Diversity of the Vascular Plants of the Gulf of Guinea Oceanic Islands

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Chapter 10
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Abstract Despite a long history of botanical collecting in the three oceanic islands of the Gulf of Guinea, no recent studies have documented floristic patterns. This chapter summarizes information on the vascular plants of the islands, including inventories conducted on Príncipe and São Tomé since 2017, as well as two recent expeditions to Annobón. An updated database of the vascular flora was compiled, which includes 14,376 records representing 1285 species and infraspecific taxa (1028 native). Príncipe has 445 species and infraspecific taxa (394 native), São Tomé has 1044 (842 native), and Annobón has 344 (274 native). Recent inventory work has generated collections of more than 90% of the endemic woody species. Several very rare taxa were rediscovered, including *Balthasaria mannii* (Oliv.) Verdc., 1969 (Pentaphylacaceae) and *Psychotria exellii* R. Alves, Figueiredo and A.P. Davis, 2005 (Rubiaceae), neither of which had been seen for more than 50 years. At least 17 species new to science were also discovered on Príncipe and São Tomé. Of the 1028 indigenous taxa, 164 (16%) are currently considered endemic to the islands. Of the 285 species evaluated according to the IUCN Red List criteria, 2 (0.7%) were Data Deficient, 226 (79.3%) Least Concern or Near Threatened, 55 (19.3%) threatened (including 3 Critically Endangered, 21 Endangered, and 31 Vulnerable), and 2 (0.7%) Extinct. On São Tomé and Príncipe, 325 plant species are used in traditional medicine, 37 of which are endemic. These results should be used to identify new priority sites for conservation, including on Annobón, where priority sites are less well defined.

Keywords Collecting effort · Endemism · Flora · IUCN red list · Species richness

Despite a long history of collecting in the three oceanic islands of the Gulf of Guinea (Príncipe, São Tomé, and Annobón), no recent studies have documented their floristic patterns. In this chapter, we synthesize current knowledge on their diversity of vascular plants: (1) briefly reviewing the history of botanical exploration, (2) documenting the spatial distribution of sampling, species richness, and endemism within and between the islands, (3) reviewing risk of extinction assessments for plant species, using the IUCN Red List criteria, and (4) providing an account of plants used in traditional medicine in São Tomé and Príncipe.

Sampling Efforts Through Time

São Tomé

Despite the relatively small area occupied by São Tomé and Príncipe compared to other African countries, their flora has been the subject of many publications (Figueiredo 1994b; Figueiredo et al. 2011; Droissart et al. 2018). The first comprehensive studies of the flora of São Tomé and Príncipe, primarily focused on São Tomé, were undertaken by Júlio Henriques from the University of Coimbra (e.g.,

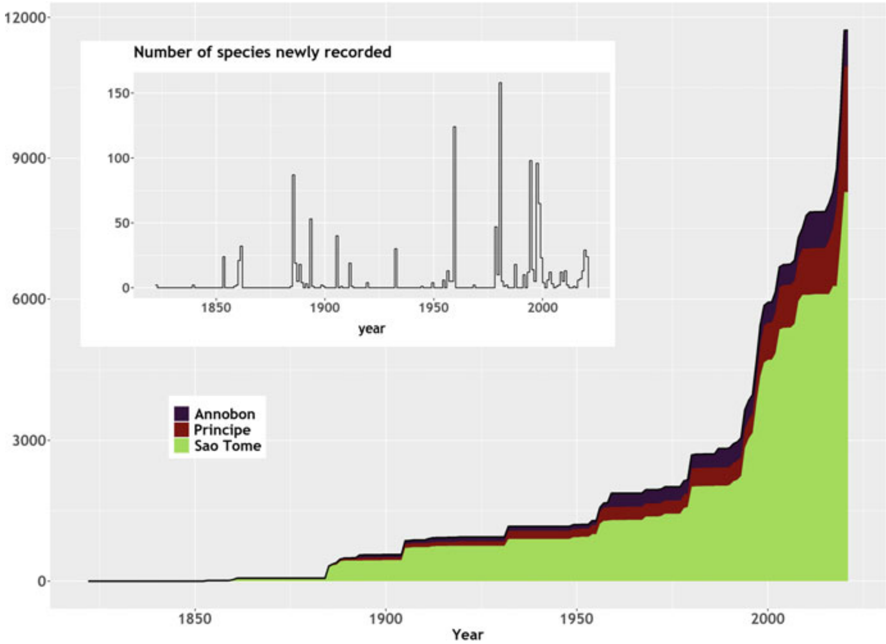

Fig. 10.1 Collecting effort in the oceanic islands of the Gulf of Guinea, showing numbers of species and records accumulated through time. Insert figure shows the number of species newly recorded per year. Specimens were excluded if they had an estimated georeferencing precision greater than or equal to 4 km. A total of 2600 records were excluded because they lacked information on the year of collection

Henriques 1892, 1917), who worked on the collections made during the 1880s by Francisco Newton, Adolfo Moller and Francisco Quintas (Figueiredo and Smith 2019; Ceríaco et al. 2022). In 1932–1933, Arthur Wallis Exell visited the three islands, collecting extensively and publishing the seminal catalogue of vascular plants (Exell 1944), in which many new species were described and several new records noted. Exell subsequently published a few additional papers (e.g., Exell 1956, 1959; Exell and Rozeira 1958), and finally produced a preliminary checklist of the Angiosperms of the islands (Exell 1973). Fieldwork largely stopped for the next 20 years, followed by an extensive period of collecting (Fig. 10.1), supported for the first 10 years by the ECOFAC project, which was funded by the European Commission. The Bom Sucesso Botanical Garden and the National Herbarium (STPH) were established on São Tomé during this period, and a few papers were published on the flora of the islands (e.g., Stévart et al. 2000; Stévart and Oliveira 2000; Stévart and Cribb 2004). In 2011, a new checklist was published, providing a good synthesis of the history of botanical studies, and the current state of knowledge of the flora with citations of herbarium specimens (Figueiredo et al. 2011). A significant collecting effort since 2016 justifies a new synthesis on the diversity of vascular plants of these islands (Fig. 10.1).

