

Patterns of plant diversity and endemism in Namibia

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ABSTRACT

Species richness, endemism and areas that are rich in both species and endemic species were assessed and mapped for Namibia. High species diversity corresponds with zones where species overlap. These are particularly obvious where there are altitudinal variations and in high-lying areas. The endemic flora of Namibia is rich and diverse. An estimated 16% of the total plant species in Namibia are endemic to the country. Endemics are in a wide variety of families and sixteen genera are endemic. Factors that increase the likelihood of endemism are mountains, hot deserts, diversity of substrates and microclimates. The distribution of plants endemic to Namibia was arranged in three different ways. Firstly, based on a grid count with the phytogeographic value of the species being equal, overall endemism was mapped. Secondly, range restricted plant species were mapped individually and those with congruent distribution patterns were combined. Thirdly, localities that are important for very range-restricted species were identified. The resulting maps of endemism and diversity were compared and found to correspond in many localities. When overall endemism is compared with overall diversity, rich localities may consist of endemic species with wide ranges. The other methods identify important localities with their own distinctive complement of species.

INTRODUCTION

Species diversity was traditionally measured by counting the number of different species recorded in a specific area or grid (Linder 2001). The 'weight' of the species was not taken into consideration. Today various measures of diversity have been proposed that give greater value to species that are taxonomically, geographically, ecologically or economically distinct, but no 'best' method for mapping species diversity has yet been found (Craven 2002b). The development of floristic databanks allows quick and efficient retrieval of phytogeographic data that can produce computerized distribution maps. This study used the computerized data of specimens housed in the National Herbarium of Namibia (WIND) and the National Herbarium in Pretoria (PRE) to survey distribution patterns of plant diversity, overall endemism and centres of endemism and diversity on a quarter-degree scale in Namibia. The endemic flora were also analysed and factors that may have contributed to the resulting distribution patterns were discussed briefly when evident from the use of map overlays. Known centres of endemism were not redefined, only species with similar patterns of distribution were recorded.

Caldecott *et al.* (1996) separated the current knowledge of biodiversity into global, regional, national, ecoregional and site information. Patterns of diversity in Namibia have been shown on continental-scale diversity maps (Mutke *et al.* 2001) and included in region-based studies such as those of Goldblatt (1978), Cowling *et al.* (1989) and Gibbs Russell (1985, 1987). The account of Linder (2001) on patterns of plant species endemism and richness for the African flora does not include arid areas such as most of Namibia.

The first national assessment and map of relative species richness in Namibia was that of Maggs *et al.*

(1994). It was based on distributional data per magisterial district following Merxmüller (1966–1972), as well as other literature. Species diversity was re-assessed for the Biodiversity Country and mapped on half-degree grid squares (Maggs 1998; Maggs *et al.* 1998). This study updates the underlying data used in Maggs' (1998) on a finer scale.

A taxon is endemic if confined to a particular area (Major 1988) which may be large or small. Clearly, data on endemism would be more useful if given by floristic province rather than political divisions (Major 1988; Van Wyk & Smith 2001), but datasets between different countries are seldom compatible in quality or quantity. Due to the fact that Namibia is home to a considerable number of endemics with adequate data, this assessment only reviews species limited to Namibia (Figure 1). An endemic is therefore defined here as a taxon that is restricted to within the political borders of Namibia. Taxa that extend marginally into another region, i.e. beyond the political borders of Namibia are referred to as near-endemic.

Centres of outstanding species diversity and endemism such as the Kaokoveld and Gariiep have long attracted attention, but their boundaries, floristic elements and origins remain fairly sketchy. Different approaches and methodologies have also contributed to the centres (sometimes with the same name) not being compatible or comparable (Van Wyk & Smith 2001; Craven 2002b). Stott (1981) suggested that the process consists of stages i.e. after taxonomic study (essential for elucidating closely related taxonomic units) using specimens, species distributions are plotted and areas of congruence identified. The plants are then arranged into recognizable groups, which on further analysis would identify phytogeographic centres determined by a high concentration of taxa with restricted distributions. This approach was pioneered in southern Africa by Weimarck (1941) and is found in taxonomic literature, for example in Nordenstam (1969) and Hilliard (1994). The approach looks at the geographical ranges of species regardless of their growth form or other factors such as topography and present

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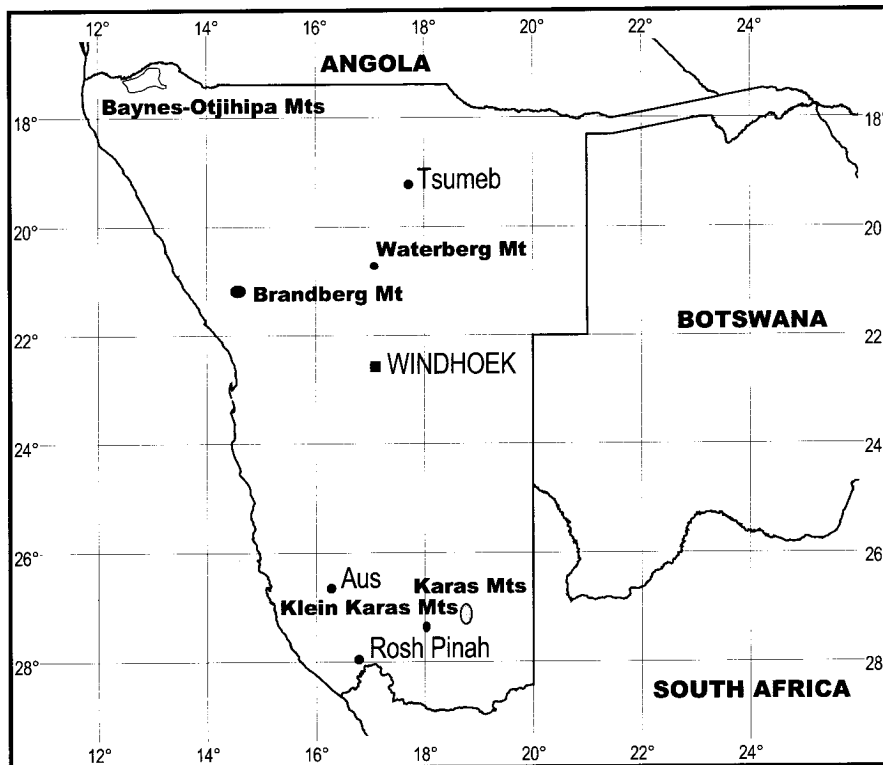


FIGURE 1.—Namibia, its neighbours, capital city and some important mountains and towns.

climate, and identifies particular geographical areas inhabited by species that are restricted to these ranges. Once such a centre is recognized, explanations are sought on how they may have arisen (e.g. past climate) and how they are being maintained. This knowledge is fundamental to understanding the origin, migration, and speciation of plants and is essential for developing strategies for biological conservation. This study did not attempt to redefine the centres presently known for Namibia, but attributes a number of new species to the centres.

Maps presenting overall patterns of diversity and endemism in Namibia have been used to identify regions of importance for conservation (Simmons *et al.* 1998; Mendelsohn *et al.* 2002). This paper shows two other methods of mapping important areas for endemics, which should also be taken into consideration.

MATERIALS AND METHODS

Database

Georeferenced specimens on the specimen database (SPMNDB) in WIND provided the grid-diversity count. This database has $\pm 120\ 000$ specimens and includes specimens housed in PRE that were collected in Namibia. All specimens of higher plants were used in the evaluation. A sizable proportion was georeferenced following the quarter-degree square system of Edwards & Leistner (1971). Gaps in coverage due to collecting biases and database input errors were corrected where possible (Craven 2002b). The number of species present in each quarter-degree square was calculated and mapped.

Distribution data for endemic species were obtained from the specimen dataset as well as literature sources. Records for endemic species were found in 722 out of over 1 200 quarter-degree squares in Namibia. These

were variously arranged and mapped: 1, endemic families, genera and species individually; 2, the number of endemic species per quarter-degree square; 3, the number of quarter-degree squares in which species occurred; and 4, areas where species restricted to only one or two quarter-degree squares were found.

Degree scale

Quarter-degree squares were chosen for the grid scale in order to show patterns of distribution on as fine a resolution as possible and allowing small or more localized centres of diversity to be apparent. Sufficient information at that scale is available for Namibia and the total area or number of quarter-degree square grids is manageable. Where no or few records were recorded in a quarter-degree square, the grids were 'revisited' and any such 'empty' square individually rechecked and improved. Records from keyword searches and literature sources, i.e. checklists for specific areas such as those of Rodin (1985), Giess & Snyman (1986), Hines (1992) and Clarke (1999) as well as collections of the first author, were incorporated.

GIS data

Shapefiles produced in ArcView [Environmental Systems Research Institute (ESRI) 2000] of Namibian features such as soils, topography and rainfall by the Agro-Ecological Zoning Programme (1996–ongoing) and Atlas of Namibia Project (2002), as well as the positions of important mountains (adapted from Irish 2002) were superimposed onto the grid-based plant data. They were used to draw accurate borders, define localities and help pinpoint possible reasons for the variations in diversity. Profiles showing altitude change across the country that were taken at selected latitudes to cut through various notable topographic features (Atlas of Namibia Project

2002) were also overlaid. The vertical scales have been exaggerated to highlight the changes in altitude.

The methodology and tables used, and examples of all stages of the process, is described in more detail in Craven (2002b).

