

# Checklist of the vascular plants of Río Muni (Equatorial Guinea): floristic analysis, diversity, endemism, and threatened status

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**Abstract.** An updated checklist of the vascular plants from the continental region of Equatorial Guinea (Río Muni) is presented. The catalogue (Appendix 1) is the result of the compilation of herbarium specimens (6850), species records (7985) from the botanical literature and online databases (10109 GBIF records and 8897 RAINBIO records). A database of 23517 georeferenced records was prepared by updating the nomenclature and standardizing the locality names from all these sources. The catalogue comprises 2707 taxa (2598 species, 81 subspecies, and 28 varieties) included in 1020 genera and 178 families. About 90.6% of the taxa are considered native, 1.17% introduced and 5.96% naturalized. The 10 most diverse families are Rubiaceae (294 species), Fabaceae (290), Orchidaceae (168), Poaceae (105), Euphorbiaceae (87), Apocynaceae (85), Cyperaceae (79), Annonaceae (68), Acanthaceae (65) and Melastomataceae (61), which comprise 49.22% of the species in Río Muni. Only 11 species can be considered endemic to Río Muni; this low number reflects the absence of natural barriers in the territory. The number of threatened taxa (VU, EN and CR) is 134 (5.02% of the total evaluated), of which 43 are at risk of extinction, being within the categories of Endangered or Critically Endangered. Five species restricted to the Gulf of Guinea are considered threatened: three Endangered (*Grossera angustifolia*, *Polyscias aequatoguineensis* and *Rhipidoglossum montealenense*), and two Critically Endangered (*Asplenium carvalhoanum* and *Macropodiella uoroensis*), thus they should be considered as priority in management plans development and conservation strategies.

**Resumen.** Se presenta un catálogo actualizado de las plantas vasculares de la región continental de Guinea Ecuatorial (Río Muni). El catálogo es fruto de la compilación de especímenes de herbario (6,850), registros de especies de la literatura botánica (7,985) y bases de datos en línea (10,109 registros de GBIF y 8,897 de RAINBIO). Se elaboró una base de datos de 23,517 registros georreferenciados realizando la actualización nomenclatural y estandarización de los nombres de localidades de todas estas fuentes. El catálogo comprende 2707 taxones (2598 especies, 81 subespecies y 28 variedades) incluidos en 1,020 géneros y 178 familias. El 90.6% de los taxones se consideran nativos, el 1.17% introducidos y el 5.96% naturalizados. Las 10 familias más diversas son Rubiaceae (294 especies), Fabaceae (290), Orchidaceae (168), Poaceae (105), Euphorbiaceae (87), Apocynaceae (85), Cyperaceae (79), Annonaceae (68), Acanthaceae (65) y Melastomataceae (61), que comprenden el 49.22% de las especies de Río Muni. Solo 11 especies pueden considerarse endémicas de Río Muni; este bajo número refleja la ausencia de barreras naturales en el territorio. El número de taxones amenazados (VU, EN y CR) es de 134 (5.02% del total evaluado) de los cuales 43 se encuentran en riesgo de extinción, al estar dentro de las categorías de En Peligro o En Peligro Crítico. Cinco especies restringidas al Golfo de Guinea se consideran amenazadas: tres En Peligro (*Grossera angustifolia*, *Polyscias aequatoguineensis* y *Rhipidoglossum montealenense*), y dos En Peligro Crítico (*Asplenium carvalhoanum* y *Macropodiella uoroensis*), por lo que deberían considerarse prioritarias en los planes de gestión y conservación.

**Keywords.** Biodiversity, endemism, flora, Equatorial Guinea, Río Muni.

**Palabras clave.** Biodiversidad, endemismo, flora, Guinea Ecuatorial, Río Muni.

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## INTRODUCTION

The Republic of Equatorial Guinea is formed by an oceanic island called Annobón (17 km<sup>2</sup>), four continental islands: Corisco (15 km<sup>2</sup>), Elobey Grande (2.27

km<sup>2</sup>) and Elobey Chico (0.19 km<sup>2</sup>), and Bioko (2,017 km<sup>2</sup>), and a continental region, Río Muni. Politically, it is divided into seven provinces: Bioko Norte and Bi-

oko Sur, Annobón, Litoral, Wele-Nzas, Kie-Ntem, and Centro Sur. The last four are on the mainland. Equatorial Guinea has maintained a close relationship with Europe. The island of Bioko was discovered in 1471, becoming part of the Portuguese crown. Four years later the same happened with the island of Annobon. In 1777, with the signing of the Treaty of San Ildefonso between Spain and Portugal, Equatorial Guinea passed to the Spanish crown, and would remain so until 1968, when it achieved its independence.

