular or minute. *Calyx* lobes triangular to narrowly triangular, ± as long as or longer than tube, 1–6 mm long; tube 1–2 mm long. *Standard* oblong, 6–10 mm long, with an apical cusp. *Wings* oblong-obovate, ± as long as or longer than keel, 6–10 mm long; apex obtuse. *Keel* asymmetrically truncate to emarginate with a broad lobe below apex. *Pistil* with style slightly incurved towards apex; ovules 2–3. *Pods* broadly oblong to ± obliquely lanceolate, 12–29 mm long, 5–9 mm wide; stipe 2–4 mm long. *Seeds* oblong to oblong-cordiform or reniform to broadly reniform or cordate-reniform.

Diagnostic characters. R. capensis subsp. *ovata* (see Figure 9.17a & b) differs from the typical subspecies in the broader, more variable leaves, the 2–9-flowered racemes (rarely single-flowered in subsp. *ovata* and invariably single-flowered in subsp. *capensis*) (see Figure 9.17b), the generally larger bracts and bracteoles, the oblong standard petal (the standard is elliptic or ovate in subsp. *capensis*), the wings which are as long as or longer than the keel (shorter than the keel in subsp. *capensis*), the invariably asymmetrically truncate keel petals (the keel may be obtuse, symmetrically truncate or asymmetrically truncate in subsp. *capensis*) and the shorter pod stipe.

Distribution and habitat. *R. capensis* subsp. *ovata* is widespread in the western Cape, from Nieuwoudtville in the north, through the Cedarberg to the Hermanus region in the south (see Map 9.21). The distributions of subsp. *ovata* and subsp. *capensis* (see Map 9.18) coincide south of the Cedarberg. *R. capensis* subsp. *ovata* grows in montane fynbos, disturbed areas or dry sand flats and grows on gentle or steep, rocky, stony, sandy slopes in shallow TMS, granitic, clay or shale soils.

Regional variation. *R. capensis* subsp. *ovata* is similarly variable to subsp. *capensis* and subsp. *dichotoma* and different regional forms are distinguished. In the northern part of the distribution range, subsp. *ovata* is a much-branched woody shrub (see Figure 9.17a), reaching a height of 1 m, with relatively small obovate leaves. The typical form, occurring in areas such as Worcester, Franschhoek, Paarl and Stellenbosch, is a smaller, herbaceous shrublet with large basal leaves and occasionally single-flowered inflorescences. The Hermanus form is similar to the broad-leaved Peninsula form of subsp. *capensis* in leaf shape and in that it has single-flowered inflorescences.

Specimens examined.

—**3119** (Calvinia): Glenridge, Nieuwoudtville (-AC), *Barker 9201* (NBG) [atypical specimen]; Arendskraal farm, near Nieuwoudtville (-AC), *Barker 9776* (NBG).

—**3218** (Clanwilliam): Gryskop, Piquetberg (-DA), *Stirton 10051* (PRE); near Piquetberg road station (-DC), *Bolus s.n. sub BOL 43009* (BOL); Piquetberg, Versveld Pass (-DC), *Campbell & Van Wyk 37* (JRAU, NBG, PRE), *Grobbelaar 2669* (PRE); Piquetberg (-DC?), *Compton 3649* (BOL), *22968* (NBG), *Guthrie 2578* (NBG), *Martin 784* (NBG), *Zinn s.n. sub SAM 54632* (SAM); hills north-west of Moutonsvlei, Piquetberg division (-DC), *Pillans 7469* (BOL).