Príncipe

The history of floristic surveys on Príncipe is largely similar to that of São Tomé. During the nineteenth and twentieth century, Príncipe was visited by several collectors during expeditions to São Tomé or Annobón (Exell 1944; Figueiredo 1994a; Figueiredo and Smith 2019, 2020; Ceríaco et al. 2022). The flora of Príncipe was included in several checklists and publications (Exell 1944, 1956, 1959, 1973; Exell and Rozeira 1958; Figueiredo et al. 2011). A few collecting expeditions were conducted in the late 1990s with support from the ECOFAC project, followed by sporadic collections during the subsequent 20 years. In 2016, a project aiming to describe the tree diversity of Príncipe was initiated, which included exhaustive collecting, especially in the southern part of the island, and the production of the first forest classification ever proposed for Príncipe (Benitez et al. 2018). This initiative also supported the creation of an unofficial herbarium at the Príncipe Natural Park headquarters, built local botanical capacity, conducted Red List assessments, and made floristic data available online (Tropicos 2021).

Annobón

An account of the history of botanical studies on Annobón was presented in its most recent checklist (Velayos et al. 2013a). The oldest collections from the island are probably those made during the nineteenth century by the British botanists Andrew B. Curror (1839–1843) and Richard Burton (1861–1864). The first study specifically dealing with the flora of Annobón was published by the German botanist Johannes Mildbraed from the Botanical Garden of Berlin, based on his collection made in 1911 (Mildbraed 1937) during the 1910–1911 Deutsche Zentral-Afrika-Expedition. As mentioned above, Exell also published on its flora (Exell 1944, 1956, 1963, 1973), including ca. 40 specimens he collected in 1933. Luís G. Sobrinho studied the material collected by Francisco Newton between November 1892 and January 1893 (Sobrinho 1953). Finally, in 2010 and 2011, botanists of the Real Jardín Botánico Madrid and the Universidad Nacional de Guinea Ecuatorial collected exhaustively on the island, subsequently publishing an updated catalogue of the plants of Annobón with citations of herbarium specimens (Velayos et al. 2013a).

Spatial Distribution of Collecting Effort

The Database

Recent data on the flora of Príncipe, São Tomé, and Annobón were included in an updated version of the RAINBIO database (Dauby et al. 2016). The quality and accuracy of georeferencing of all specimen records were assessed first by verifying whether they fell within the limits of the islands and, if not, at what distance from the coast, using the CoordinateCleaner R package (Zizka et al. 2019). When errors or inaccuracies were detected, or when coordinates were entirely missing, georeferencing was corrected or added manually using the locality information indicated on specimen labels. A scale from one to nine was used to indicate the precision of the georeferencing of each record, assigned based on label coordinates, either manually or automatically (Dauby et al. 2016). When the elevation was provided on the specimen label, it was recorded in the database, otherwise it was retrieved from an elevation raster based on the geo-coordinates. The resulting database includes 14,376 records, among which 12,077 represent collections identified to the species level, and 12,790 are georeferenced, constituting the largest and most comprehensive dataset ever compiled for the islands.

Collecting Effort

Collecting effort is highly heterogeneous on all islands (Fig. 10.2). In Príncipe, most fieldwork has been concentrated at higher elevations, centered on Pico Papagaio and near Pico do Príncipe. The same is true for São Tomé, where they are concentrated around Pico de São Tomé and between Bom Sucesso and Lagoa Amélia. In Annobón, they have focused around Lake Apot, but also on the coast near Punta Yalba. All of these locations but the last are at higher altitudes and harbor relatively intact vegetation (Dauby et al. 2022). When standardized by area (Fig. 10.3), highlands clearly appear as the most intensely collected, while the lowlands and the rugged central portions of the islands are the most under-collected (Fig. 10.2). This pattern of collection suggests that botanists tend to conduct fieldwork in accessible areas that have less impacted vegetation, while more heavily impacted areas at lower elevations or very remote locations remain undersampled.

Species richness has a bimodal distribution with respect to elevation gradient on São Tomé. It should be stated that this decrease is *only* due to the fact that elevated areas are much less extensive. In fact, when you look at areas of comparable size (Fig. 10.2) the diversity is *higher* in elevated areas. Species richness is, however, also well correlated with sampling effort, so it is not clear to what extent these patterns are biased by sampling. The second explanation is obviously the correct one: 1100–1200 m is the area where lowland and montane species overlap, hence the higher diversity.

On Príncipe, Pico de Príncipe was relatively less well collected than Pico Papagaio because it is less accessible, the trail being uncovered by the first modern field surveys during the ECOFAC project in the 1990s (Baillie 1999). The southern part of the island was poorly collected until recently because it is usually accessed by boat. The recent field expedition conducted as part of the Global Tree Campaign allowed surveying the flora around Rio Porco, where the last remaining example of original littoral forest can be found on the islands (Benitez et al. 2018).

