

The flora of Angola: first record of diversity and endemism

Estrela Figueiredo¹, Gideon F. Smith² & Joaquim César³

¹ Herbarium, Instituto de Investigação Científica Tropical, Trav. Conde da Ribeira 9, 1300-142 Lisboa, Portugal/
H.G.W.J. Schweickerdt Herbarium, Department of Botany, University of Pretoria, Pretoria, 0002 South Africa.
estrelafigueiredo@hotmail.com (author for correspondence)

² Office of the Chief Director: Biosystematics Research and Biodiversity Collections, Private Bag X101, Pretoria, 0001
South Africa / John Acocks Chair, H.G.W.J. Schweickerdt Herbarium, Department of Botany, University of Pretoria,
Pretoria, 0002 South Africa. smithg@sanbi.org

³ Instituto de Investigação Agronómica, Estrada de Catete, km 5, C.P. 2104, Luanda, Angola. joaquimcesar@hotmail.com

Angola is the only southern African country for which a plant inventory has not been produced to date. The lack of a country-level floristic checklist has seriously hampered the estimation of levels of diversity and endemism, and other conservation-driven initiatives. This deficiency was addressed in a collaborative initiative recently concluded among over 30 international project participants. This paper presents the results of the project that aimed, among other things, to survey the Angolan flora as part of producing a floristic checklist. The study revealed that Angola has a total number of 6,735 indigenous species, and a total vascular flora of 7,296 taxa (including naturalised taxa), of which 1,069 taxa (997 species and 72 infraspecific taxa) are endemic.

KEYWORDS: Angola, endemism, floristics, southern Africa

INTRODUCTION

Comprehensive inventories that catalogue the occurrence of components of biodiversity in any given geographical region remain fundamental, indeed essential, research tools for conservation planners and other users of biodiversity information. Access to basic biodiversity information is therefore critical for managing the biological resources of any country. Without a basic taxonomic platform, it is exceedingly difficult to evaluate the conservation status of rare plants and it may prove to be difficult to implement proposed conservation measures and assess their success. Likewise, ecological and vegetation studies that often depend on plant diversity catalogues and a taxonomic framework cannot be adequately and reliably developed (Smith & Wolfson, 2004).

In spite of its richness and diversity, the flora of Angola presented a serious gap in the knowledge of the southern African plant diversity which has been referred in the literature (e.g., Huntley & Matos, 1994; Soares & al., 2007; Figueiredo, 2008). Although progress had been made with compiling an inventory of the flora of that country, for example through the Southern African Botanical Diversity Network (SABONET) project, a complete checklist remained elusive. Until now, the figures for vascular plant diversity and endemism in Angola were unknown and could only be estimated.

One reason for this gap in the knowledge of the plant diversity is that, unlike most African countries, Angola was not included in any of the major African regional Flora

projects. Instead, its flora was treated separately in the work *Conspectus Florae Angolensis* (CFA), which remains incomplete (Exell & Mendonça, 1937, 1951, 1954, 1955; Exell & Fernandes 1962, 1966; Exell & al., 1970; Schelpe & al., 1977; Fernandes, 1982; Diniz, 1993). While other regional Floras, such as the *Flora of Tropical East Africa* and *Flora Zambesiaca* are now nearing completion, production of the CFA has stopped, leaving much of the flora uncatalogued and certainly under-studied. Furthermore, with a war in Angola over a period of 30 years, field work became impossible and collections kept locally became unavailable for study. At present, existing collections of Angolan plant material available to researchers are still mostly those kept in several European herbaria, dating from the pre-war years. The European herbaria that are usually visited by researchers, such as K (Royal Botanic Gardens, Kew), BM (The Natural History Museum, London) and P (Muséum National d'Histoire Naturelle, Paris) are rich in Angolan type material (collections mostly of F. Welwitsch from the 19th century and J. Gossweiler from the first half of the 20th century) but lack a good representation of more recent collections (i.e., from the 1960s to the 1970s). These can mostly be found at LISC, the Herbarium of the Instituto de Investigação Científica Tropical, Lisbon (IICT). The need to examine the collections kept in this Herbarium by researchers working on groups with a significant representation in Angola, cannot be overemphasized. It is estimated that the two tropical herbaria in Lisbon, LISC and LISU (University of Lisbon), hold ca. 90,000 collections from Angola, including the first sets of the Welwitsch

and Gossweiler collections. A large number of specimens of the more recent collections remain undetermined.

To contribute to the improvement of the knowledge of Angolan plant diversity, an international project, *Flora of Angola* (FLAN), was developed as a collaboration among three institutions: the South African National Biodiversity Institute (SANBI) in South Africa, the IICT in Portugal and the Instituto de Investigação Agronómica (IIA) in Angola (Figueiredo & Smith, 2008). The expertise existing at SANBI, acquired through running the SABONET initiative and several projects on the compilation of plant diversity data, and the richness in Angolan collections of the Herbarium of the IICT, made these two institutions the preferred partners for a project with the IIA, which holds one of the most important herbaria in Angola (the Herbarium LUA from Huambo, currently temporarily housed in Luanda).