—**3219** (Wupperthal): Near top of Pakhuis Pass, below Faith, Hope and Charity Peaks (-AA), *Campbell & Van Wyk 42* (JRAU); Clanwilliam, Pakhuis Pass (-AA), *Goldblatt 3083* (NBG, PRE); Cedarberg wilderness area, Krakadouwpoort (-AA), *Haynes 1264* (PRE); Clanwilliam division, Pakhuis mountains (-AA), *Leipoldt 3370* (BOL); Clanwilliam division, Heuningvlei (-AA), *Stokoe s.n. sub SAM 55789* (SAM); near Algeria Forest Station, Cedarberg (-AC), *Acocks & Hafström 708* (PRE), *Compton 6210* (NBG), *Taylor 2936* (NBG); Nieuwoudt's Pass (-AC), *Perry 3247* (NBG); Algeria, Cedarberg (-AC), *Rycroft 2632* (NBG); Algeria Nature Reserve, Cedarberg, Ventersberg (-AC), *Taylor 7506* (NBG, PRE); Cedarberg, Rocky Pass between Sneeuberg hut and Maltese Cross (-AC), *Taylor 10516* (NBG, PRE); Cedarberg, main road from Algeria to Citrusdal (-AC), *C.M. van Wyk 2554* (JRAU, PRE); Ceres, between Olifantsrivier and Kromrivier, (-CA), *Andreae 201* (NBG); Middelberg plateau, Cedarberg (-CA), *Compton 12729* (NBG); Clanwilliam, Suurvleiberg (-CA), *Esterhuysen 2492* (BOL); Cedarberg, north-east of Citrusdal (-CA), *Goldblatt 7263* (NBG); Olifantsrivier mountains, Warmbad (-CA), *Stephens 7031* (SAM); Tulbagh district, Zuurvlakte (-CC), *Andreae 654* (NBG); Cardouw Pass, Piquetberg (-CC), *Barker 8121* (NBG), *Lewis 3590* (SAM); top of Dasklip Pass, Cardouw, Piquetberg (-CC), *Barker 10294* (NBG); Porterville, about half way up Dasklip Pass to Zuurvlakte, Groot Winterhoek State Forest (-CC), *Campbell & Van Wyk 32*, 1 & 2, *110* (JRAU); Olifantsrivier mountains, behind Porterville (-CC), *Edwards 93* (BOL); 6.5 km from turn-off to Dasklip Pass (-CC), *Grobbelaar 2735* (PRE); top of Dasklip Pass (-CC), *Grobbelaar 2880* (PRE); near Aguurkop, Koue Bokkeveld mountains (-CC), *Hanekom 1759* (NBG); Olifantsrivier valley, Grootfontein above Toorgat (-CC), *Oliver 3978* (NBG, PRE); Clanwilliam division, Grasruggens, Olifantsrivier mountains (-CC), *Pillans 8794* (BOL), *8770* (BOL, PRE), *Van Zyl 3090* (NBG, PRE); Olifantsrivier valley (-CC), *Pillans s.n. sub STE 24881* (NBG).

—**3318** (Cape Town): Piquetberg division, Porterville (-BB), *Loubser 803* (BOL); Paarlberg (-DB), *Bolus 2752* (BOL); Jonkershoek State Forest, Langrivier catchment, Stellenbosch (-DD), *Anon. 307* (PRE), *Haynes 1118* (NBG, PRE, 1 & 2), *Kerfoot K6269* (NBG, PRE), *McDonald 947* (NBG, PRE); Jonkershoek, Stellenbosch (-DD), *Borchardt 56* (PRE), *Compton 15340* (NBG), *Wedermann & Oberdieck 341* (PRE); Jonkershoek State Forest, Botmaskop (-DD), *Forsyth 377* (NBG, PRE); Drakenstein mountains, Banghoek, Stellenbosch (-DD), *Ihlenfeldt 1744* (PRE); Jonkershoek State Forest, The Valley (-DD), *Kruger 120* (NBG, PRE); Jonkershoek Forest Reserve, upper Tierkloof (-DD), *Kruger KR839* (NBG, PRE); Biesievlei, Jonkershoek (-DD), *Levyns 8514* (BOL); Jonkershoek, Jakkalsvlei (-DD), *Taylor 4207* (NBG, PRE); Stellenbosch (-DD), *Van der Merwe 838* (NBG, 1 & 2, PRE); Swartboskloof, Stellenbosch (-DD), *Van der Merwe 2204* (NBG, PRE).