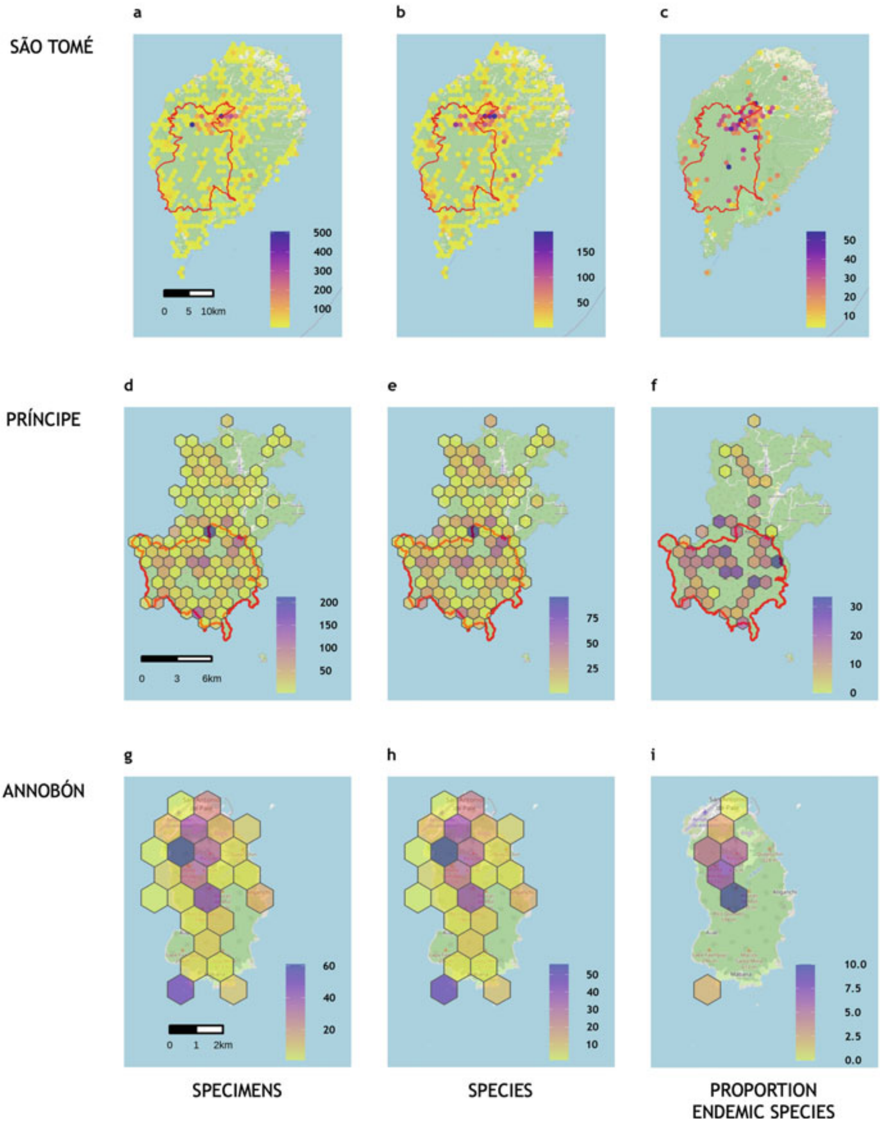

Fig. 10.2 Maps of Príncipe, São Tomé, and Annobón, showing the number of specimens, number of species, and proportion of endemic species per 1 km-sided hexagon. The proportion of endemic species is only shown in hexagons with at least 25 specimen records for Annobón and 20 elsewhere. Specimens whose estimated georeferencing precision is greater than 4 km were excluded. The red outline demarks the boundaries of Natural Parks

On São Tomé, some lowland areas have been relatively well explored, namely around São Miguel, São João dos Angolares, and the mouths of Xufe-Xufe or Iô Grande River. These have been less sampled than the highlands, thus remaining