Inventory

The inventory of species endemic to Namibia, taxonomic limits and nomenclature of species follows Craven (1999). The numerous sources for endemic status and updates are listed in Craven (2002b). Genera listed as endemic follow Leistner (2000). Over 600 species (Appendix 1) were investigated and eventually, records for ± 540 endemic spermatophyte species were available for the analysis and maps. Not all endemics were included in the analysis because endemism in some genera appears inflated due to numerous infraspecific taxa (Maggs *et al.* 1998), whereas other genera e.g. *Crassula* (Crassulaceae), *Euphorbia* (Euphorbiaceae), *Salsola* (Chenopodiaceae), *Tetragonia* (Aizoaceae) and some in the family Mesembryanthemaceae need to be revised. Species that are known to occur just over the border of the country were not included, e.g. a number of species in the genus *Commiphora* (Burseraceae) and family Acanthaceae, particularly the genus *Petalidium*.

Maps

Arcview (ESRI 2000) was used to produce the maps. Overall species richness and overall endemism could therefore be superimposed to find possible geographical correlation. Similarly, the shapefiles of the ± 540 species endemic to Namibia for Craven (2002b) were overlaid and the resulting maps scrutinized for congruent patterns. Areas were identified and their species listed, because as

Van Wyk & Smith (2001) point out, such areas will have their own distinctive complement of species.

Endemic species not included by previous authors were assigned to known centres, i.e. Kaokoveld, Gariiep, Waterberg-Otavi and Namibia Central and Southern Highland Centres, where possible. This required looking at locality data of collected specimens for the last two centres, as elements occur at higher elevations or on a specific substrate. The large data set of georeferenced specimens was also used to find subcentres or more localized areas of significance.

RESULTS

Overall patterns of species richness and endemism

Species diversity is higher in localities where one vegetation type shifts to another. Variations in altitude and the maximum altitude in any grid are also significantly related to grid diversity (Figure 2). Only two localities in the northeast region can attribute high species richness to high rainfall. Where summer rainfall species overlap with winter rainfall species, however, there is an increase in diversity, e.g. the Rosh Pinah area. Another influencing factor is mist that occurs along the Namibian coast, which may be responsible for more favourable microclimates and increased species richness inland, e.g. the Namukluft near Rosh Pinah and Aus areas.

Namibian endemics were not found in the northeast, which forms part of the Zambezi Domain of White (1983) as this domain continues into countries further north. The southeast is part of the Kalahari Desert, which extends into Botswana, and no endemics were found there because of the general paucity of species and the

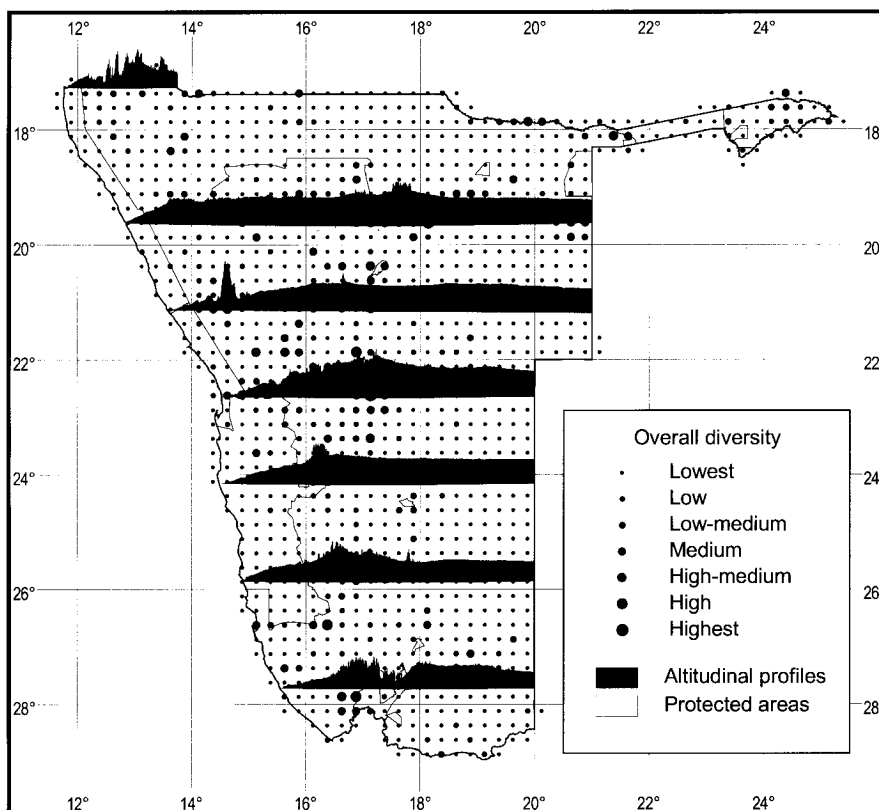


FIGURE 2.—Grid-diversity for Namibia depicted in five classes with altitude profiles showing correlation between changes in altitude and diversity.

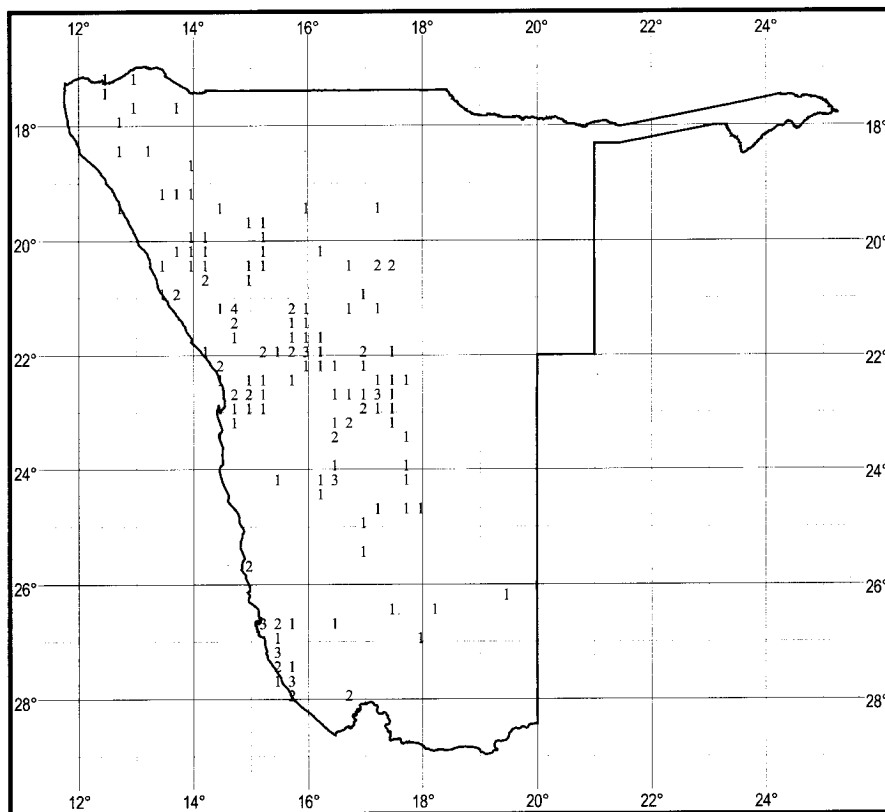


FIGURE 3.—Distribution and number of Namibian endemic genera per quarter-degree grid.

artificial definition of endemic used here. In the rest of Namibia, the map of overall distribution of endemic species does not show any particular spatial pattern. Localities where the quarter-degree squares with the most endemics occur, are often associated with mountains in Namibia. The best example is the Brandberg, which also confirms that endemism increases when mountains are located in deserts. Substrate-specific endemic plants are well known and in Namibia, four *Jamesbrittenia* species occur only in the limestone of the Waterberg-Otavi area (Hilliard 1994). Hot deserts have very high endemism in spite of their limited flora and vegetation and this has been shown in Namibia by the number of endemic species confined to the Namib (Craven 2002b). ArcView shapefiles for physical features of Namibia, e.g. soils, aspects of climate, did not show marked patterns of similarity at this level of resolution.

Geographical comparison of the overall pattern of diversity and that of endemism, as well as areas of importance for localized endemics and that of overall endemics, show a degree of congruence. Important localized areas however, do not always coincide. Because the count is based purely on the number of species or endemics within that square, areas of richness cannot be distinguished by a particular combination of plant species or endemics. In addition, squares with associated floral elements cannot be identified. Thus a particularly rich area may consist of very widespread species.

Families endemic to Namibia

There are no families of higher plants restricted to the political borders of Namibia. The most well-known family that occurs only in southwest Angola and Namibia is Welwitschiaceae.

Genera endemic to Namibia

The natural ranges of sixteen genera fall within Namibia (Figure 3). They are listed in Table 1 with an indication of the number of quarter-degree square grids in which they have been found. With the exception of the genus *Ondetia* (Asteraceae), most of the endemic genera occur in the central and western parts of Namibia. *Arthraerua* (Amaranthaceae), *Marlothiella* (Apiaceae), *Eremothamnus* (Asteraceae), *Namibia*, *Synaptophyllum* (Mesembryanthemaceae) and *Neoluederitzia* (Zygophyllaceae) occur along the coast, whereas *Baynesia* (Apocynaceae) and *Namacodon* (Campanulaceae) grow at higher altitudes. *Manuleopsis*

TABLE 1.—Genera endemic to Namibia and the number of quarter-degree squares in which they occur

Family	Genus	No. QDS
Asteraceae	<i>Ondetia</i>	42
Scrophulariaceae	<i>Manuleopsis</i>	28
Amaranthaceae	<i>Arthraerua</i>	18
Poaceae	<i>Kaokochoa</i>	16
Scrophulariaceae	<i>Chamaegigas</i>	12
Campanulaceae	<i>Namacodon</i>	9
Asteraceae	<i>Eremothamnus</i>	8
Apiaceae	<i>Phlyctidocarpa</i>	6
Apiaceae	<i>Marlothiella</i>	5
Mesembryanthemaceae	<i>Synaptophyllum</i>	5
Mesembryanthemaceae	<i>Namibia</i>	3
Apocynaceae	<i>Baynesia</i>	1
Mesembryanthemaceae	<i>Jensenobotrya</i>	1
Mesembryanthemaceae	<i>Ruschianthus</i>	1
Scrophulariaceae	<i>Dintera</i>	1
Zygophyllaceae	<i>Neoluederitzia</i>	1

QDS, quarter-degree square.