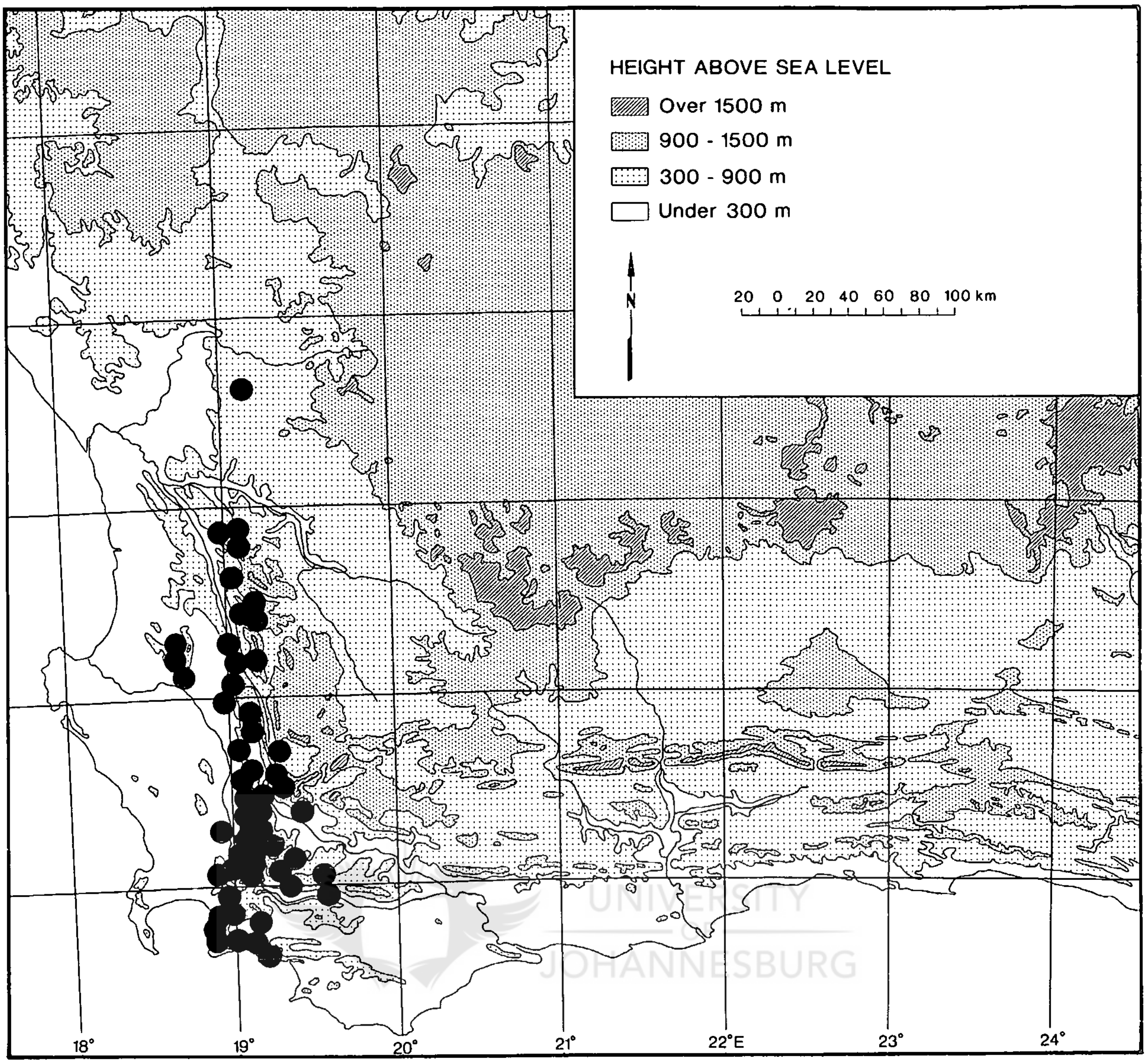
—**3319** (Worcester): Tulbaghkloof (-AA), *Bolus 2752, 5009; 8429* (BOL), *Davis s.n. sub SAM 65716* (PRE, SAM), *Guthrie 2115* (NBG), *Lamb 428* (SAM), *Zeyher s.n. sub STE 31487* (NBG); Groot Winterhoek, Tulbagh (-AA), *Bolus s.n. sub BOL 43027* (BOL), *Phillips 1736* (SAM); Piquetberg, Vier-en-Twintigriviers mountains (-AA), *Esterhuysen 16109* (BOL); Groot Winterhoek, above De Tronk (-AA), *Low 1079a* (NBG, PRE); Sneeugat, Groot Winterhoek, Tulbagh (-AA), *Phillips 1737* (SAM); Ceres division, between Rosendalfontein and Visgat (-AA), *Pillans 9652* (BOL); Elandskloof, north of Wellington (-AC), *Bond 623* (NBG), *Compton 22694* (NBG), *Galpin 12267* (PRE), *Stokoe s.n. sub SAM 69771* (SAM); Roodesandsberg, Tulbagh (-AC), *Compton 6499* (NBG); Tulbagh waterfall (-AC), *Compton 12401* (NBG), *Esterhuysen 34389* (BOL); Steendal, Tulbagh (-AC), *MacOwan s.n. sub STE 13611* (NBG); Paarl division, foot of Elandskloof mountains, north of Wellington (-AC), *Stokoe s.n. sub PRE 53124* (PRE); Ceres, Mitchell's Pass (-AD), *Bolus s.n. sub BOL 43014* (BOL), *Compton 6715* (NBG), *Esterhuysen 6155* (BOL); Ceres, Mitchell's Pass, Slab Peak (-AD), *Compton 11963* (NBG), *Stokoe s.n. sub SAM 55819* (SAM); Waaihoekberg (-AD), *Esterhuysen 8289* (BOL); Ceres, upper valley (-AD), *Guthrie 2142* (NBG); Du Toitskloof (-CA), *Barker 5971, 7165* (NBG), *Grobbelaar 1179, 2242, 2705, 2706* (PRE), *Lewis 3589* (SAM), *Pillans 8401* (BOL), *Stokoe s.n. sub STE 31486* (NBG), *s.n. sub PRE 53138* (PRE), *s.n. sub SAM 65712* (SAM), *Walters 1429* (NBG); Du Toitskloof valley, entrance to Tierkloof (-CA), *Boucher 5339* (NBG); Molenaarsberg (-CA), *Compton 20144* (NBG); Paarl division, Seven Sisters Mountain (-CA), *Esterhuysen 30031* (BOL); Hawequas State Forest (-CA), *Richardson 7* (NBG, PRE); Baineskloof (-CA), *Schlechter 9100* (PRE); Tulbagh division, Bailey Peak (-CA), *Stokoe s.n. sub SAM 55818* (SAM); Lategan farm, Breederivier (-CA), *Walters 890* (NBG); Worcester (-CB), *Fine G166* (PRE); Paarl, top of Franschhoek Pass (-CC), *Barker 4165, 8537* (NBG), *Phillips 1102* (SAM, 1 & 2), *Salter 2970* (BOL), *Schlechter s.n. sub TM 136* (PRE), *9318* (BOL, PRE, 1 & 2); Paarl, Wemmershoek (-CC), *Compton 4832* (NBG); Tierkloof, Wemmershoek, Paarl (-CC), *Gray s.n. sub BOL 50526* (BOL); Hawequas State