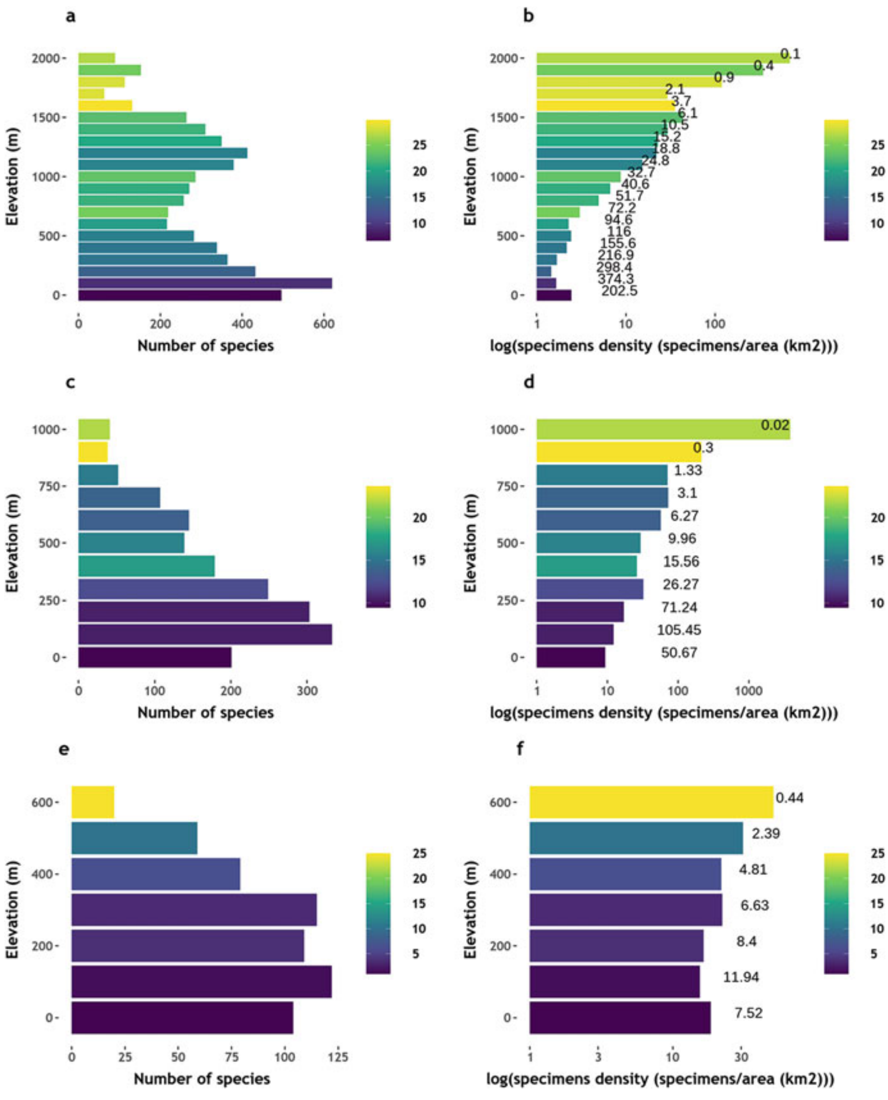

Fig. 10.3 (**a, c, e**) Number of species and (**b, d, f**) sampling effort relative to area along 100 m elevational bands for (**a**, **b**) São Tomé, (**c**, **d**) Príncipe and (**e**, **f**) Annobón. Sampling effort was obtained from specimen density per unit of area, and numbers indicate the area covered by each elevational band in km^2. The color scale represents the proportion of endemic species. Specimens whose estimated georeferencing precision is greater than 4 km were excluded. When available, elevation was retrieved from the specimen label, otherwise it was estimated from the elevation raster based on coordinates

overall poorly sampled given their much larger area (Fig. 10.3). Observed species richness on São Tomé (Fig. 10.2b) is particularly high around the Pico de São Tomé, Lagoa Amélia, and Bom Sucesso, but is also highly correlated with specimen density

(Pearson correlation $R = 0.94$) and is therefore certainly underestimated in most other parts of the island.

On Annobón, the number of species per 1 km-sided hexagons is also correlated with collecting effort (Fig. 10.2g–h), but the proportion of endemic plants is higher in the elevated area of the island (Figs. 10.2i and 10.3).

Floristic Diversity

The numbers of vascular plant taxa recorded from São Tomé and Príncipe were indicated in the most recent checklist (Figueiredo et al. 2011): 135 families (of which 29 are introduced), 624 genera (172 introduced), and 1104 species (301 introduced), along with 12 infraspecific taxa, including 119 endemic taxa (107 species and 12 infraspecific taxa). However, these figures only concern São Tomé and Príncipe, and extensive inventories have since been conducted on Príncipe (Benitez et al. 2018) and on São Tomé (Flora Ameaçada 2021). An updated calculation indicates that 1285 species and infraspecific taxa (1028 native) are known to occur on the three islands (Table 10.1). Príncipe has 445 species and infraspecific taxa (394 native), São Tomé has 1044 (842 native), and Annobón has 344 (274 native). Príncipe has the highest proportion of native flora (88.5%), followed by São Tomé (80.7%), while Annobón has the lowest (79.7%).

The three most species-rich families are Orchidaceae (163 taxa), Rubiaceae (94 taxa), and Fabaceae (86 taxa); however, many of the Fabaceae are not native (Table 10.2). Euphorbiaceae *s.l.*, as previously delimited, was one of the most speciose families, but its members have recently been divided among Euphorbiaceae *s.str.* (44 taxa) and Phyllanthaceae (27 taxa).

The genera with the most species and infraspecific taxa are *Asplenium* L. (28), *Bulbophyllum* Thouars (27), and *Polystachya* Hook. (26) (Table 10.3), all of which are wind-dispersed.

Table 10.1 Family, genus, species, and infraspecific taxon richness on each of the three oceanic islands of the Gulf of Guinea

	Príncipe	São Tomé	Annobón	Total
Families	94	143	90	**155**
Genera	264	561	241	**627**
Species and infraspecific taxa richness (SR)	445	1044	344	**1285**
SR native	394	842	274	**1028**
% of the flora which is native	88.5	80.7	79.7	**80.0**
Individuals	1876	8182	773	**11,388**

The number of native species or infraspecific taxa is given as well as the native proportion of each island's flora

Table 10.2 The most species-rich families on the oceanic islands of the Gulf of Guinea

	SR	Príncipe	São Tomé	Annobón	Grand total
Orchidaceae	163	85	125	25	**235**
Rubiaceae	94	46	73	18	**137**
Fabaceae	86	14	70	38	**122**
Poaceae	46	4	40	24	**68**
Euphorbiaceae	44	14	32	12	**58**
Cyperaceae	34	8	25	14	**47**
Asteraceae	31	2	28	9	**39**
Aspleniaceae	28	14	25	5	**44**
Phyllanthaceae	27	14	20	6	**40**
Malvaceae	26	1	21	12	**34**

Numbers indicate specific and infraspecific taxon richness (SR) for all islands taken together and for each individual island. The grand total represents the total number of species-presences recorded across the islands