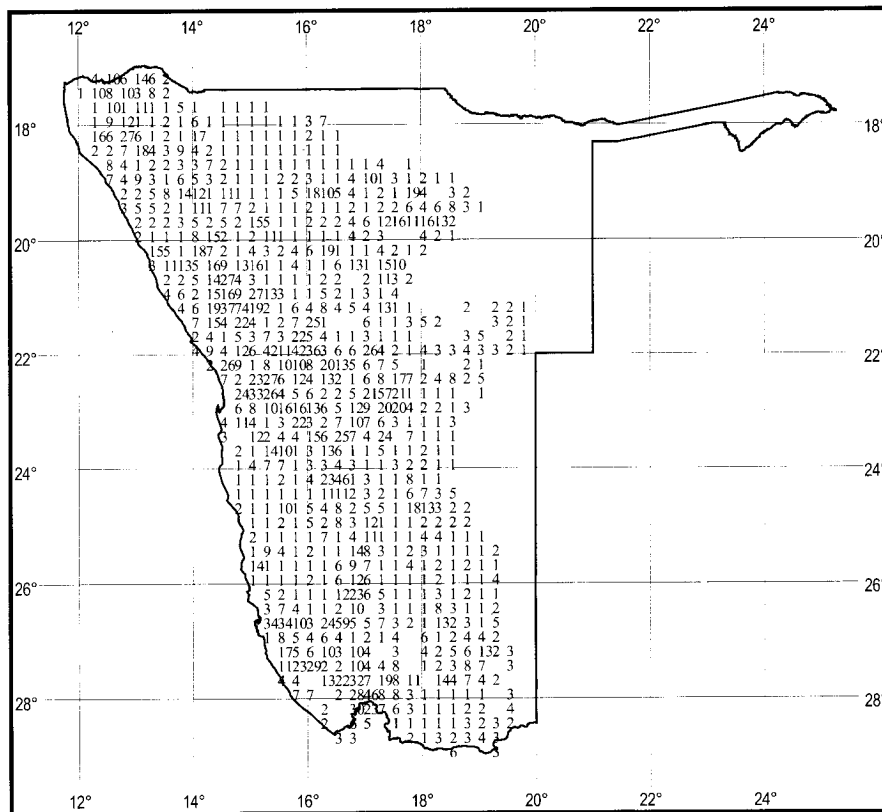


FIGURE 4.—Distribution and number of Namibian endemic species per quarter-degree grid.

(Scrophulariaceae) is fairly widespread, but generally found on higher ground. *Chamaeigigas* (Scrophulariaceae) is a hydrophyte that inhabits pools in granite outcrops in central Namibia.

All four genera in family Mesembryanthemaceae occur in the winter rainfall region of southwest Namibia. Family Apiaceae, with two endemic genera, is of particular interest as it has very few representatives in species and number of individuals in Namibia. A recently described genus, *Baynesia* (Bruyns 2000), attests to the fact that new genera may still be described in Namibia, especially in certain families that require revision, e.g. Mesembryanthemaceae. *Ondetia* occurs close to Botswana and may eventually be found there (Craven & Klaassen 1998). It is very closely related to *Geigeria* (which is presently under revision) and often mistaken for a *Geigeria* species in the field.

There are also four near-endemic genera, i.e. they occur in Namibia and southwestern Angola, namely *Antiphonia* (Asteraceae), *Marcelliopsis* (Amaranthaceae), and *Welwitschia* (Welwitschiaceae). *Volkiella* (Cyperaceae) has been recorded once in Zambia. *Ruschianthemum* (Mesembryanthemaceae), which occurs just over the border in the northern Cape, has been included in *Stoeberia* (Chesselet & Van Wyk 2002).

Species endemic to Namibia

Approximately 600 of the nearly 4 000 indigenous species recorded for Namibia are considered endemic to within the borders of the country (Figure 4) and are found in many different families and genera; 62 of the 157 families in Namibia have endemic species, whereas 231 genera out of 958 genera have endemic species.

The most important families are the Mesembryanthemaceae, Asteraceae and Acanthaceae. The genera *Aloe* (Asphodelaceae), *Euphorbia* (Euphorbiaceae), *Hermannia* (Sterculiaceae), *Jamesbrittenia* (Scrophulariaceae), *Petalidium* (Acanthaceae), *Salsola* (Crassulaceae), *Stipagrostis*, *Eragrostis* (Poaceae) and *Zygophyllum* (Zygophyllaceae) have the most endemic species besides *Conophytum* and *Lithops* (Mesembryanthemaceae), which have numerous infraspecific taxa. Distributions of about 600 endemic species and certain families and genera are mapped in Craven (2002b). Two examples showing distinctive patterns are illustrated here. Family Mesembryanthemaceae (Figure 5) is mainly restricted to the southwestern corner of Namibia which is also the only area with winter rainfall. Figure 6 shows endemism in *Commiphora* which occurs more commonly in the north with few plants in the winter rainfall zone. Some species have very widespread distributions and are well represented in the collection, whereas others are limited to one locality and one collection. One endemic was recorded in 195 different quarter-degree squares, and nine quarter-degree squares had more than 40 endemics. The quarter-degree square with the highest number of species were tabulated (Table 2) and the grid in which the Brandberg occurs is shown to have the most endemic species, followed by the Windhoek area.

Species endemic to localized areas are found mainly in western Namibia, but also in the central regions associated with high elevations. A number of localities were found to house four or more very restricted-range species.

The dominant life form of the endemics of the southwest winter rainfall region is succulents, whereas further inland, i.e. east of the Hunsberg, dwarf shrubs are more

common. The only region with endemic trees is the Kaokoveld. The distribution of endemic grasses shows them to be widespread.

Namibian near-endemic species

Near-endemics are defined here as species that extend marginally into another region, i.e. beyond the political borders of Namibia. Two noteworthy areas for endemics and near-endemics in Namibia have been identified under the auspices of the IUCN Plant Conservation Programme. These centres of exceptional species richness and endemism (Davis & Heywood 1994) are the Kaokoveld in the northwest and the Gariiep in the southwest. Further analysis of near-endemics is needed, including the species in this study. The number of species per quarter-degree square in the northwest and south will be higher.

Taxon phylogeographic centres

Kaokoveld Centre

Considering the topography and climate, it is no wonder that mapped plant distributions show two main subregions besides the Brandberg, namely the coastal strip, which is affected by fog and cooler temperatures, and the inland highlands. Endemics of the coast include *Ectadium rotundifolium*, *Merremia multisecta*, *Hermannia gariiepina* and grasses such as *Chloris flabellata* and *Sporobolus virginicus*. Most of the endemic taxa occurring on the highlands will not be found on the coastal plains. They are more numerous and often confined to mountainous areas.

Subcentres of importance are the Baynes Mountains and the area around Sanitatis and Orupembe. Both areas

have six localized endemics each. Four endemics are found in the Sesfontein area. The family with the most endemics is the Acanthaceae with five representatives and the other endemics are from a wide variety of families.

Gariiep Centre

Relatively numerous local endemics were found around Aus, the Huib Hoch Plateau to Namus Mountains, the Hunsberg and a section of the Warmbad District. Species limited to these subcentres come from a variety of families and vary from grasses and geophytes to succulent Euphorbiaceae and Mesembryanthemaceae. Life form type shows a certain degree of uniformity in some of the subcentres. Dwarf shrubs such as *Caesalpinia merxmullerana* and *Petalidium cymbiforme* are characteristic of the endemics of the Hunsberg, whereas more succulent species, including three in *Euphorbia*, are found on the western side of the Hunsberg in the Numas Mountains. Three succulent mesems are also endemic to the Warmbad District, namely *Antimima eendornensis*, *Schwantesia constanceae* and *S. succumbens*. No specific life forms are characteristic of the Aus area, which is characterized by varying substrates, or the Huib Hoch Plateau areas. Although field work will probably result in many of these species being recorded further afield, some conspicuous plants such as *Caesalpinia merxmullerana* and *Zygophyllum giessii* have not been found to be widespread despite intense searching.