Forest, Zachariashoek experimental catchment, Kasteelkloof catchment (-CC), *Haynes 686* (NBG, PRE), *Lamb 114* (NBG, PRE), *Van Wilgen 200* (NBG, PRE); Franschhoek, Klein Drakenstein mountains, upper Bakkerskloof (-CC), *Kruger KR778* (NBG, PRE); Paarl division, Haelsneeukop (-CC), *Stokoe s.n. sub SAM 56281* (SAM); Drakenstein, near Wellington (-CC), *Tyson 2358* (SAM); La Motte Forest Station, Zachariashoek, Kasteelkloof (-CC), *Viviers 691* (NBG, PRE); Caledon district, above High Noon, Kaaimansgat, Villiersdorp mountains (-CD), *Esterhuysen 33367* (BOL); Villiersdorp, summit of Elandskloof Pass (-CD), *Gillett 722* (BOL); Elandskloof, upper slopes north-west of Klein Tafelberg (-CD), *Oliver 8663* (PRE); Onklaarberg, 20 miles (32 km) south of Worcester (-CD), *Stokoe 1190a* (PRE).

—3418 (Simonstown): Simonstown (-AB), *Bolus 4793* (BOL); Hottentotsholland mountains, near Palmietrivier (-BB), *Bolus 4133* (BOL); Hottentotsholland mountains, near Gordon's Bay (-BB), *Bolus s.n. sub BOL 42888* (BOL); Arieskraal, Caledon (-BB), *Compton 16513* (NBG); Sir Lowry's Pass (-BB), *Guthrie 2785* (NBG), *Schlechter 400* (PRE), *7286* (BOL); south of Gordon's Bay, Stellenbosch (-BB), *Marloth 10011* (PRE, 1 & 2); Highlands Forest Reserve, near Kogelberg (-BB), *Stokoe s.n. sub SAM 68748* (SAM); Kogel Bay, Blousteenberg (-BD), *Boucher 968* (NBG, PRE); Palmietrivier, Caledon (-BD), *Compton 14094* (NBG); Paardeberg, Caledon (-BD), *Taylor 4295* (NBG).

—3419 (Caledon): Houhoek (-AA), *Guthrie 2577* (NBG), *Schlechter 119*, *9399* (PRE); Hemel-en-Aarde (-AC), *Barker 7620* (NBG); Fernkloof Nature Reserve, Hermanus (-AC), *Burman 1016* (BOL), *Orchard 133* (PRE), *369* (NBG, PRE); Hermanus, near western end of Rotary Way (-AC), *Campbell & Van Wyk 147* (JRAU, NBG, PRE); Kleinmond (-AC), *De Vos 460* (BOL, NBG), *1241* (NBG); Heuningklip farm (-AC), *Flynn & Davis APF660* (NBG); *Taylor 4854* (NBG); Hermanus (-AC), *Rogers 26439* (PRE), *A.E. van Wyk 2092* (PRE); Kleinmond, Botrivier (-AC), *Schlechter 9447* (PRE), *Taylor 3797* (NBG); Greyton Nature Reserve, Riviersonderend mountains (-BA), *Goldblatt 8669* (PRE); Riviersonderend mountains, Kanonberg, Greyton, above Platkloof (-BA), *Rycroft 3182* (NBG, PRE).

Precise locality unknown: *Anon. 26177* (NBG); *Drège s.n. sub PRE 9509* (PRE); *Sidey 4097* (PRE); 'e Cap. b. spei', *Thunberg s.n. sub THUNB-UPS 16431* (UPS) [microfiche only]; 'Swartberg, Caledon, Tulbagh, Steendal, Winterhoek, waterfall', *Zeyher s.n. sub SAM 15210* (SAM, 1–3).