Table 10.3 The most species-rich genera on the oceanic islands of the Gulf of Guinea

	SR	Príncipe	São Tomé	Annobón	Grand total
Asplenium	28	14	25	5	**44**
Bulbophyllum	27	14	20	4	**38**
Polystachya	26	12	21	6	**39**
Cyperus	22	2	16	11	**29**
Psychotria	13	4	12	2	**18**
Ipomoea	12	2	8	4	**14**
Begonia	11	5	10	2	**17**
Ficus	11	3	10	3	**16**
Pteris	11	7	9	1	**17**
Desmodium	10	1	9	9	**19**

Numbers indicate specific and infraspecific taxon richness (SR) for all islands taken together and for each individual island. The grand total represents the total number of species-presences recorded across the islands

Main Findings of the Botanical Expeditions on São Tomé and Príncipe, 2019–2020

To improve the documentation of the current floristic diversity of São Tomé and to identify conservation priorities, several botanical expeditions were undertaken between 2019 and 2021 (Flora Ameaçada 2021). Various localities across the island were visited, from the dry North to the wet South, and from the coast to the summit of the Pico de São Tomé at 2024 m, covering most vegetation types. More than 90% of the endemic woody species were seen during this fieldwork. Some very rare species were rediscovered, including *Balthasaria mannii* (Oliv.) Verdc., 1969 (Pentaphylacaceae) (Fig. 10.4.2–4), and *Psychotria exellii* R. Alves, Figueiredo and A.P. Davis, 2005 (Rubiaceae), both restricted to near the summit of the Pico

Fig. 10.4 Species endemic to São Tomé and Príncipe: (**1**) *Santiria balsamifera* Oliv., 1887 (Burseraceae); (**2–4**) *Balthasaria mannii* (Oliv.) Verdc., 1969 (Theaceae); (**5**) *Cleistanthus sp. nov.* (Euphorbiaceae); (**6**) *Impatiens manteroana* Exell, 1944 (Balsaminaceae). Photos credits: (**1**, **6**) Tariq Stévart, (**3–5**) Olivier Lachenaud, (**2**) Gilles Dauby

de São Tomé and not seen for more than 50 years. Even more interesting is the finding of at least 17 species new to science—a number likely to increase as the ongoing identification of specimens continues. The most remarkable of these is a new species of *Cleistanthus* Hook. f. ex Planch., 1848 (Phyllanthaceae) (Fig. 10.4.5), which is the dominant tree of dry forest remnants in the North of the island. Several earlier collections of this species are deposited in herbaria, but they had not yet been identified. Although locally abundant, the new species of *Cleistanthus* is highly threatened by wood exploitation and charcoal production, and its habitat is in need of protection. In addition, 42 species represent new country records for São Tomé and Príncipe, most of which are widespread on the mainland. One of them, *Phyllocosmus sessiliflorus* Oliv., 1868 (Ixonanthaceae), is the first record of its family from the islands. Other species previously known from the country are new island records, namely five for São Tomé and 26 for Príncipe.

Complementing the efforts undertaken since 2016 to understand tree diversity in the southern forests of Príncipe (Benitez et al. 2018), since 2019, several botanical expeditions have focused on the drier North (Flora Ameaçada 2021). This work included areas of secondary or presumably degraded forest, extending from coastal and lowland forests to the northern plateau of the island, but also involved collecting in areas in the south that had not been assessed during previous years, such as the summit of Pico do Príncipe (947 m). These inventories resulted in the discovery of eight species new to science, six of which are only known from Príncipe.

Endemism

The flora of the Gulf of Guinea Islands comprises approximately 1700 indigenous species of angiosperms (Figueiredo 1994b), and is well known for its high level of endemism. Bioko is a continental island, while Príncipe, São Tomé and Annobón are oceanic, never having been connected to the mainland or to one another. It is therefore not surprising that Bioko has a more speciose flora (1558 species, Velayos et al. 2013b), but exhibits much lower levels of endemism (3.6% according to Exell 1973).

Of the 1028 indigenous species and infraspecific taxa documented from Príncipe, São Tomé, and Annobón, approximately 164 are endemic (Table 10.4, Figs. 10.4, 10.5, 10.6 and 10.7), yielding a rate of endemism of about 16%. Estimates for endemism on Príncipe have varied significantly over the years, from 12.7% (Exell 1944), to 9.9% (Exell 1973), and to the current 14.7% for vascular plants (Table 10.4). Calculations of endemism in São Tomé have decreased from 19.4% (Exell 1944) to 15.4% (Exell 1973) and the current 14.5% (Table 10.4). On Annobón, they are estimated to be at 6.9% (Table 10.4).

The families with the largest numbers of endemic taxa are Orchidaceae (30), Rubiaceae (29), and Euphorbiaceae *s.str*. (15) (Table 10.5). The genera *Polystachya* (Orchidaceae), *Begonia* L., 1753 (Begoniaceae) and *Psychotria* L., 1759 (Rubiaceae) have the largest numbers of endemic species (Table 10.6). Some

Table 10.4 Plant endemism in the oceanic islands of the Gulf of Guinea (including 17 putative new species)

	Príncipe	São Tomé	Annobón	Total
Single-island endemic species	28	90	14	**132**
Shared endemics between islands	30	32	5	**32**
Total endemics	58	122	19	**164**
Indigenous species	394	842	274	**1028**
Endemic rate (3 islands)	14.7	14.5	6.9	**16.0**
Endemic rate (strict)	7.6	3.8	1.8	**3.1**

emblematic endemic species are the gigantic species *Begonia baccata* Hook.f., 1866 and *Begonia crateris* Exell, 1944, which can reach a height of 4 m. *Afrocarpus mannii* (Hook.) C.N. Page, 1988 (Podocarpaceae), the only native gymnosperm, is endemic to São Tomé and is widely grown in many botanic gardens around the world. The proportion of endemic species tends to increase with elevation with an endemic rate between 20 and 25% in the highlands of the three islands (Fig. 10.3).