MATERIAL AND METHODS

For one year (2007) the project was developed at and conducted from the National Herbarium of SANBI in Pretoria, in collaboration with IICT and IIA. One of the primary aims of the project was to produce an inventory of the vascular flora of Angola by compiling it from existing hardcopy, electronic and herbarium specimen information, and by obtaining input from experts in a short period of time for the quick delivery of a preliminary list of accepted names complemented with synonyms applicable to the country. Some 32 researchers from nine countries collaborated in this joint effort, contributing to the production of the list. Ultimately, the compilation of data was accomplished in 18 months, following an introductory project scoping period of 6 months. For many families, the list also contains reference to specimens (particularly types) and geographical distribution ranges. The list is published as a book (Figueiredo & Smith, 2008) and it will also be made available through the internet in the SANBI website (<http://www.sanbi.org>). Although it is expected that a list produced over such a short period may have omissions and errors, it will serve as a basis for further research and it will eventually be improved as studies are developed in specific groups.

The data were compiled making use of several electronic facilities and this list can be considered an example of how these facilities can result in a much quicker delivery of biodiversity data compilations. Researchers can now access lists of taxa and synonyms available in several online databases, such as the African Flowering Plants Database (<http://www.ville-ge.ch/cjb/bd/africa/> or <http://www.sanbi.org/frames/dbasesfram.htm>), the World Checklist of Selected Plant Families (<http://www.kew.org/wcsp/home.do>) or the International Legume Database and Information

Service (<http://www.ildis.org/>). Floras are also available online (e.g., Flora Zambesiaca, <http://www.kew.org/efloras/namesearch.do>). Herbaria have collections online (e.g., Kew Herbarium Catalogue, <http://www.kew.org/herbcat/gotoHomePage.do>), and these can be accessed either directly or through a platform such as GBIF (<http://data.gbif.org/welcome.htm>). Nomenclature issues can mostly be checked in the International Plant Names Index (IPNI) site (<http://www.ipni.org/index.html>) or the W³Tropicos site (<http://mobot.mobot.org/W3T/Search/vast.html>). The ALUKA website (<http://www.aluka.org/>) also proves to be an invaluable tool for locating and examining type material, even though it has restricted access.

RESULTS AND DISCUSSION

The FLAN list (Figueiredo & Smith, 2008) provides taxon-based figures on the diversity of the vascular flora of Angola for the first time. Up to the present, the figure estimated for this flora was ca. 5,000 species (Lebrun & Stork, 1991) or 5,185 species (http://www.sabonet.org.za/countries/countries_angola_factsheet.htm, accessed in January 2008). It had also been estimated that the 2,137 species recorded in CFA constituted 40% of the total number (Kendrick, 1989), i.e., the total flora would be ca. 5,342 species. The results presented here (Table 1) show that these figures were underestimated by about 20%! According to our results, the total number of indigenous species is 6,735 and the total flora (including naturalized species) consists of 7,296 taxa in 250 families and 1,745 genera. Compared to the floras of other southern and southern tropical African countries (Table 2), the flora of Angola appears to be the second richest in diversity, after that of South Africa. The Fabaceae, Poaceae and Asteraceae are the most diverse families (Table 3) and the Fabaceae, Rubiaceae and Euphorbiaceae are those with the highest levels of endemism.

With regard to endemism, the figure presented in the SABONET fact sheets (http://www.sabonet.org.za/countries/countries_angola_factsheet.htm, accessed in January 2008) is 1,260 endemic plants. The same figure had been quoted by Stuart & Adams (1990) and Brenan (1978) referring to species. The figure obtained in our list (Table 1)

Table 1. Diversity^a and endemism in the vascular flora of Angola.

Taxonomic rank	Total	Indigenous	Introduced	Endemics
Species	6,961	6,735	226	997
Infraspecific	335	331	4	72

^a“diversity” here refers to the smallest taxonomic units.

is 997 species. The figure of 1,260 species is reported in Brenan (1978) as an estimate based on a sample. Since this figure is not based on a list of taxa it is impossible to determine the reasons for this discrepancy. Assessing the number of endemics is a complex task. Often there is no indication in the literature whether figures refer to strict endemics or whether they include near-endemics, or even if they refer to species only or if they include infraspecific taxa. Furthermore, the numbers of endemics are subject to constant change as known areas of distribution expand (when plants listed as endemic to a particular area are determined to occur elsewhere) or if endemic taxa are taxonomically included under more widespread taxa. For the same reasons, the numbers presented in our list have also to be taken with caution. For many species, the lack of information did not allow us to assess the distribution, which in some cases may be restricted to Angola. We believe the number of plants endemic to Angola will be higher once research is conducted on undetermined specimens and unnamed entities are described.