Waterberg-Otavi Centre

Additional species restricted to this centre identified here, but not necessarily only occurring on limestone, are *Heteromorpha papillosa* (Apiaceae), *Pentatrachia avas-montana* (Asteraceae), *Plectranthus dinteri* (Lamiaceae)

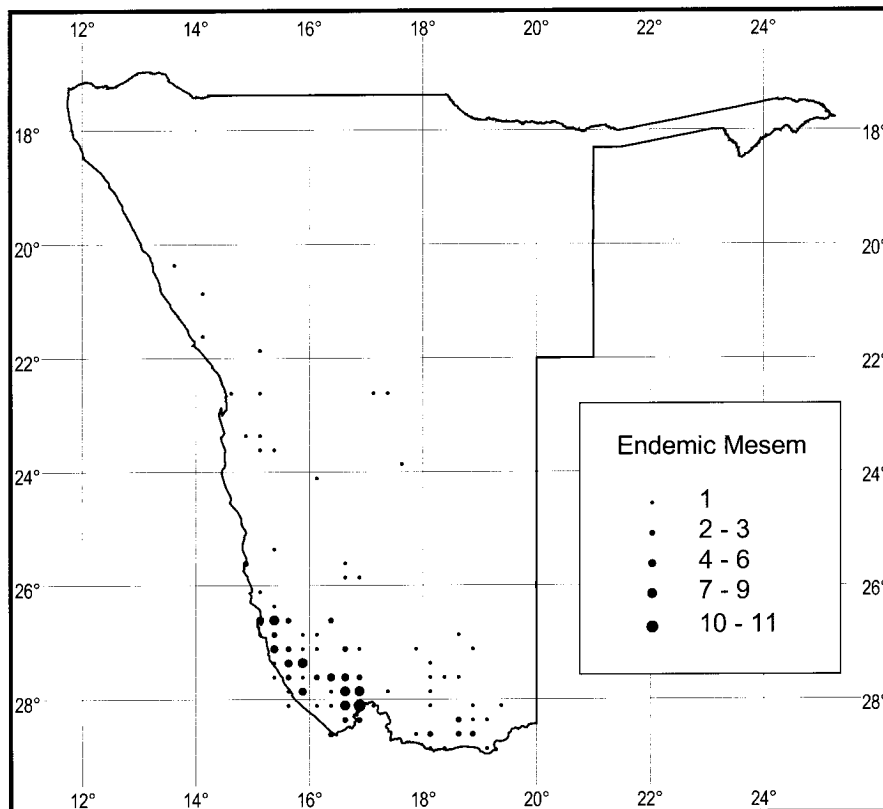


FIGURE 5.—Distribution of endemic plants in Mesembryanthemaceae and diversity per quarter-degree grid.

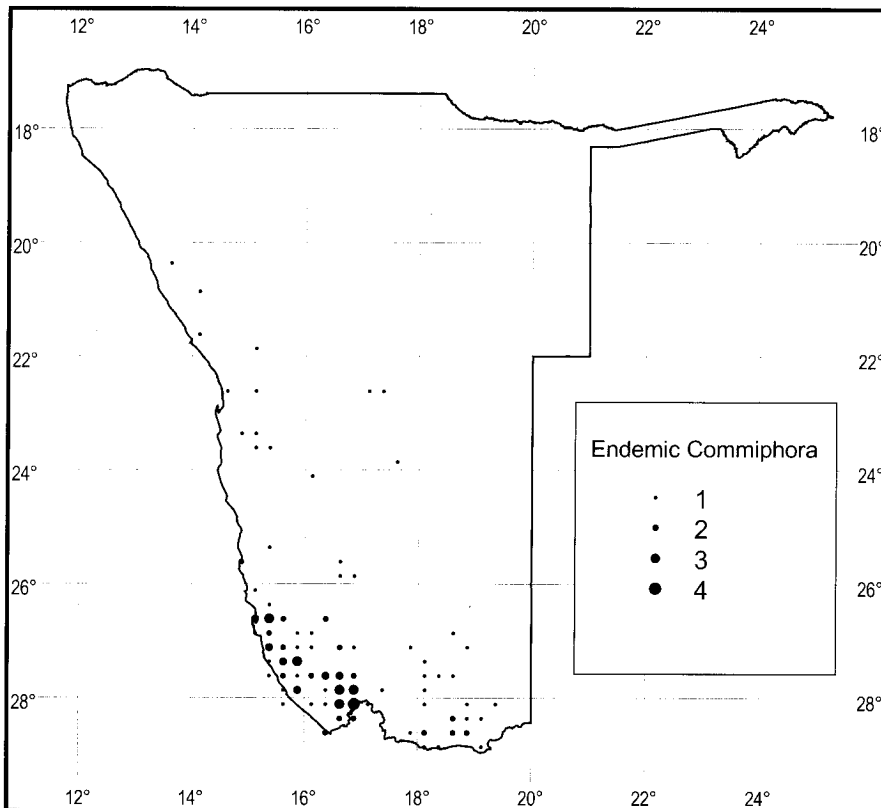


FIGURE 6.—Distribution of endemic plants in *Commiphora* and diversity per quarter-degree grid.

which is also in the Windhoek region, and *Thesium xerophyticum* (Santalaceae) also on the Gamsberg. In addition, *Thesium* is in need of revision and although both the genera *Plectranthus* and *Heteromorpha* have been revised, little or no field work was carried out in Namibia. *Pentatrichia* is presently under revision. Species reported to date only from the Waterberg are *Dintera pterocaulis* (Scrophulariaceae), *Eriospermum citrinum* and *E. lavranosii* (Eriospermaceae).

Central Namibia and Southern Highland Centre

Fifteen Manuleae (Scrophulariaceae) were found to occur in a highland centre (Hilliard 1994) that included the Brandberg, Erongo, Khomashochland, Auas, Gamsberg, Naukluft, Tiras, Karasberg and surrounding high ground, usually above ± 900 m. It excludes the limestone area of the Waterberg, but may stretch into Botswana. An analysis of mapped endemics and habitat data show that numerous range-restricted species are confined to higher elevations, as prescribed by the definition of this centre by Hilliard (1994). The floristic elements range from shrubs (*Nicotiana africana*) and dwarf shrubs (*Corchorus merxmulleri*, *Hermannia merxmulleri*) to geophytes (*Haemanthus avasmontanus*, *Lapeirousia avamontana*) with a few very localized succulents (*Ebracteola montis-moltkei*, *Euphorbia monteiroi* subsp. *brandbergensis*, *Aloe viridiflora*).

DISCUSSION

Numerous hypotheses have been proposed to explain patterns of species diversity (Schmidha & Wilson 1985), but none have been found to apply well to all bodies of data. Underlying datasets and resolution can also result in different patterns of diversity. This is seen when

Namibia is mapped continentally (Mutke *et al.* 2001), regionally (Rebello 1994) or nationally (Maggs *et al.* 1994). In spite of the finer resolution used here, the most species-rich areas in Namibia do not differ much from those first indicated (Maggs *et al.* 1994). The differences lie in better definition of the boundaries, additional localities and important smaller localities. Examples are the Naukluft, Windhoek and Aus regions. The inclusion of the Naukluft as an important area by Maggs *et al.* (1994) was suspected to be an artifact of high collecting intensity and this was proved here to be the case. On the other hand, species richness in the Windhoek area is not necessarily an artifact of good collecting, despite being close to a high population of potential collectors. It includes the second highest mountain in Namibia (Irish 2002), and a number of grasses (Klaassen & Craven 2003), and other species that are not known from elsewhere in Namibia are found here. It indicates that this flora includes outliers from more distant areas and is in agreement with Major (1988), who considers mountains to be mesic refugial islands, which form ideal refuges in times of climate change. Another area of high diversity, near Aus, housed a concentration camp during World War II where the interned German citizens botanized to

TABLE 2.—Quarter-degree squares (QDS) with the most endemic species recorded

QDS	Locality	No. endemic spp.
2114BA	Brandberg area	74
2217CA	Windhoek/Auas Mtn area	63
2616CB	Region around town of Aus	55
2416AB	East of Naukluft Mtns/Farm Bullsport	49
2716DD	Namuskluft Farm, Namus Mtns	43

pass the time. Factors that contribute to the richness of this area include the diverse nature of the topography (the start of the escarpment) and varying substrate (scattered granite outcrops in the area) as well as the fog coming inland from the coast.

Although the plant species diversity map is the most detailed map of its kind for Namibia, care should be taken before using it for management purposes or predictions. Both the delimited areas and the numbers of species predicted for the regions need further refinements. Two aspects of conservation value that it does indicate are: 1, that many areas are more diverse than may appear during periods of harsh conditions, which may last for years or decades; and 2, the relationship between areas set aside as formal conservation areas and diversity. It is apparent that certain areas of high species richness are not afforded any formal protection.

The first map to show the overall distribution of endemic species in Namibia (Maggs *et al.* 1994) was based on 145 species. Endemics of southern Africa, including Namibia, were mapped by Rebelo (1994). Differences between the latter map (regional) and the present one for Namibia (national) are noticeable because of the scale, definition of the word endemic, and datasets used. Maps published in Simmons (1998) and Simmons *et al.* (1998) were based on updated data in Maggs *et al.* (1997) using half-degree squares, because according to Simmons *et al.* (1998), bird data show that this scale reduces collecting bias. The results presented here justify the use of quarter-degree, because working on a national level, more quality control of the data is possible and other sources such as literature, field work and shapefiles of physical features can be used. An undefined 'escarpment' area was said to be the main centre for endemic plants by Simmons *et al.* (1998). Overlaying a defined escarpment developed by the Atlas of Namibia Project (2002) onto the endemic data indicates that this is only partially correct. Although there is an association between increased numbers of endemic species and the escarpment, the area between the northern and southern escarpments also show localities of importance, not only in general, but also for those with limited ranges.

The maps resulting from this study are published by the Atlas of Namibia Project (2002), where they are also combined with maps of Namibian fauna. Mendelsohn *et al.* (2002) conclude that the most notable zones of high diversity for fauna and flora occur in the northeast, in the Karstveld around Tsumeb, in highland areas in the centre of Namibia, and in various scattered areas of higher ground further west. Plant endemism was also combined with that of animals, and Mendelsohn *et al.* (2002) conclude that the overall patterns of endemism in Namibia are quite different from those of overall diversity. The greatest majority of endemics are found in the dry, western and northwestern regions of Namibia. On a regional scale of plants only (and lower resolution), Rebelo (1994) reports a stronger correlation between species richness and endemism.