Conservation

From 1998 to 2020, risk of extinction assessments were performed for 285 native and introduced plant species from Príncipe, São Tomé, and Annobón Islands (IUCN 2021). These taxa belonged to 207 genera and 86 families, and over 13% are endemic to São Tomé and Príncipe. *Cyperus* L., 1753 (Cyperaceae) is the best-represented genus, with twelve species assessed; the remaining genera are represented by between one and four species each. Seven families have more than ten species assessed: Orchidaceae (34.9% of all species assessed), Fabaceae (29.1%), Cyperaceae (24.4%), Rubiaceae (23.3%), Euphorbiaceae (17.4%), Apocynaceae and Phyllanthaceae (11.6% each). Thirty-two assessments were made in 1998 and 62 more were done between 2000 and 2017. The number of species assessed has more than doubled between 2018 and 2020 (Fig. 10.8). Of the 285 species evaluated to date, 0.7% are Data Deficient, 19.3% are threatened (3 Critically Endangered, 21 Endangered, and 31 Vulnerable), and 78.3% are Least Concern or Near Threatened. Two Orchidaceae species (*Angraecopsis dolabriformis* (Rolfe) Schltr., 1918 and *Angraecum astroarche* Ridl., 1887) are considered Extinct (Simo et al. 2018a, b), since they were not recorded after intensive surveys in the locations where they had previously been documented. The number of species assessed as threatened per year has decreased over time, even though the total number of assessments performed each year has increased: 22 of 32 species were assessed as threatened in 1998, compared to just 21 of 191 assessments done over the last three years (Fig. 10.7; Table 10.7). This is partly due to numerous recent assessments on widespread non-threatened tree species (e.g., *Symphonia globulifera* L. f., 1782, *Xylopia aethiopica* (Dunal) A. Rich., 1845, *Cola digitata* W. Mast.,

Fig. 10.5 Species endemic to São Tomé and Príncipe: (**1**) *Carapa gogo* A. Chev. ex Kenfack, 2011 (Meliaceae); (**2–3**) *Palisota pedicellata* K.Schum., 1897 (Commelinaceae); (**4**) *Polystachya expansa* Ridl., 1887 (Orchidaceae); (**5**) *Pandanus thomensis* Henriq., 1887 (Pandanaceae); (**6–7**) *Lobelia barnsii* Exell, 1944 (Campanulaceae); (**8–9**) *Impatiens buccinalis* Hook.f., 1864 (Balsaminaceae). Photo credits: (all, except **6**) Tariq Stévart, (**6**) Gilles Dauby

Fig. 10.6 Species endemic to São Tomé and Príncipe: (**1**) *Thunbergianthus quintasii* Engl., 1897 (Scrophulariaceae); (**2**) *Costus giganteus* Welw. ex Ridl., 1887 (Costaceae); (**3**) *Rhipidoglossum pendulum* (la Croix & P.J.Cribb) Farminhão & Stévart, 2018 (Orchidaceae); (**4**) *Dicranolepis thomensis* Engl. & Gilg, 1894 (Thymelaeaceae); (**5**) *Tabernaemontana stenosiphon* Stapf, 1895 (Apocynaceae); (**6**) *Leea tinctoria* Lindl. ex Baker, 1868 (Leeaceae); (**7**) *Elatostema thomense* Henriq., 1892 (Urticaceae); (**8**) *Begonia crateris* Exell, 1944 (Begoniaceae); (**9**) *Erica thomensis* (Henriq.) Dorr & E.G.H.Oliv., 1999 (Ericaceae). Photo credits: (all, except **8**) Tariq Stévart, (**8**) Olivier Lachenaud

Fig. 10.7 Species endemic to São Tomé and Príncipe: (**1**) *Erica thomensis* (Henriq.) Dorr & E.G. H.Oliv., 1999 (Ericaceae); (**2**) *Chytranthus mannii* Hook.f., 1867 (Sapindaceae); (**3**) *Strephonema sp. nov.* (Combretaceae). Photo credits: (**1**) Davy Ikabanga, (**2**) Laura Benitez, (**3**) Tariq Stévart

1868, and *Santiria trimera* (Oliv.) Aubrév., 1948) (Fig. 10.4.1). Some species require better knowledge before they can be assessed (e.g., *Santiria trimera*) or are outside of their native range (*Coffea arabica* L., 1753), and therefore their presence

Table 10.5 The ten families with the largest number of endemic species and infraspecific taxa on the three oceanic islands of the Gulf of Guinea

Family	Príncipe	São Tomé	Annobón	Total
Orchidaceae	10	22	2	**30**
Rubiaceae	10	21	3	**27**
Euphorbiaceae	6	11	2	**15**
Begoniaceae	2	5		**6**
Melastomataceae		5	2	**6**
Sapotaceae	2	2		**4**
Violaceae	1	3		**4**
Acanthaceae		3		**3**
Aspleniaceae	1	2	1	**3**
Balsaminaceae	1	2		**3**