Table 2. Diversity and endemism in the floras of southern and south tropical Africa.

Country (area)	Flora (species)	Endemic species ^a	Rate of endemism
Angola (1,246,700 km ²)	6,735	997	14.80%
Botswana (581,730 km ²)	2,151	15	0.69%
Lesotho (30,355 km ²)	1,591	17	1.06%
Malawi (118,484 km ²)	5,500	122	2.21%
Mozambique (801,590 km ²)	5,692	177	3.10%
Namibia (824,268 km ²)	3,961	687 ^b	17.34%
South Africa ^c (1,220,088 km ²)	19,581	11,700	59.75%
Swaziland (17,365 km ²)	3,400	12	0.35%
Zambia (752,614 km ²)	4,747	201	4.23%
Zimbabwe (390,759 km ²)	4,440	214	4.81%

Source: http://www.sabonet.org.za/countries/countries_angola_factsheet.htm, accessed in January 2008.

^aNumbers for “endemic plants” in the source are given; it is here assumed that they refer to species.

^bAs given by Maggs & al. (1998).

^cAs given by Steenkamp & Smith (2006).

Table 3. Vascular plant families with highest values for diversity^a and/or endemism in Angola.

Family	Species ^b	Infraspecific taxa
Acanthaceae	206 (33E)	3
Amaranthaceae	68 (13E 11I)	2 (2I)
Anacardiaceae	61 (18E 5I)	0
Annonaceae	74 (18E)	4
Anthericaceae	45 (23E)	3
Apocynaceae	222 (17E 3I)	4
Asphodelaceae	33 (16E)	1 (1E)
Asteraceae	463 (45E 6I)	26 (5E)
Capparaceae	39 (14E)	1 (1E)
Convolvulaceae	88 (8E 3I)	5
Cucurbitaceae	64 (8E 2I)	0
Cyperaceae	267 (25E 1I)	15
Euphorbiaceae	276 (77E 12I)	17 (6E)
Fabaceae	934 (173E 62I)	79 (14E 1I)
Hyacinthaceae	40 (24E)	0
Lamiaceae	202 (50E 2I)	12 (1E)
Malvaceae	91 (1E 3I)	3
Melastomataceae	66 (19E)	3 (2E)
Orchidaceae	231 (17E 1I)	4
Orobanchaceae	78 (7E)	4 (2E)
Poaceae	526 (2E 13I)	14
Rubiaceae	444 (79E 1I)	40 (6E)
Tiliaceae	73 (26E)	0
Vitaceae	52 (12E 1I)	1

^a“diversity” here refers to the smallest taxonomic units.

^bE = endemic; I = introduced.

Exell & Gonçalves (1973) published an analysis of the endemism in the flora of Angola—out of a sample of 1,379 species, 378 (27.3%) were endemic. Since then, it has often been inferred in the literature that the rate of endemism of that flora is higher than that of the floras of neighboring countries. For example, Linder (2001) noted that “much of Angola is surprisingly high in endemism”, but his analysis was based on a sample of 1,818 entities (including the speciose genus *Crotalaria* which has 46 species endemic to Angola). In fact, the rate of endemism in Angola appears to be much lower than it had been generally estimated based on the results of Exell & Gonçalves (1973), and lower than that determined for Namibia. The data in Exell & Gonçalves was based on volumes 2, 3 and 4 of CFA (Exell & Mendonça, 1954, 1955; Exell & Fernandes 1962, 1966; Exell & al., 1970) and included the family with the higher rate of endemism in Angola, the Leguminosae. In

CFA, 271 taxa of Leguminosae were recorded as endemic to Angola. Even though Exell & Gonçalves (1973) state that they updated the nomenclature (hence the figure they used for Leguminosae may have been lower than that given in CFA), the endemics of the family still accounted for at least 50% of their sample. A recent analysis of endemism of this family in Angola (Soares & al., 2007) has shown that out of the 271 CFA endemics, 93 are no longer considered endemic to the country. Forty-seven names have been reduced to synonyms of widespread taxa, and 46 taxa have been found to occur elsewhere. As a consequence there was a reduction of ca. 32% of the figure for endemism in this family. This may explain why the rate of endemism of 27.3% recorded by Exell & Gonçalves (1973) was much higher than the actual value of 14.8%.

ACKNOWLEDGEMENTS

The South African National Biodiversity Institute (SANBI) is thanked for supporting the implementation of FLAN project. Ms Emsie du Plessis of Research Publications and Support Services of SANBI, Pretoria, is thanked for critically commenting on a first draft of the paper.