Namibian endemic plants, as in other parts of the world, are usually associated with altitude, substrate, or variations in geography, which provide numerous microhabitats. The most important areas for species

richness in Namibia, however, are 'transitional' areas, which Shmida & Wilson (1985) define as areas between different ecological regions, i.e. zones in which species overlap. Variations in altitude and the maximum altitude in any grid are significant as reported for Africa as a whole (Linder 1999). Superimposing altitudinal profiles onto the shapefile of species richness shows this clearly (Figure 2). It is also substantiated by studies which show variations in species diversity with altitude for specific sites or localities (Moisel 1982; Rutherford 1992).

Centres of diversity and endemism in Namibia, such as the Kaokoveld and the Gariiep Centre, although lacking consistency in definition, have been discussed by numerous authors. Volk (1964) proposed a Kaoko Element, which was elaborated on by Nordenstam (1974). Hilliard (1994) included two taxa, *Jamesbrittenia canescens* var. *laevior* and *J. heucherifolia* (Scrophulariaceae), which are confined to southern Angola and northern Namibia. Other authors that recognized the Kaokoveld Centre are Hilton-Taylor (1994a), Maggs *et al.* (1994), Maggs *et al.* (1998), Van Wyk & Smith (2001) and Craven (2002a). Hilton Taylor (1994b) considers the Gariiep to be essentially a geographic rather than a phytogeographic centre, but both Nordenstam (1969) and Hilliard (1994) recognize it as a taxon phytogeographic centre of importance for numerous species.

Mapping all Namibian endemics has shown that the distributions of many elements need to be reassessed. Species presently regarded as e.g. Kaokoveld elements, (*Welwitschia mirabilis*, *Acanthosicyos horridus*, *Cyphostemma currorii*, *Acacia robyniana* and *Moringa ovalifolia*) may stretch far beyond what is generally regarded as the centre. Another example is the Brandberg, which is considered an outlier of the Kaokoveld Centre by Nordenstam (1974) and Hilton Taylor (1994a). Provisional results of the floristic elements of the Brandberg (Craven & Craven 2000) show that numerous range-restricted species also occur on other highlands further south and it is rather a part of the Highland Centre as suggested by Hilliard (1994).

The Kaokoveld and the Gariiep Centres are basically geographic regions, so inclusion of species within the centres was based on presence or absence in the area. This is not possible with the Namibia Central and Southern Highland Centre and the Waterberg-Otavi Centre as they are identified by determinants such as habitat or substrate specificity. These centres do not show a clear geographic pattern of distribution on a map until altitude contours or outlines of mountains are included. More endemic species will probably be included in these centres once more is known about such habitat requirements.

The name, Gariiep, has also been used in large-scale mapping by Jürgens (1991) despite a different approach, i.e. including life form and climate in the analyses. Such approaches must not be confused with that of taxon phytogeography as discussed here.

In general, the variable nature of most aspects of Namibia's rainfall, as well as the paucity of overall climatic data, precludes using climate at this level of resolution. It is, however, true to say that Namibia differs from Africa as a whole, because the most species-rich areas

are in the wetter parts of the continent (Linder 1999). This study highlighted the need for the microclimatic conditions in which so many endemics thrive, to be studied and documented in a systematic way. Defining these habitats is essential to understanding the distributions of endemic plants. The same can be said for peculiar or isolated substrata (serpentine, limestone, quartzite, calcareous sands) which is a widespread phenomenon in some areas (Major 1988; Cowling *et al.* 1992), and Namibia is no exception.

Although distribution of endemics among life form classes was not studied here in detail, it is evident that life forms change with locality as recorded for endemic species in general (Major 1988). This is ascribed to climate, history of the flora and competition with the associated flora (Major 1988).

Certain taxa require floristic study and field work, but a provisional assessment suggests that a locality may be home to a variety of species from various taxonomic groups as suggested by Cowling *et al.* (1992).

Knowledge of local endemism will help create a better basis for future policy (Brenan 1978). This study does provide sufficient information on certain aspects of Namibia's endemic plants to start formulating conservation strategies, but there is still a need for satisfactory taxonomic knowledge as well as more distribution data. It is also imperative that the information is used correctly. Simmons *et al.* (1998) concluded that another 11% of the land area would be required to protect Namibia's endemic plants. If the endemic plants already found within protected areas had been removed from the dataset prior to the analysis, the resulting value would be much lower. No matter how highly a species is regarded, as soon as it is adequately conserved, it is no longer used as an argument to conserve another area (Kirkpatrick 1983). Because species are not spread evenly around the world and unique concentrations may occur in relatively small areas, i.e. within the political borders of a country like Namibia, the onus is on Namibia to protect these species.

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APPENDIX 1.—List of Namibian endemic plants used in the evaluation

= Species name in italics indicates a synonym used in the original evaluation.

* Endemic species not used in the evaluation due to lack of data or species described since the evaluation.

• Species that have been collected outside Namibia since the evaluation. Unless otherwise stated, species indicated by • are near-endemic and mainly based on collections of Craven or Bruyns, particularly from Angola.

Acanthaceae

Barleria

- damarensis *T.Anderson*
- dinteri *Oberm.*
- jubata *S.Moore*
- kaloxytona *Lindau*
- lanceolata (*Schinz*) *Oberm.*
- meeuseana *P.G.Mey.*
- merxmülleri *P.G.Mey.*
- solitaria *P.G.Mey.*

Blepharis

- ferox *P.G.Mey.*
- fleckii *P.G.Mey.*
- gigantea *Oberm.*
- meyeri *Vollesen*
- pruinosa *Engl.*
- spinifex *Merxm.*

Hygrophila gracillima (*Schinz*) *Burkill*

Justicia

- cuneata *Vahl* subsp. hoerleiniana (*P.G.Mey.*) *Immelman*
- guerkeana *Schinz*
- platysepala (*S.Moore*) *P.G.Mey.*

Monechma

- calcaratum *Schinz*
- callothamnum *Munday*
- crassiusculum *P.G.Mey.*
- desertorum (*Engl.*) *C.B.Clarke*

grandiflorum *Schinz*

- leucoderme (*Schinz*) *C.B.Clarke*
- serotinum *P.G.Mey.*
- tonsum *P.G.Mey.*

Peristrophe

- grandibracteata *Lindau*
- hereroensis (*Schinz*) *K.Balkwill*
- namibiensis *K.Balkwill*
- subsp. brandbergensis *K.Balkwill*
- subsp. namibiensis

Petalidium

- canescens (*Engl.*) *C.B.Clarke*
- cymbiforme *Schinz*
- giessii *P.G.Mey.*
- lanatum (*Engl.*) *C.B.Clarke*
- linifolium *T.Anderson*
- luteo-album *A.Meeuse*
- *ohopohense *P.G.Mey.*
- pilosi-bracteolatum *Merxm. & Hainz*
- ramulosum *Schinz*
- rautanenii *Schinz*
- subcrispum *P.G.Mey.*

Rhinacanthus kaokoensis *K.Balkwill & S.Williamson*

Ruellia

- aspera (*Schinz*) *E.Phillips*
- brandbergensis *Kers*

Aizoaceae

- Aizoanthemum
 dinteri (Schinz) Friedrich
 galenioides (Fenzl ex Sond.) Friedrich
 rehmannii (Schinz) H.E.K.Hartmann = *Aizoanthemum membrum-connectens* Dinter ex Friedrich
 Aizoon giessii Friedrich
 Tetragonia
 rangeana Engl.
 •schenckii (Schinz) Engl.
 Trianthema hereroensis Schinz

Alliaceae

- Tulbaghia calcarea Engl. & K.Krause, insuff. known

Amaranthaceae

- Arthroa leubnitziae (Kuntze) Schinz
 Calicorema squarrosa (Schinz) Schinz
 Hermbstaedia spatulifolia (Engl.) Baker
 Marcellipsis splendens (Schinz) Schinz

Amaryllidaceae

- Ammocharis nerinoides (Baker) Lehmillier
 Crinum
 paludosum I. Verd.
 rautanenianum Schinz
 Haemanthus avasmontanus Dinter
 *Namaquanula bruynsii Snijman
 *Nerine pusilla Dinter
 Strumaria
 hardyana D.Müll.-Doblies & U.Müll.-Doblies
 phonolithica Dinter

Anacardiaceae

- Rhus
 problematodes Merxm. & Roessler
 volkii Suess.

Apiaceae

- Anginon streyi (Merxm.) I.Allison & B.-E.van Wyk
 Heteromorpha papillosa C.C.Towns.
 Marlothiella gummifera H.Wolff
 Phlyctidocarpa flava Cannon & W.L.Theob.
 Polemanniopsis sp. = Merxmuller & Giess 32010

Apocynaceae

- Australiuma peschii = *Caralluma peschii* Nel
 Baynesia lophophora Bruyns
 Brachystelma
 blepharantthera H.Huber
 codonanthum Bruyns
 recurvatum Bruyns
 schinzii (K.Schum.) N.E.Br.
 schultzei (Schltr.) Bruyns
 •Ceropegia dinteri Schltr.
 Cynanchum meyeri (Decne.) Schltr.
 Ectadium
 latifolium (Schinz) N.E.Br.
 rotundifolium (H.Huber) Venter & Kotze
 •Gomphocarpus semiplectens K.Schum.
 Hoodia
 juttiae Dinter
 officinalis (N.E.Br.) Plowes subsp. delaetiana (Dinter) Bruyns
 ruschii Dinter
 triebneri (Nel) Bruyns
 Huernia
 hallii E.Lamb & B.M.Lamb
 plowesii L.C.Leach
 Larryleachia tirasmontana Plowes = *Lavrania picta* (N.E.Br.) Plowes
 subsp. *parvipunctata* Bruyns
 Lavrania haagnerae Plowes
 Microloma
 hereroense Wanntorp
 penicillatum Schltr.
 Orbea
 albocastanea (Marloth) Bruyns
 maculata (N.E.Br.) L.C.Leach
 •subsp. *kaokoensis* Bruyns
 subsp. *rangeana* (Dinter & A.Berger) Bruyns
 Raphionacme
 haeneliae Venter & R.L.Verh.
 namibiana Venter & R.L.Verh.