Numbers indicate specific and infraspecific taxon richness (SR)

Table 10.6 The ten genera with the largest number of endemic species and infraspecific taxa on the three oceanic islands of the Gulf of Guinea

Genus	Príncipe	São Tomé	Annobón	Total
Polystachya	4	5	1	**8**
Psychotria		8		**8**
Begonia	2	4		**6**
Diaphananthe	2	2		**4**
Rinorea	1	3		**4**
Tristemma		3	1	**4**
Asplenium	1	2	1	**3**
Cassipourea	1	1	1	**3**
Chassalia	2	2		**3**
Dryopteris		2	1	**3**

Numbers indicate specific and infraspecific taxon richness (SR)

on these islands is irrelevant for Red Listing, and they were not included in this analysis. For example, a recent taxonomic revision of *Santiria* Blume, 1850, in Africa revealed that a threatened species (*S. balsamifera* Oliv., 1886) occurs on São Tomé and Príncipe (Ikabanga et al. 2019). Additional efforts will be needed to assess other endemic and range-restricted species to enable a more accurate assessment of the true proportion of threatened plant species on the oceanic islands of the Gulf of Guinea.

Recent Red List activities and field expeditions have shown that the flora of São Tomé and PrÚncipe is highly threatened, in addition to historical threats that have ceased, such as large-scale plantations that profoundly changed the natural vegetation of the two islands (Muñoz-Torrent et al. 2022). On Príncipe, current threats are relatively limited and not clearly defined, but certainly include the development of infrastructure for tourism (Lima et al. 2022), whose impact on the flora remains to be quantified. The development of human activities adds pressure on the remaining forests in the north, which are already threatened by small-scale agriculture, charcoal production, firewood collection, and logging (D'Avis 2022). The collection and use of medicinal plants are also subjecting some species to the risk of local extinction.

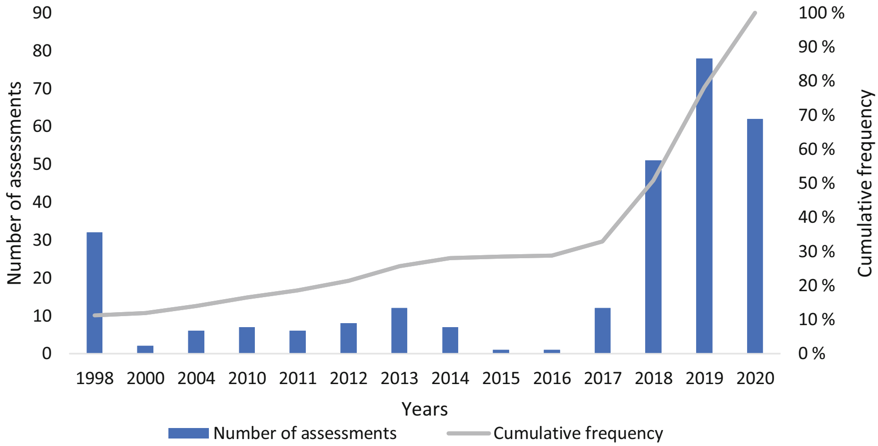

Fig. 10.8 Progress of the number of risk of extinction assessments made for species occurring on Príncipe, São Tomé, and Annobón islands from 1998 to 2020

Table 10.7 Number of threatened species recorded on Príncipe, São Tomé, and Annobón islands from 1998 to 2020

Years	Threatened species			Total
	CR	EN	VU	
1998	0	1	21	22
2000	1	0	0	1
2004	0	2	4	6
2013	0	1	1	2
2014	0	1	3	4
2018	2	9	0	11
2019	0	1	1	2
2020	0	6	1	7
Total threatened species				**55**

Indeed, most of the plants harvested by traditional healers and by commercial sellers who collect medicinal plants for alcoholic beverages come from forests, and very few plants are cultivated for medicinal purposes. On São Tomé, threats include local logging around the parks, and the widespread presence of invasive species (Lima et al. 2022). These threats do not affect most species directly, but they impact the quality of their habitat. The most severe current threats on São Tomé are, however, the presence of an oil palm plantation in the southwest of the island, and charcoal production is also an important threat, especially in the north (Oyono et al. 2014). These activities have expanded in recent years and directly impact populations of plant species. On Annobón, plants occurring in almost all parts of the island are threatened by small-scale agriculture. The dry northern part of the island, from the sea to Lake Apot, is particularly heavily impacted by agriculture, urbanization, and infrastructure construction (Norder et al. 2020).

The Medicinal Plants of São Tomé and Príncipe

Many medicinal plants have been used for centuries on São Tomé and Príncipe and are often the only available therapeutic agents. Until the end of the twentieth century, uses were not well documented, and few ethnopharmacological studies had been conducted on the medicinal plants used by the population of the two islands. Between 1993 and 2001, an exhaustive collection of the medicinal flora was conducted to record ethnomedical information from the most renowned local traditional healers. More than 350 taxa were identified, for which voucher specimens were deposited at the University of Coimbra herbarium (COI), and more than 1000 traditional preparation procedures and their respective uses were recorded (Madureira et al. 2003). Exhaustive bibliographic research was also conducted, resulting in a monograph for each species containing traditional uses and scientific data (Madureira et al. 2003; Madureira 2006, 2010).