Río Muni is the continental region of Equatorial Guinea. It is in the Atlantic sector of Central Africa. It occupies 26017 km<sup>2</sup> between latitudes 1°01'N and 2°21'N, and longitudes 9°00' E (the Atlantic coast) and 11°20'E. It limits to the north with Cameroon, along the Ntem River, and to the east and south with Gabon. Río Muni is part of a large granite plateau that runs from the Atlantic coast to the Adamawa Massif on the north, to the Angola Plateau on the south and to the Congo River Basin on the west. This granite block comes into contact with sandstones and marls of the Tertiary by the west and with sandstones and slates of the Secondary by the southwest.

From a biogeographical point of view, Río Muni is included entirely in the strip of lowland and plain African rainforest, which barely exceeds 1000 m in altitude. It is integrated within the Guineo-Congolian Region, in the Nigerian-Cameroonian Province (Takhtajan 1986: 199; Linder & al. 2012; Droissart & al. 2018). This biogeographical province contains several endemic genera and many endemic species, and is currently covered by dense equatorial rainforests.

The soils of Río Muni are derived from the decomposition of granite and gneiss. They are lateritic soils with a concentration of iron oxide, aluminum, titanium, and magnesium hydrates higher than 30% (De Castro & De la Calle 1985; Fa 1991: 19).

The climate is equatorial with two dry seasons: one from July to September, the most important, and another from December to mid-February, and two rainy seasons: one from September to November and another from March to June. The average temperature is 25°C with an oscillation not exceeding 5°C. The average relative humidity is 90%, dropping slightly, to 85%, in the dry season. Annual precipitation ranges from 1800 to 3800 mm mainly between the months of September to December, with a considerable decrease in precipitation from March to May (De Castro & De la Calle 1985: 15-16; Fa 1991: 20). However, these figures vary greatly from one year to another, with an estimated mean precipitation of 2500 mm/year (Wilks & Issembé 2000: 3). Rainfall decreases from west to east and from south to north. Mountainous

areas, such as Mount Mitra, and the basin drained by the Mitemele river (Utamboni), on the southern border with Gabon, are the most humid areas.

#### *Botanical collectors in Río Muni*

The mainland of Equatorial Guinea has been much less explored than the island territories. The first known collections were made by the German Gustaf Mann (1836-1916), expeditionary of the Baikie's Niger Expedition. Although he focused his work on Bioko, he also collected fifty specimens in Litoral province (Corisco, Elobey, and in the Kongui river [Congüe]) in 1862. These specimens are preserved mainly in the K herbarium.

It took almost half a century for the explorations in this area to continue, carried out by another German explorer, Günther Tessmann (1884-1969), who in 1908 collected 100 specimens in Litoral province and especially in Wele Nzas (hosted at K), at the Nkolentangan (Alén), Uelleburg and Bebai stations. In 1928, the Spanish forestry engineer Fernando Nájera, commissioned by the "Dirección General de Marruecos y Colonias", visited the continental area to study the forest richness of Spanish Guinea. During the four months that he stayed in Río Muni, he studied and identified around 60 types of wood. These collections were probably lost from the Madrid "Escuela de Ingenieros de Montes" due to a fire. The result of Nájera's study was published by the "Instituto Forestal de Investigaciones y Experiencias" (Nájera 1930).