Map 9.21 The known geographical distribution of *R. capensis* subsp. *ovata*.

18f. ***Rafnia capensis*** (L.) Schinz subsp. ***elsieae*** G.J. Campbell & B-E. van Wyk subsp. nov., a subspeciebus ceteris habitu minori prostrato differt. Etiam a subsp. *capensi* foliis in ramis floriferis semper alternis (in subsp. *capensi* suboppositis vel oppositis), foliis semper obovatis (in subsp. *capensi* forma variis), et racemis 4–8-floribus (in subsp. *capensi* unifloribus) differt. Type: South Africa, Western Cape Province, Worcester, Waaihoek Peak, *Esterhuysen 28730* (BOL!, holotype; BOL!, NBG!, isotypes).

Prostrate, decumbent shrublet, much-branched from base, up to 0.3 m tall. *Leaves* narrowly obovate to obovate to ± angular-obovate; leaves on flowering branches invariably alternate, 12–17 (–20) mm long, 4–8 mm wide; basal leaves 9–15 mm long, 3–6 mm wide. *Inflorescences* few-flowered, 4–8 flowers. *Flowers* 9–12 mm long. *Pedicel* 4–7 mm long. *Bract* 1–2 mm long. *Bracteoles* subulate, 0.5–0.7 mm long. *Calyx* lobes triangular to narrowly triangular, longer than tube, 4–6 mm long; tube 2–3 mm long. *Standard* elliptic or ovate, 8–9 mm long and wide, with an apical cusp; claw ± 3 mm long. *Wings* oblong, shorter than keel, 7–8 mm long, 3–4 mm wide; apex obtuse; claw ± 3 mm long. *Keel* asymmetrically truncate to emarginate with a broad lobe below apex, 7–8 mm long; upper margin basally convex; claw 2–3 mm long. *Stamens* monadelphous. *Pistil* with style not incurved towards apex; ovules 4. *Pods* oblong, 17—18 mm long, ± 7 mm wide; stipe 5–6 mm long; upper margin slightly convex. *Seeds* unknown.

Diagnostic charaters. R. capensis subsp. *elsieae* differs from the other subspecies in the smaller, prostrate habit, and it differs from the typical subspecies in the invariably alternate leaf arrangement on the flowering branches (subopposite to opposite in subsp. *capensis*), the basal leaves which are smaller than the upper leaves (the basal leaves are larger than the upper leaves in subsp. *capensis*), the uniformly obovate leaves (leaves variable in subsp. *capensis*), the 4–8-flowered racemes (single-flowered in subsp. *capensis*) and the longer calyx lobes which are longer than the tube (about as long as the tube in subsp. *capensis*).

Distribution and habitat. *R. capensis* subsp. *elsieae* is known only from three localities, i.e. Waaihoek Peak, Milner Peak and Fonteintjiesberg in the Worcester area (see Map 9.22) and it occurs in montane fynbos, especially in recently burnt veld, and is associated with shale bands on rocky slopes.

Specimens examined.

—**3319** (Worcester): Waaihoekberg (-AD), *Esterhuysen 8308* (BOL, NBG, PRE); Waaihoek Peak (-AD), *Esterhuysen 9927* (PRE), *28730* (BOL, 1 & 2, NBG, PRE); Milner Peak (-AD), *Esterhuysen 14858* (BOL, PRE); Fonteintjiesberg (-CB), *Forsyth 312* (PRE).

18g. ***Rafnia capensis*** (L.) Schinz subsp. ***pedicellata*** G.J. Campbell & B-E. van Wyk subsp. nov., a subspeciebus ceteris racemis 20–45-floribus (in ceteris usque 9-floribus), et pedicellis longis (in subsp. *pedicellata* longioribus quam floribus; in ceteris infra dimidio minoribus quam floribus), differt. Type: South Africa, Western Cape Province, Fernkloof Nature Reserve, Hermanus, *Van Wyk 2085* (NBG!, holotype).