Stapelia

- kwebensis N.E.Br. = *Stapelia longipedicellata* (A.Berger) N.E.Br.,
 not endemic
 pearsonii N.E.Br.
 *remota R.A.Dyer
 schinzii A.Berger & Schltr.
 *var. *bergeriana* (Dinter) L.C.Leach
 var. *schinzii*
 •Stapeliopsis urniflora Lavranos
 Stigmatorhynchus hereroensis Schltr.
 Tridentea
 marientalensis (Nel) L.C.Leach subsp. *albipilosa* (Giess) L.C.Leach
 •pachyrrhiza (Dinter) L.C.Leach
 Tromotriche ruschiana (Dinter) Bruyns
 •Tylophora fleckii (Schltr.) N.E.Br.

Aponogetonaceae

- Aponogeton azureus H.Bruggen

Asphodelaceae

- Aloe
 argenticauda Merxm. & Giess
 asperifolia A.Berger
 corallina I. Verd.
 dewinteri Giess
 •dinteri A.Berger
 erinacea D.S.Hardy
 *hereroensis Engl. var. *lutea* A.Berger
 namibensis Giess
 omavandae Van Jaarsv.
 pachygaster Dinter
 sladeniana Pole Evans
 viridiflora Reynolds

Bulbine

- caput-medusae G.Will.
 francescae G.Will. & Baijnath
 namaensis Schinz
 praemorsa = *Bulbine tetraphylla* Dinter, not endemic
 *rhopalophylla Dinter
 Trachyandra
 ensifolia (Sölch) Roessler
 glandulosa (Dinter) Oberm.
 lanata (Dinter) Oberm.
 peculiaris (Dinter) Oberm.

Asteraceae

- Amphiglossa thuja (Merxm.) Koekemoer
 Anisopappus
 pinnatifidus (Klatt) O.Hoffm. ex Hutch.
 pseudopinnatifidus S.Ortiz & Paiva
 Antiphiona
 fragrans (Merxm.) Merxm.
 pinnatisecta (S.Moore) Merxm.
 Arctotis frutescens T.Norl.
 Aspilia eenii S.Moore
 Berkheya schinzii O.Hoffm.
 Calostephane marlothiana O.Hoffm.
 *Chrysocoma puberula Merxm.
 Crassocephalum coeruleum (O.Hoffm.) R.E.Fr.
 Dairesia alliariifolia (O.Hoffm.) B.Nord. & Pelsner = *Senecio alliariifolius* O.Hoffm.
 Dicoma
 cuneneensis Wild
 dinteri S.Moore
 *obconica S.Ortiz & Pulgar
 Eremothamnus marlothianus O.Hoffm.
 Eriocephalus
 dinteri S.Moore
 giessii M.A.N.Müller
 kingesii Merxm. & Eberle
 klinghardtensis M.A.N.Müller
 pinnatus O.Hoffm.
 Euryops
 mucosus B.Nord.
 walterorum Merxm.
 Felicia
 alba Grau
 gunillae B.Nord.
 smaragdina (S.Moore) Merxm.
 *Garuleum schinzii O.Hoffm. subsp. *critum* (Dinter) Merxm.
 Gazania thermalis Dinter

Geigeriaodontoptera *O.Hoffm.*ornativa *O.Hoffm.* subsp. ornativa var. filifolia (Mattf.) *S.Ortiz & Rodr.Oubiña* = *G. englerana* Muschl. & *Geigeria otaviensis* (Merxm.) Merxm.pilifera *Hutch.*plumosa *Muschl.**subsp. angustifolia *S.Ortiz & Rodr.Oubiña*subsp. brachycephala *S.Ortiz & Rodr.Oubiña* = *G. brachycephala* Muschl.rigida *O.Hoffm.*Gorteria diffusa *Thunb.* subsp. parviligulata *Roessler*

Helichrysum

amboense *Schinz*deserticola *Hilliard*erubescens *Hilliard*marlothianum *O.Hoffm.*

Lasiopogon

ponticulus *Hilliard*volkii (*B.Nord.*) *Hilliard*Myxopappus hereroensis (*O.Hoffm.*) *Källersjö*

Nicolasia

heterophylla *S.Moore*subsp. affinis (*S.Moore*) *Merxm.*

subsp. heterophylla

Nidorella nordenstamii *Wild*Nolletia tenuifolia *Mattf.**Norlindhia aptera *B.Nord.*Ondetia linearis *Benth.*

Osteospermum

montanum *Klatt*muricatum *E.Mey. ex DC.* subsp. longiradiatum *T.Norl.*

Othonna

brandbergensis *B.Nord.*clavifolia *Marloth**graveolens *O.Hoffm.*sparsiflora (*S.Moore*) *B.Nord.*

Pegoletia

pinnatilobata (*Klatt*) *O.Hoffm. ex Dinter*plumosa *M.D.Hend.*

Pentatrachia

avasmontana *Merxm.*rehmii (*Merxm.*) *Merxm.**Philyrophyllum brandbergense *P.P.J.Herman*Pentzia tomentosa *B.Nord.*

Pteronia

eenii *S.Moore*polygalifolia *O.Hoffm.*pomona *Merxm.*rangei *Muschl.*spinulosa *E.Phillips*Rennera eenii (*S.Moore*) *Källersjö*

Senecio

engleranus *O.Hoffm.*giessii *Merxm.*hermannii *B.Nord.*windhoekensis *Merxm.*Sphaeranthus wattii *Giess ex Merxm.*Tripteris nervosa *Hutch.*Ursinia frutescens *Dinter*

Vernonia

obionifolia *O.Hoffm.*subsp. dentata *Merxm.*

subsp. obionifolia

Boraginaceae*Ehretia namibiensis *Retief & A.E.van Wyk* subsp. kaokoensis *Retief & A.E.van Wyk*Heliotropium albiflorum *Engl.**Trichodesma angustifolium *Harv.* subsp. argenteum *Retief & A.E.van Wyk***Brassicaceae**

Heliophila

*deserticola *Schltr.* var. micrantha *A.Schreib.*obibensis *Marais***Burseraeae**

Commiphora

*dinteri *Engl.*giessii *J.J.A.van der Walt**kaokoensis *W.Swanepoel*kraeuseliana *Heine**saxicola *Engl.**virgata *Engl.***Campanulaceae**Namacodon schinzianum (*Markgr.*) *Thulin*

Wahlenbergia

densicaulis *Brehmer*erophiloides *Markgr.**intricata (*Dinter & Markgraf*) *P.Craven*, ined. = *Lightfootia dinteri*Engl. ex *Dinter*subumbellata *Markgr.***Capparaceae**

Cleome

carnosa (*Pax*) *Gilg & Gilg-Ben.*foliosa *Hook.f.* var. namibensis (*Kers*) *Codd*laburnifolia *Roessler*suffruticosa *Schinz***Chenopodiaceae***Chenopodium amboanum (*Murr*) *Aellen*

Salsola

albisejala *Aellen*arborea *C.A.Sm. ex Aellen**arabica *Botsch.*campyloptera *Botsch.*cauliflora *Botsch.*columnaris *Botsch.*cryptoptera *Aellen*denudata *Botsch.*dinteri *Botsch.*dolichostigma *Botsch.*etoshensis *Botsch.**garubica *Botsch.*gemmata *Botsch.*giessii *Botsch.*hoanibica *Botsch.*hottentottica *Botsch.*huabica *Botsch.*kleinfonteini *Botsch.*koichabica *Botsch.*marginata *Botsch.*mirabilis *Botsch.*namibica *Botsch.*okaukuejensis *Botsch.**omaruruensis *Botsch.**parviflora *Botsch.*procera *Botsch.*ptiloptera *Botsch.*robinsonii *Botsch.**schreiberiae *Botsch.*scopiformis *Botsch.*seminuda *Botsch.**seydelii *Botsch.*spenceri *Botsch.*swakopmundi *Botsch.*ugabica *Botsch.*unjabica *Botsch.*

Suaeda

articulata *Aellen*salina *B.Nord.***Colchicaceae**Androcymbium exiguum *Roessler* subsp. exiguumOrnithoglossum calcicola *K.Krause & Dinter***Convolvulaceae**Convolvulus argillicola *Pilg.*

Merremia

bipinnatipartita (*Engl.*) *Hallier f.*guerichii *A.Meeuse***Crassulaceae**

Adromischus

schuldianus (*Poelln.*) *Poelln.**subsp. brandbergensis *B.Nord. & Van Jaarsv.*subsp. juttiae (*Poelln.*) *Toelken*

subsp. schuldianus

Crassula

- aurisbergensis *G.Will.*
 ausensis *Hutchison*
 subsp. ausensis
 subsp. giessii (*Friedrich*) *Toelken*
 *subsp. titanopsis *Pavelka*
 elegans *Schönland & Baker f.* subsp. namibensis (*Friedrich*)
 Toelken
 luederitzii *Schönland*
 numaisensis *Friedrich*
Tylecodon
 aridimontanus *G.Will.*
 *aurisbergensis *G.Will. & Van Jaarsv.*