These investigations show a strong correlation between the traditional use of most medicinal plants and their proven pharmacological activity, demonstrating that many of them have a recognized efficacy: e.g., *Spermacoce verticillata* L., 1753, *Desmodium adscendens* (Sw.) DC., 1825, *Dracaena arborea* (Willd.) Link, 1821, *Phyllanthus amarus* Schumach. & Thonn., 1827, *Phyllanthus urinaria* L., 1753, *Piper capense* L.fil., 1781, *Scoparia dulcis* L. 1753 (Madureira 2006, 2008), along with *Tithonia diversifolia* (Hemsl.) A. Gray, 1883, an introduced species that has antimalarial activity and could be a very interesting alternative to commercially available antimalarials (Madureira 2010). An analysis of the composition of essential oils from eighteen species widely used in traditional medicine for the treatment of infections was carried out, and the preliminary study of the antibacterial and antifungal activities of these essential oils proved their activity, highlighting the oils of *Cymbopogon citratus* (DC.) Stapf, 1906, *Ocimum gratissimum* l., 1753, *Santiria balsamifera* and *Zingiber officinale* Roscoe, 1807, which showed the best activities (Martins 2002). Some of these medicinal plants have been studied for their antiviral properties (*Phyllanthus amarus*, *Scoparia dulcis*, *Momordica charantia* L., 1753, and *Margaritaria discoidea* (Baill.) G.L. Webster, 1967). Other species have shown some promising results regarding their antitumor activity, such as *Desmodium adscendens*, *Piper capense*, and *Momordica charantia* (Madureira 2008), and more recently the identification of natural compounds from *Voacanga africana* Stapf, 1894, that show multiple biological activities of interest for Alzheimer's disease (Currais et al. 2014).

The families with the largest numbers of species used for medicinal purposes are Euphorbiaceae (13 species), Asteraceae (12), Rubiaceae (11), Moraceae (10), Malvaceae (9), Rutaceae (8), and Apocynaceae (7). The fact that many families (57) and genera (134) are represented on the list of medicinal species illustrates the high level of knowledge of the flora among traditional healers, and it is possible to infer that there are a great variety of chemical structures and pharmacological activities among the medicinal plants collected in the region.

The traditional uses of the medicinal plants are highly diverse: analgesic, anti-inflammatory or anti-rheumatic action represent the main group of traditional records (218), followed by diseases of the digestive system (204); diseases related to the respiratory system represent the third group with 179 traditional records; genito-urinary system (134); skin diseases (97); traditional medicines for the treatment of febrile conditions (38) and malaria (23); diseases of the cardiovascular system (43); 14 preparations for the treatment and control of diabetes, and 16 indications for diseases of the central nervous system. Finally, on São Tomé and Príncipe, many medicinal plants are also used for food, representing about 15.0% of the total species collected for medicinal purposes (Madureira 2012).

Among the 350 medicinal species used, 37 are endemic to the islands of the Gulf of Guinea (e.g., *Tabernaemontana stenosiphon*, *Begonia baccata*, *Croton stellulifer* Hutch. 1944, *Hernandia beninensis* Welw. ex Henriq., 1892, *Staudtia pterocarpa* Warb., 1897, *Pandanus thomensis* Henriq., 1887, *Afrocarpus mannii*, *Chytranthus mannii* Hook.f., 1867, and *Costus giganteus* Welw. ex Ridley, 1887), which indicates an evident dynamism of the local traditional medicine, with traditional healers maintaining and perfecting their traditional therapeutic wisdom, and taking advantage of the native available resources of São Tomé and Príncipe.

Improving Local Botanical Practices and Knowledge

The literature review for this chapter revealed a heavy reliance on a few key publications for the identification of medicinal plant species based on local vernacular names (Rozeira 1958; Roseira 1984; Figueiredo 2002; Figueiredo et al. 2011), the majority of which lack the citation of voucher specimens. Vernacular names are important for identification of plants locally, but to be reliable and of use for scientific studies, they must be unambiguously linked to scientific names, which requires the collection and storage of voucher specimens. This need is particularly pressing considering that local names vary from region to region, sometimes multiple species having the same name, or multiple names referring to a single species (e.g., Figueiredo et al. 2011). This is especially true in the case of medicinal plant parts that are sold in the markets, for which accurate identification to species is even more difficult, but also for ecological studies such as tree inventories, which have so far mostly used local names (e.g., Salgueiro and Carvalho 2001).

Basic botanical skills are also largely lacking, especially with respect to plant taxonomy and botanical nomenclature. The correct botanical name of an individual plant, linked to a voucher specimen, is the sine qua non of phytomedical research. Without the unique taxonomic identifier, research cannot accurately be linked to the existing literature. This uncertainty, thus obstructs the accuracy and reproducibility of results—a cornerstone of science. It is therefore vital to increase local scientific literacy, and continue training local botanists with different skills, from field identification, to the management of herbarium specimens, and more advanced scientific capacities to ensure increased local autonomy for research and conservation. To overcome these handicaps, the publication of a practical field guide to facilitate plant identification and stimulate the interest for botany is highly recommended.

Concluding Remarks

Significant collecting effort, especially since 2016, has created a huge updated wealth of information for the islands, which is readily available online (Tropicos 2021). Nevertheless, this information is still being compiled and will require extensive taxonomic work and numerous publications until it can produce an updated vascular plant checklist for the islands. The same is true for Red List assessments, many of which seem to be focusing on species that are widespread, while endemic and range-restricted species that are more likely to be threatened remain unassessed. This calls for a major, consolidated focus on conservation assessments, which are currently being conducted through several mostly uncoordinated projects. The results of this work could and should then be used to identify new priority sites for conservation (D'Avis 2022; Lima et al. 2022), including on Annobón, where priority sites are less well defined.

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