The history of Spanish botanical collections in the continental region begins with the pharmaceutical inspector Lope del Val Cordón (1896-1967), who visited the area between June and July 1939, collecting 650 specimens in the four continental provinces. The first botanist to take a decided interest in the flora of Equatorial Guinea was Emilio Guinea López (1907-1985). He made only one trip to the continent between June and September 1945. Guinea indicates that he collected 3,000 specimens. This number is difficult to confirm due to the complicated numbering system that he used. What we know for sure is that more than 1000 vouchers are preserved in MA. A part of these specimens is found in Lisbon (LISC), where Emilio Guinea traveled to identify this material, and perhaps in London (K). The itinerary of his trip shows that he traveled through most of the continental region, with long walking journeys through the most intricate of the tropical forest. Although he collected in the four provinces, it is noteworthy his systematic and intense tours to the Wele Nzas and Kie Ntem provinces. A first advance of his work was published in the *Anales del Jardín Botánico de Madrid* (Guinea 1945). The following year he published what

is still today the main work on the flora of Río Muni: *Ensayo Geobotánico de la Guinea Continental española* (Guinea 1946). Guinea was occasionally accompanied by J. Gómez Moreno. It will be almost fifty years after (1946), before floristic studies were resumed in the continental region starting in 1990. The Spanish-Portuguese Manuel Fidalgo do Carvalho, who had already collected in Bioko, moved his residence from Malabo (Bioko) to Bata on April 10, 1991, although he had already made some collections in Río Muni in December 1990. Carvalho remained on the continent until September of 1997. During his time in Río Muni, he made 1896 botanical collections. The abundant material that he collected from each specimen is very remarkable, always from fertile plants, and perfectly prepared and preserved. A complete series of his collections is held in MA, with numerous duplicates in major European and North American herbaria (AAU, B, BM, BR, COI, FI, G, H, K, LG, LISC, MO, NY, P, S, UPS, US, WAG, etc.) as well as in the National Herbarium of Equatorial Guinea (BATA).

At the same time of Guinea's collecting work, in the 90s, the CUREF ("Conservación y Utilización Racional de los Ecosistemas Forestales de Guinea Ecuatorial") project, funded by the European Union, started, with special emphasis on the study of plants. The botanical leader of the project was Jean Lejoly (BRLU) with the invaluable help of Stanislaw Lisowski (POZG). Several European botanists collected with the support of this project: Tariq Stévant (BRLU, MO), Ingrid Parmentier (BRLU), Bruno Senterre (BRLU) and Stephan Porembski (ROST) who collaborated in the training of a group of Guinean botanists from the INDEFOR ("Instituto de Desarrollo Forestal"), under the newly created BATA herbarium: Crisantos Obama, Pablo Esono, Norberto Nguema, Ildefonso Ndong, Domingo Ngomo, Francisca Eneme, and Diosdado Obiang Mbomio. In addition, there were six additional plant collectors who sometimes accompanied the CUREF-INDEFOR collecting team: Pierre van Asbroeck (BRLU) who collected in 1998 with Lejoly; N. Biedinger (BRLU) in 1998 with Porembski and N. Nguema, and Elad Maurice Epah (BRLU) in 1998 with Lejoly.

In 1997, with the financial support, of the "Agencia Española de Cooperación Internacional y Desarrollo" first, and later the Spanish Ministerio de Ciencia (in their different denominations), the Real Jardín Botánico, CSIC, began a project to study the flora of Equatorial Guinea, including Río Muni, Bioko and Annobón. It was directed by Mauricio Velayos (1955-) from the Real Jardín Botánico, CSIC. Since then, apart from M. Velayos, a team of researchers participated and directed the exploration and collection trips through the

four continental provinces: C. Aedo (MA), F.J. Cabezas (MA, currently at MACB), M. de la Estrella (MA, currently at COA), P. Barberá (MA, currently at MO) and M. Fero Meñe (MA, currently at UNGE). In total, 6,800 specimens were collected under the Flora of Equatorial Guinea project.

Other people also participated in plant collecting campaigns organized by the Real Jardín Botánico: Raquel Pérez-Viso, who lived in Bata between 1998 and 2000 and collected intensively in Río Muni (4,500 specimens, especially from the Centro Sur Province). Myriam López Serrano, a pharmacist from Granada, focused on the study of the traditional use of medicinal plants of the Centro Sur Province. Encarnación Gómez Marín and Laureano Merino Cristóbal collected 160 plant specimens for the publication of the book *Plantas Medicinales de Guinea Ecuatorial*. Up to 48 more botanists visited Equatorial Guinea sporadically and collected in the country, but all together collected less than 100 specimens.