Cucurbitaceae

- Citrullus rehmsii *De Winter*
 Cucumella clavipetiolata *J.H.Kirkbr.*

Cyperaceae

- Bulbostylis mucronata *C.B. Clarke*
 Cyperus rehmsii *Merxm.*

Ebenaceae

- Euclea asperrima *Friedr.-Holzh.*

Eriospermaceae

- Eriospermum**
 buchbergense *Dinter*, insuff. known
 citrinum *P.L.Perry*
 flexum *P.L.Perry*
 *graniticolum *Dinter ex Poelln.*, insuff. known
 halenbergense *Dinter*
 lavranosii *P.L.Perry*
 volkmaninae *Dinter*

Euphorbiaceae

- Euphorbia**
 angrae *N.E.Br.*
 baliola *N.E.Br.*
 caperonioides *R.A.Dyer & P.G.Mey.*
 chamaesycoides *B.Nord.*
 •cibdela *N.E.Br.*
 damarana *L.C.Leach*
 friedrichiae *Dinter*
 giessii *L.C.Leach*
 insarmentosa *P.G.Mey.*
 juttiae *Dinter*
 kaokoensis (*A.C.White, R.A.Dyer & B.Sloane*) *L.C.Leach*
 lavrani *L.C.Leach*
 leistneri *R.H.Archer*
 mauritanica *L.* var. foetens *Dinter ex A.C.White, R.A.Dyer & B.Sloane*
 monteiroi *Hook.f.* subsp. brandbergensis *B.Nord.*
 namibensis *Marloth*
 namuskluftensis *L.C.Leach*
 otjipembana *L.C.Leach*
 pergracilis *P.G.Mey.*
 *pseudoduseimata *A.C.White, R.A.Dyer & B.Sloane*
 rudis *N.E.Br.*
 *spartaria *N.E.Br.*
 *spinea *N.E.Br.*
 venenata *Marloth*
 verruculosa *N.E.Br.*
 volkmaninae *Dinter*
Phyllanthus dinteri *Pax*
Tragia
 dinteri *Pax*
 lancifolia *Dinter ex Pax & K.Hoffm.*

Fabaceae

- Acacia montis-usti *Merxm. & A.Schreib.*
 Bolusia amboensis (*Schinz*) *Harms*
 Caesalpinia
 merxmullerana *A.Schreib.*
 pearsonii *L.Bolus*
Crotalaria
 aurea *Dinter ex Baker f.*
 colorata *Schinz* subsp. colorata
 kurtii *Schinz*
 Decorsea dinteri (*Harms*) *Verdc.*
 Elephantorrhiza
 rangei *Harms*
 schinziana *Dinter*

Eriosema harmsiana *Dinter*

- Erythrina decora *Harms*
 Haematoxylum dinteri (*Harms*) *Harms*
Indigofera
 acanthoclada *Dinter*
 anabibensis *A.Schreib.*
 giessii *A.Schreib.*
 hochstetteri *Baker* subsp. streyana (*Merxm.*) *A.Schreib.*
 merxmulleri *A.Schreib.*
 pechuelii *Kuntze*
 rautaneii *Baker f.*
Lebeckia
 dinteri *Harms*
 obovata *Schinz*
Lessertia
 acanthorhachis (*Dinter*) *Dinter*
 cryptantha *Dinter*
 eremicola *Dinter*
Lotononis
 bracteosa *B.-E.van Wyk*
 mirabilis *Dinter*
 pachycarpa *Dinter ex B.-E.van Wyk*
 pallidirosea *Dinter & Harms*
 schreiberi *B.-E.van Wyk*
Sesbania pachycarpa *DC.* subsp. dinterana *J.B.Gillett*
Tephrosia
 griseola *H.M.L.Forbes*
 monophylla *Schinz*
 pallida *H.M.L.Forbes*

Frankeniaceae

- Frankenia pomonensis *Pohnert*

Geraniaceae

- Monsonia**
 deserticola *Dinter ex R.Knuth*
 drudeana *Schinz*
 ignorata *Merxm. & A.Schreib.*
 trilobata *Kers*
Pelargonium
 cortusifolium *L'Hér.*
 mirabile *Dinter*
 otaviense *R.Knuth*
 paniculatum *Jacq.*
Sarcocaulon
 inermis *Rehm*
 marlothii *Engl.*
 peniculinum *Moffett*

Hyacinthaceae

- Albuca**
 amboensis (*Schinz*) *Oberm.*
 *englerana *K.Krause & Dinter*
 hereroensis *Schinz*
 *karasbergensis *P.E.Glover*
 *reflexa *Dinter & K.Krause*
Drimia
 namibensis (*Oberm.*) *J.C.Manning & Goldblatt* = *Rhadamanthus namibensis* *Oberm.*
 secunda (*B.Nord.*) *J.C.Manning & Goldblatt* = *Rhadamanthus secundus* *B.Nord.*
Lachenalia
 giessii *W.F.Barker*
 klinghardtiana *Dinter*
 namibiensis *W.F.Barker*
 nutans *G.D.Duncan*
 pearsonii (*P.E.Glover*) *W.F.Barker*
Ledebouria scabrata *Jessop*
Ornithogalum
 candidum *Oberm.*
 rautaneii *Schinz*
 stapffii *Schinz*
 tubiforme (*Oberm.*) *Oberm.*

Hypoxidaceae

- Hypoxis dinteri *Nel*

Iridaceae

- Babiana longicollis *Dinter*
 •Ferraria schaeferi *Dinter*
Lapeirousia
 avasmontana *Dinter*
 gracilis *Vaupel*

Moraea

- garipensis *Goldblatt*
 *granitica *Goldblatt*
 hexaglottis *Goldblatt*
 namibensis *Goldblatt*
 rigidifolia *Goldblatt*

Kirkiaceae

- Kirkia dewinteri* *Merxm. & Heine*

Lamiaceae

- Acrotome fleckii* (*Gürke*) *Launert*
Aeollanthus namibiensis *Ryding*
Hemizygia floccosa *Launert*
Plectranthus
 dinteri *Briq.*
 unguentarius *Codd*
Stachys dinteri *Launert*
 • *Tetradenia kaokoensis* *Van Jaarsv. & A.E. van Wyk*

Lobeliaceae

- Lobelia hereroensis* *Schinz*

Loranthaceae

- Agelanthus discolor* (*Schinz*) *Balle*

Lythraceae

- Nesaea luederitzii* *Koehne* var. *hereroensis* *Koehne*

Malvaceae

- Hibiscus*
 dinteri *Hochr.*
 discophorus *Hochr.*
 fleckii *Gürke*
 merxmuelleri *Roessler*
 sulfuranthus *Ulbr.*
Pavonia rehmannii *Szyszl.*

Mesembryanthemaceae

- Amphibolia saginata* (*L.Bolus*) *H.E.K.Hartmann*
Antimima
 argentea (*L.Bolus*) *H.E.K.Hartmann*
 aurasensis *H.E.K.Hartmann*
 buchbergensis (*Dinter*) *H.E.K.Hartmann*
 dolomitica (*Dinter*) *H.E.K.Hartmann*
 eendornensis (*Dinter*) *H.E.K.Hartmann*
 modesta (*L.Bolus*) *H.E.K.Hartmann*
 quarzitica (*Dinter*) *H.E.K.Hartmann*
Astridia hallii *L.Bolus*
Brownanthus
 • *arenosus* (*Schinz*) *Ihlenf. & Bittrich*
 namibensis (*Marloth*) *Bullock*
 pubescens (*N.E.Br. ex Maass*) *Bullock*
Cephalophyllum
 • *compressum* *L.Bolus*
 confusum (*Dinter*) *Dinter & Schwantes*
Cheiridopsis caroli-schmidtii (*Dinter & A.Berger*) *N.E.Br.*
Conophytum
 halenbergense (*Dinter & Schwantes*) *N.E.Br.*
 klingshardense *Rawe*
 subsp. *baradii* (*Rawe*) *S.A.Hammer*
 subsp. *klingshardense*
 quaesitum (*N.E.Br.*) *N.E.Br.* subsp. *densipunctum* (*L.Bolus*)
 S.A.Hammer
 ricardianum *Loesch & Tischer*
 subsp. *ricardianum*
 subsp. *rubiflorum* *Tischer*
 taylorianum (*Dinter & Schwantes*) *N.E.Br.*
 subsp. *ernianum* (*Loesch & Tischer*) *de Boer ex S.A.Hammer*
 subsp. *taylorianum*
Delosperma klingshardianum *Schwantes*
Dinteranthus microspermus (*Dinter & Derenb.*) *Schwantes* subsp.
 impunctatus *N.Sauer*
 • *Dracophilus delaetinus* (*Dinter*) *Dinter & Schwantes*
Drosanthemum
 nordenstamii *L.Bolus*
 pauper (*Dinter*) *Dinter & Schwantes*
Eberlanzia clausa (*Dinter*) *Schwantes*
Ebracteola
 derenbergiana (*Dinter*) *Dinter & Schwantes*
 montis-moltkei (*Dinter*) *Dinter & Schwantes*

- Fenestraria rhopalophylla* (*Schltr. & Diels*) *N.E.Br.* subsp. *rhopalophylla*