Erect or procumbent shrublet, not much-branched, up to 0.5 m tall. *Leaves* broadly elliptic or obovate to broadly obovate or obovate-lanceolate or ovate or round; leaves on flowering branches invariably alternate, 31–42 mm long, 12–18 mm wide; basal leaves (29–) 33–60 mm long, 7–30 (–34) mm wide. *Inflorescences* multi-flowered, 20–45 flowers, aggregated into umbel-like racemes. *Flowers* 11–14 mm long. *Pedicel* long, 13–18 mm long. *Bract* 1.5–3 mm long. *Bracteoles* subulate to narrowly triangular. *Calyx* lobes triangular to narrowly triangular, ± as long as or longer than tube, 3–6 mm long; tube 2–3 mm long. *Standard* oblong, 9–11 mm long, 8–11 mm wide, without an apical cusp; claw ± 3 mm long. *Wings* oblong, ± as long as or longer than keel, 9–11 mm long, 4–5 mm wide; apex obtuse; claw 3–5 mm long. *Keel* symmetrically truncate without a broad lobe below apex, 8–9 mm long; claw 3–4 mm long. *Stamens* monadelphous. *Pistil* with style ± as long as or shorter than ovary, sometimes slightly incurved towards apex; ovules 2–3. *Pods* obliquely lanceolate, (26–) 31–40 mm long, 9–12 mm wide; stipe 6–11 mm long; upper margin straight. *Seeds* unknown.

Diagnostic characters. R. capensis subsp. *pedicellata* (see Figure 9.17c) differs from the other subspecies in the 20–45-flowered racemes (usually single-flowered or up to 9-flowered in the other subspecies) and the long pedicels, which are longer than the flowers in subsp. *pedicellata* and less than half as long as the flowers in the other subspecies. It also differs from the typical subspecies in the invariably alternate leaves on the flowering branches (leaves subopposite to opposite in subsp. *capensis*), the larger leaves and flowers, the longer calyx lobes, the oblong standard petal (elliptic or ovate in subsp. *capensis*), the wings which are about as long as or longer than the keel (shorter than the keel in subsp. *capensis*), the invariably symmetrically truncate keel (keel obtuse or symmetrically or asymmetrically truncate in subsp. *capensis*) and the larger, obliquely lanceolate pods (pods oblong in subsp. *capensis*).

Distribution and habitat. This subspecies is restricted to the Palmietrivier and Bredasdorp regions (see Map 9.22), where it occurs in montane or coastal fynbos, at river mouths, near the beach and in disturbed areas, on gentle or steep, dry rocky, stony slopes and is associated with TMS soil.

Specimens examined.

—3418 (Simonstown): Groot Hangklip (-BD), *Boucher 520* (NBG, PRE); Caledon division, Palmietrivier mouth (-BD), *Compton 6087* (NBG), *Gray s.n. sub BOL 26050* (BOL), *Stokoe s.n. sub SAM 61407* (PRE, SAM); Davidskraal, between Palmietrivier and Hangklip, Caledon (-BD), *Compton 6095* (NBG); Rooiels, Caledon (-BD), *Esterhuysen 14119* (BOL), *Levyns 10369* (BOL); Palmietrivier (-BD), *Gillett 4248* (PRE), *Martin 783* (NBG); 5 km from Rooiels to Kleinmond (-BD), *Grobbelaar 2766* (PRE); Betty's Bay, Caledon (-BD), *Jordaan 1242* (NBG), *Levyns 10207* (BOL), *Van Rensburg 2154* (NBG, PRE), *Vogts 7* (PRE), *Walters 287*, *1135* (NBG); between Rooiels and Pringle Bay, Caledon (-BD), *Parker 4812* (BOL, NBG, PRE); Caledon division, mountains near Rooiels and Hangklip (-BD), *Stokoe s.n. sub SAM 52461* (SAM); Caledon division, Palmietrivier valley, Platteberg (-BD), *Stokoe s.n. sub SAM 65715* (SAM); between Betty's Bay and Palmietrivier (-BD), *Van Wyk 3135* (BOL); Kleinmond, Kogelberg State Forest, about 1 km north-east of Oudebosch house (-BD), *Vlok, Van Wyk & Schutte 45* (K, PRE).

—3419 (Caledon): Houhoek (-AA), *Bolus 9879* (BOL); Caledon (-AB?), *Bolus s.n. sub PRE 53164* (PRE); Hermanus (-AC), *Barker 1614* (NBG, PRE); Pietersfontein, Hermanus (-AC), *Bolus 9833* (BOL); Fernkloof Nature Reserve, Hermanus (-AC), *Campbell & De Castro 85* (JRAU), *Orchard 133* (NBG), *Schutte 436* (JRAU), *695* (MO), *Van Wyk 2085* (NBG); Kleinmond (-AC), *Compton 3452* (BOL); Palmiet mountain ridges (-AC), *De Vos 1406* (NBG); Botrivier (-AC), *Schlechter 9447* (BOL); Palmietrivier (-AC), *Stokoe s.n. sub SAM 59608* (SAM); Belladonna Street, Sandbaai, Hermanus (-AC), *Walters 1935* (NBG); Mosselrivier, near Hermanus (-AD), *Compton 23688* (NBG), *Maguire 1269* (NBG); Voëlgat (-AD), *Williams 2605* (NBG, PRE); Bredasdorp, Hagelkraal (-DA), *Compton 20442* (NBG); Elim (-DB), *Bolus 6789* (BOL, NBG, PRE, 1 & 2), *8534* (BOL, NBG).