LITERATURE CITED

- Brenan, J.P.M.** 1978. Some aspects of the phytogeography of tropical Africa. *Ann. Missouri Bot. Gard.* 65: 437–478.
- Diniz, M.A.** 1993. Bignoniaceae. *Conspectus Florae Angolensis*, Fam. 122. Instituto de Investigação Científica Tropical, Lisbon.
- Exell, A.W. & Fernandes, A.** 1962. *Conspectus Florae Angolensis*, vol. 3, fasc. 1. Junta de Investigações do Ultramar, Lisbon.
- Exell, A.W. & Fernandes, A.** 1966. *Conspectus Florae Angolensis*, vol. 3, fasc. 2. Junta de Investigações do Ultramar, Lisbon.
- Exell, A.W., Fernandes, A. & Mendes, E.J.** 1970. *Conspectus Florae Angolensis*, vol. 4. Junta de Investigações do Ultramar and Instituto de Investigação Científica de Angola, Lisbon.
- Exell, A.W. & Gonçalves, M.L.** 1973. A statistical analysis of a sample of the flora of Angola. *Garcia de Orta, Ser. Bot.* 1(1–2): 105–128.
- Exell, A.W. & Mendonça, F.A.** 1937. *Conspectus Florae Angolensis*, vol. 1, fasc. 1. Junta de Investigações Coloniais, Lisbon.
- Exell, A.W. & Mendonça, F.A.** 1951. *Conspectus Florae Angolensis*, vol. 1, fasc. 2. Junta de Investigações Coloniais, Lisbon.
- Exell, A.W. & Mendonça, F.A.** 1954. *Conspectus Florae Angolensis*, vol. 2, fasc. 1. Junta de Investigações do Ultramar, Lisbon.
- Exell, A.W. & Mendonça, F.A.** 1955. *Conspectus Florae Angolensis*, vol. 2, fasc. 2. Junta de Investigações do Ultramar, Lisbon.
- Fernandes, R.** 1982. Crassulaceae. *Conspectus Florae Angolensis*, Fam. 70. Instituto de Investigação Científica Tropical/Junta de Investigações do Ultramar, Lisbon.
- Figueiredo, E.** 2008. The Rubiaceae of Angola. *Bot. J. Linn. Soc.* 156: 537–638.
- Figueiredo, E. & Smith, G.F.** 2008. *Plants of Angola*. *Strelitzia* 22. South African National Biodiversity Institute, Pretoria.
- Huntley, B.J. & Matos, E.M.** 1994. Botanical diversity and its conservation in Angola. *Strelitzia* 1: 53–74.
- Kendrick, K.** 1989. Equatorial Africa (Cameroun, People's Republic of Congo, Central African Republic, Angola, Zaire, Rwanda and Burundi). Pp. 203–216 in: Campbell, D.G. & Hammond, H.D. (eds.), *Floristic Inventory of Tropical Countries*. The New York Botanical Garden, New York.
- Lebrun, J.-P. & Stork, A.L.** 1991. *Énumération des Plantes à Fleurs D'Afrique Tropicale*, vol. 1, *Généralités et Annonaceae à Euphorbiaceae et Pandanceae*. Conservatoire et Jardin Botaniques de la Ville de Genève, Geneva.
- Linder, H.P.** 2001. Plant diversity and endemism in sub-Saharan tropical Africa. *J. Biogeogr.* 28: 169–182.
- Maggs, G.L., Craven, P. & Kolberg, H.H.** 1998. Plant species richness, endemism, and genetic resources in Namibia. *Biodiv. Cons* 7: 435–446.
- Smith, G.F. & Wolfson, M.M.** 2004. Mainstreaming biodiversity: the role of taxonomy in bioregional planning activities in South Africa. *Taxon* 53: 467–468.
- Schelpé, E.A.C.L.E., Jermy, A.C. & Launert, E.** 1977. *Conspectus Florae Angolensis*, vol. *Pteridophyta*. Junta de Investigações Científicas do Ultramar, Lisbon.
- Soares, M., Abreu, J., Nunes, H., Silveira, P., Schrire, B. & Figueiredo, E.** 2007. The Leguminosae of Angola: diversity and endemism. *Syst. Geogr. Pl.* 77: 141–212.
- Steenkamp, Y. & Smith, G.F.** 2006. Introduction to *A checklist of South African plants*. Pp. iv–ix in: Germishuizen, G., Meyer, N.L., Steenkamp, Y. & Keith, M. (eds.), *A Checklist of South African Plants*. Southern African Botanical Diversity Network Report 41. SABONET, Pretoria.
- Stuart, S.N. & Adams, R.J.** 1990. *Biodiversity in Sub-saharan Africa and its Islands*. Occasional Papers of the IUCN Species Survival Commission (SSC) 6. IUCN, Gland, Switzerland.