- Jensenobotrya lossowiana* *A.G.J.Herre*

Juttadinteria

- attenuata* *Walgate*
 • *ausensis* (*L.Bolus*) *Schwantes*
 deserticola (*Marloth*) *Schwantes*
 simpsonii (*Dinter*) *Schwantes*
Lithops
 dinteri *Schwantes*
 subsp. *dinteri*
 • subsp. *multipunctata* (*de Boer*) *D.T.Cole*
 • *francisci* (*Dinter & Schwantes*) *N.E.Br.*
 • *gracilidelineata* *Dinter* subsp. *brandbergensis* (*de Boer*) *D.T.Cole*
 • *hermetica* *D.T.Cole*
 julii (*Dinter & Schwantes*) *N.E.Br.* subsp. *julii*
 karasmontana (*Dinter & Schwantes*) *N.E.Br.*
 • subsp. *bella* (*N.E.Br.*) *D.T.Cole*
 • subsp. *eberianzii* (*Dinter & Schwantes*) *D.T.Cole*
 • *optica* (*Marloth*) *N.E.Br.*
 pseudotruncatella (*A.Berger*) *N.E.Br.*
 • subsp. *archerae* (*de Boer*) *D.T.Cole*
 • subsp. *dendritica* (*Nel*) *D.T.Cole*
 • subsp. *volkii* (*Schwantes ex de Boer & Boom*) *D.T.Cole*
 • *ruschiorum* (*Dinter & Schwantes*) *N.E.Br.*
 schwantesii *Dinter*
 • subsp. *gebseri* (*de Boer*) *D.T.Cole*
 subsp. *schwantesii*
 • *vallis-mariae* (*Dinter & Schwantes*) *N.E.Br.*
 wernerii *Schwantes ex H.Jacobsen*

- *Malephora engleriana* (*Dinter & A.Berger*) *Schwantes*

- Mesembryanthemum pellitum* *Friedrich*

Namibia

- cinerea* (*Marloth*) *Dinter & Schwantes* = *Namibia ponderosa*
 (*Dinter & Schwantes*) *Dinter & Schwantes*
 pomona (*Dinter*) *Dinter & Schwantes ex Walgate*
Psammophora
 • *nissenii* (*Dinter*) *Dinter & Schwantes*
 • *saxicola* *H.E.K.Hartmann*

Psilocaulon

- gessertianum* (*Dinter & A.Berger*) *Dinter & Schwantes*
 • *salicornioides* (*Pax*) *Schwantes*

Ruschia

- deminuta* *L.Bolus*
 • *namusmontana* *Friedrich*
 • *odontocalyx* (*Schltr. & Diels*) *Schwantes*
 • *pollardii* *Friedrich*
 • *ruschiana* (*Dinter*) *Dinter & Schwantes*
 vulvaria (*Dinter*) *Schwantes*

- Ruschianthus falcatus* *L.Bolus*

Schwantesia

- constanceae* *N.Zimm.*
 succumbens (*Dinter*) *Dinter*
Synaptophyllum juttiae (*Dinter & A.Berger*) *N.E.Br.*
 • *Titanopsis schwantesii* (*Schwantes*) *Schwantes*
 • *Trichodiadema littlewoodii* *L.Bolus*

Molluginaceae

- *Corbichonia rubriviolacea* (*Friedrich*) *Jeffrey*
Hypertelis caespitosa *Friedrich*
Mollugo walteri *Friedrich*
Suessenguthiella caespitosa *Friedrich*

Nyctaginaceae

- Boerhavia deserticola* *Codd*
Commicarpus
 • *decipiens* *Meikle*
 fruticosus *Pohnert*

Orobanchaceae

- Alectra*
 pseudobarleriae (*Dinter*) *Dinter*
 schoenfelderi *Dinter & Melch.*

Oxalidaceae

- Oxalis*
 ausensis *R.Knuth*
 hunsbergensis *ined.*

Oxalis (cont.)

- luederitzii *Schinz*
 pseudo-cernua *R.Knuth*
 schaeferi *R.Knuth*

Passifloraceae

- *Adenia pechuelii* (*Engl.*) *Harms*

Pedaliaceae

- Rogeria bigibbosa* *Engl.*
Sesamothamnus leistneranus, ined. = *De Winter & Leistner 5504*
Sesamum
 abbreviatum *Merxm.*
 marlothii *Engl.*

Plumbaginaceae

- Limonium dyeri* *Lincz.*
Plumbago
 pearsonii *L.Bolus*
 wissii *Friedrich*

Poaceae

- **Brachiaria schoenfelderi* *C.E.Hubb. & Schweick.*
Eragrostis
 aristata *De Winter*
 kingesii *De Winter*
 omahekensis *De Winter*
 pygmaea *De Winter*
 sabiniae *Launert*
 scopelophila *Pilg.*
 stenothyrsa *Pilg.*
 walteri *Pilg.*
 • *Kaokochloa nigrirostris* *De Winter*
Merxmuellera rangei (*Pilg.*) *Conert*
 **Panicum pearsonii* *F.Bolus*
Pennisetum foermeranum *Leeke*
Pogonarthria leiarthra *Hack.*
Setaria finita *Launert*
Sporobolus nebulosus *Hack.* (endemic to southern Africa)
Stipagrostis
 • *damarensis* (*Mez*) *De Winter*
garubensis (*Pilg.*) *De Winter*
gonatostachys (*Pilg.*) *De Winter*
 • *hermannii* (*Mez*) *De Winter*
lanipes (*Mez*) *De Winter*
namibensis *De Winter*
pellytronis *De Winter*
 • *ramulosa* *De Winter*
sabulicola (*Pilg.*) *De Winter*
seelyae *De Winter*

Polygalaceae

- *Polygala guericiana* *Engl.*

Portulacaceae

- Anacampseros filamentosa* (*Haw.*) *Sims* subsp. *tomentosa* (*A.Berger*)
Gerbaulet
Avonia dinteri (*Schinz*) *G.D.Rowley* = *Anacampseros dinteri* *Schinz*
 • *Ceraria longipedunculata* *Merxm. & Podlech*

Rubiaceae

- Amphiasma*
 divaricatum (*Engl.*) *Bremek.*
 merenskyanum *Bremek.*
Kohautia
 amboensis (*Schinz*) *Bremek.*
 azurea (*Dinter & K.Krause*) *Bremek.*

Santalaceae

- Thesium xerophyticum* *A.W.Hill*

Scrophulariaceae

- Anticharis*
 ebracteata *Schinz*
 imbricata *Schinz*
 inflata *Marloth & Engl.*
Aptosimum
 arenarium *Engl.*
 suberosum *F.E.Weber*
Chamaegigas intrepidus *Dinter ex Heil*
Cromidon pusillum (*Roessler*) *Hilliard*
Diclis tenuissima *Pilg.*
Dintera pterocaulis *Stapp*

Jamesbrittenia

- acutiloba* (*Pilg.*) *Hilliard*
barbata *Hilliard*
bicolor (*Dinter*) *Hilliard*
chenopodioides *Hilliard*
dolomitica *Hilliard*
fimbriata *Hilliard*
fleckii (*Theell.*) *Hilliard*
fragilis (*Pilg.*) *Hilliard*
giessii *Hilliard*
hereroensis (*Engl.*) *Hilliard*
lyperioides (*Engl.*) *Hilliard*
pallida (*Pilg.*) *Hilliard*
pilgeriana (*Dinter*) *Hilliard*
primuliflora (*Theell.*) *Hilliard*
sessilifolia (*Diels*) *Hilliard*

Manulea

- dubia* (*Skam*) *Overkott ex Roessler*
namibensis (*Roessler*) *Hilliard*
tenella *Hilliard*

Manuleopsis dinteri *Theell.*

Nemesia

- karasbergensis* *L.Bolus*
violiflora *Roessler*

• *Phyllopodium hispidulum* (*Theell.*) *Hilliard*

Selago

- amboensis* *Rolfe*
lepida *Hilliard*
nachtigalii *Rolfe*

Solanaceae

- Lycium grandicalyx* *Joubert & A.M.Venter*
Nicotiana africana *Merxm.*
Solanum
 damarense *Bitter*
 dinteri *Bitter*
 rigescentoides *Hutch.*

Sterculiaceae

- Dombeya rotundifolia* (*Hochst.*) *Planch.* var. *velutina* *I.Verd.*

Hermannia

- amabilis* *Marloth ex K.Schum.*
 **complicata* *Engl.*
elliottiana (*Harv.*) *K.Schum.*
engleri *Schinz*
glandulosissima *Engl.*
juttae *Dinter & Engl.*
merxmuelleri *Friedr.-Holzh.*
minimifolia *Friedr.-Holzh.*
solaniflora *K.Schum.*

Tecophilaeaceae

- *Eremiolirion amboensis* = *Cyanella amboensis* *Schinz*

Tiliaceae

- Corchorus merxmuelleri* *Wild*

Turneraceae

- Turnera oculata* *Story* var. *paucipilosa* *Oberm.*

Verbenaceae

- Priva auricoccea* *A.Meeuse*

Vitaceae

- Cyphostemma*
bainesii (*Hook.f*) *Desc.*
 **juttae* (*Dinter & Gilg*) *Desc.*
omburense (*Gilg & M.Brandt*) *Desc.*

Zygophyllaceae

- Neoluederitzia sericeocarpa* *Schinz*
Zygophyllum
 applanatum *Van Zyl*
 cylindrifolium *Schinz*
 giessii *Merxm. & A.Schreib.*
 hirticaule *Van Zyl*
 longistipulatum *Schinz*
 • *stapffii* *Schinz*, previously known as *Z. orbiculatum* in Angola