—3420 (Bredasdorp): Bredasdorp (-CA), *Van Bredá 1464* (PRE).

Precise locality unknown: Cape Town Wild Flower Show, *Anon. s.n. sub BOL 43019* (BOL).

19. ***Rafnia globosa*** G.J. Campbell & B-E. van Wyk sp. nov. a *R. capensi* pseudoracemis globosis foliosis (in *R. capensi* inflorescentiis in pseudoracemis non aggregatis), lobis calycis valde reflexis (in *R. capensi* minus reflexis), et petalo fere rostrato infra apicem cum lobo parvo (in *R. capensi* plerumque truncato vel emarginato), differt. Type: South Africa, Western Cape Province, Cedarberg, Algeria, 0.8 km from Algeria campsite along Nieuwoudt's Pass, before sign 'Groothoek', *Campbell & Van Wyk 125* (NBG!, holotype; BOL!, JRAU!, K!, MO!, NBG!, PRE!, UPS!, isotypes).

Erect suffrutex, not much-branched, up to 0.6 m tall. *Leaves* round, obovate, elliptic, broadly obovate, often penninerved; leaves on flowering branches invariably opposite, 20–33 mm long, 9–15 (–18) mm wide; basal leaves 25–44 mm long, 14–26 mm wide. *Inflorescences* single-flowered, aggregated into globose pseudoracemes. *Flowers* 10–14 mm long. *Pedicel* 2–5 mm long. *Bract* narrowly triangular to linear, 1–2 mm long. *Bracteoles* 0.3–0.4 mm long. *Calyx* lobes triangular to narrowly triangular, ± as long as or shorter than tube, 3–5 mm long; upper lobes ± as broad as lateral lobes; lobes often curl backwards over tube after the flowers have fallen off; upper sinus rarely deeper than others; tube 3–4 mm long. *Standard* broadly ovate, slightly folded in along lower edges, 9–11 (–14) mm long, 10–13 mm wide; without an apical cusp; claw 2–3 mm long. *Wings* oblong, 7–10 mm long, 4–5 mm wide; apex obtuse; claw not broadly attached to blade, 4–5 mm long. *Keel* almost rostrate, slightly lobed below apex, 7–8 mm long, 3–4 mm wide; claw ± 4 mm long. *Stamens* monadelphous. *Pistil* with style slightly incurved towards apex, shorter than or ± as long as ovary; stigma small, fibrillose; ovules 2. *Pods* ± oblong, 14–16 mm long, 5–8 mm wide; stipe 4–5 (–8) mm long; upper margin convex; lower margin straight, proximally convex, sharply upcurved into stipe. *Seeds* cordate-reniform; broadly oblong to suborbicular or sometimes oblique-cordiform, 3–5 mm long and wide; sinus deep; testa rough.

Diagnostic characters. *R. globosa* (Figure 9.17d) is distinguished from the other species of *Rafnia* by the inflorescences which are secondarily aggregated into globose, leafy pseudoracemes. It also differs from *R. capensis* in the extremely strongly reflexed calyx lobes (less reflexed or not reflexed in *R. capensis*), and the almost rostrate keel petal, which has a slight lobe below the apex (usually truncate to emarginate in *R. capensis*).

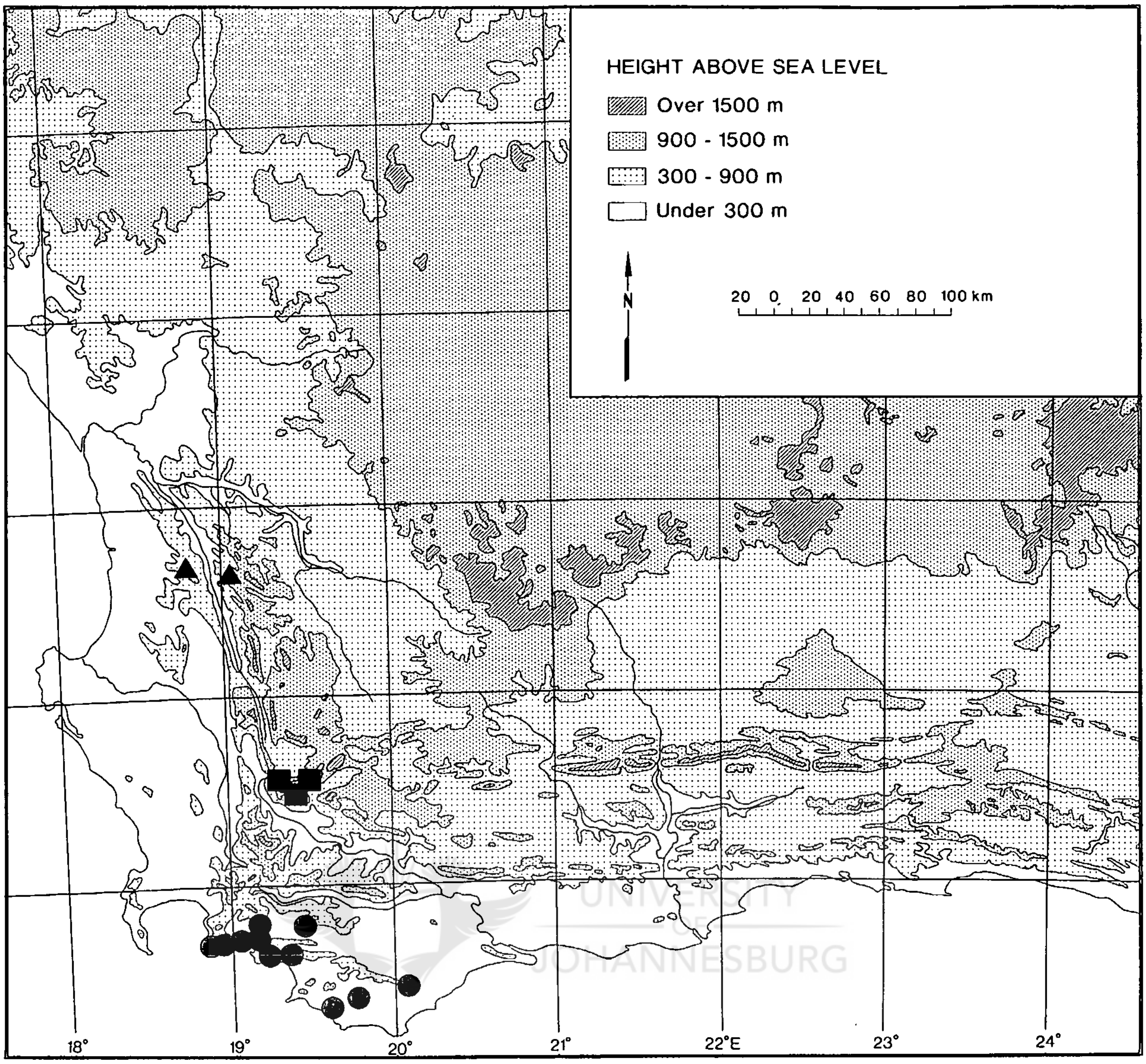
Distribution and habitat. *R. globosa* is known only from two localities, i.e. Algeria in the Cedarberg and Clanwilliam (Map 9.22) and is associated with montane fynbos and TMS-derived soils.

Specimens examined.

—3218 (Clanwilliam): Between Witelskloof and Lambertshoekberg (-BD), *Pillans 9081* (BOL).

—3219 (Wupperthal): Nieuwoudt's Pass (-AC), *Andrag 143* (NBG), *Compton 4779* (NBG); Algeria Forest Reserve, central Cedarberg (-AC), *Campbell & Van Wyk 125* (BOL, 1 & 2, JRAU, 1–5, K, 1 & 2, MO, 1 & 2, NBG, 1–3, PRE, 1–3, UPS), *Compton 12676* (NBG), *Levyns 2197*, *3001* (BOL), *Salter 7565* (BOL), *Story 2957* (PRE), *Taylor 2937* (NBG), *6201*, *11568* (NBG, PRE); Cedarberg, near Algeria Forest Station (-AC), *Galpin 10572* (PRE); 13.1 km from Citrusdal-Clanwilliam road to Algeria (-AC), *Grobbelaar 2673* (PRE); Cedarberg State Forest, research site 12 (-AC), *Le Maitre 262* (NBG, PRE); road to Algeria, overlooking Rondegatrivier (-AC), *McDonald 1204* (NBG, PRE).

Precise locality unknown: Clanwilliam district, Cedarberg, *Primos s.n. sub PRE 53096* (PRE).



Map 9.22 The known geographical distributions of *R. capensis* subsp. *elsieae* (squares), *R. capensis* subsp. *pedicellata* (dots) and *R. globosa* (triangles).

Figure 9.17 Habit, inflorescences and flowers of *R. capensis* subsp. *ovata* (a & b), *R. capensis* subsp. *pedicellata* (c) and *R. globosa* (d): **a,** woody, much-branched shrub; **b,** 2–9-flowered inflorescences, and note the standard petals which are folded in along the edges and the truncate keel petals; **c,** procumbent shrublet with multi-flowered inflorescences; **d,** single-flowered inflorescences aggregated into globose pseudoracemes, and note the strongly reflexed calyx lobes.

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