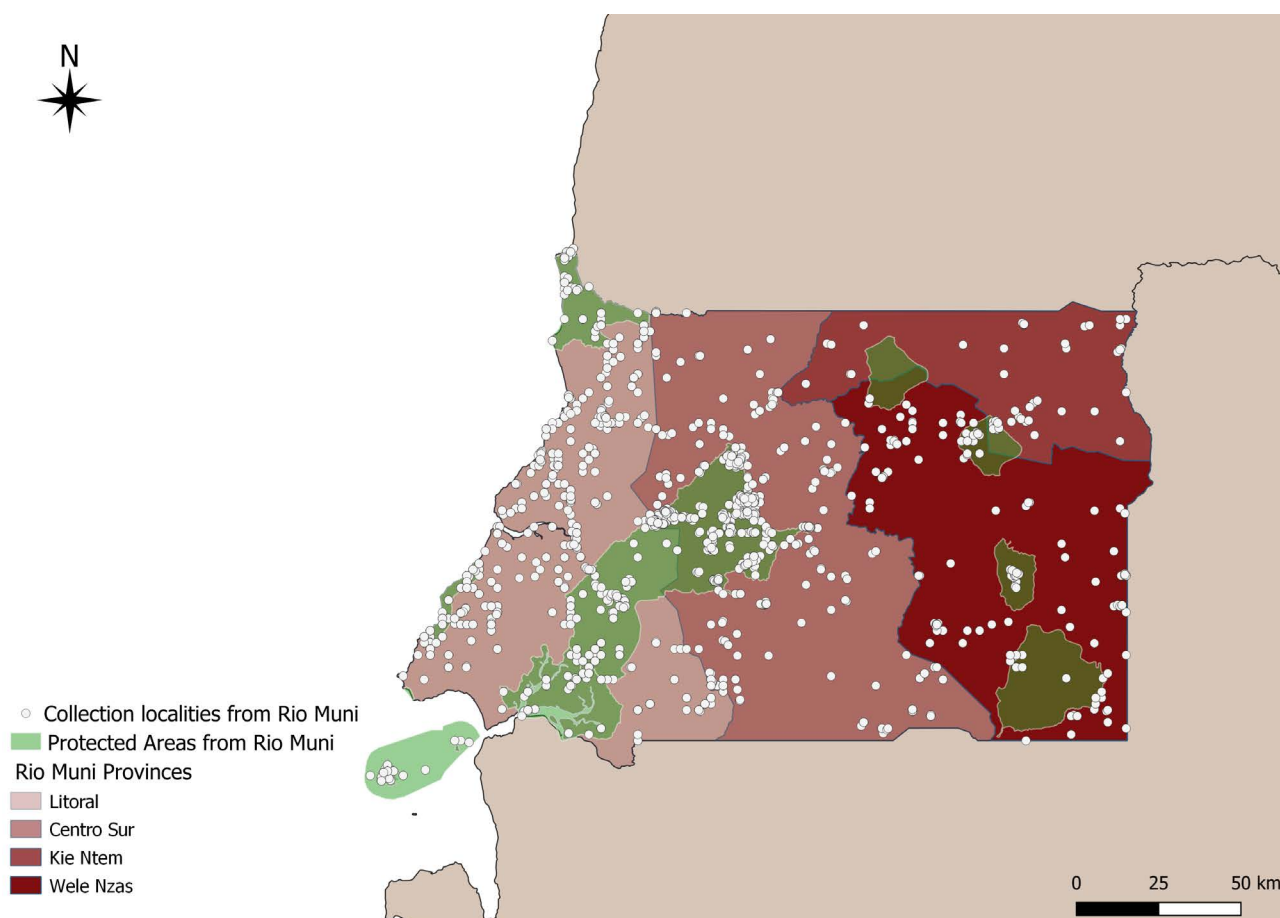
#### Floristic knowledge

Most recent published data from Río Muni are those of Sosef & al. (2017). In this study, the reported plant species richness for the whole of Equatorial Guinea is 3,049 species, increasing the estimated figure up to 3,821 species. This approach was based on the study of 15,341 records reflecting a Collection Density Index (CDI) for the country (number of collections/100 km<sup>2</sup>) of 54.69 (Campbell 1989). When CDI is calculated, the figures reveal a moderate level of knowledge of the region and more precisely from the continental region. These authors suggest a minimum of a CDI of 100 before one can state that the botanical inventory of a country or a region is of an acceptable level. If we calculate the CDI of the four provinces of Río Muni, only the Litoral Province is near the level of the CDI of 100, being Kie Ntem and Wele Nzás the provinces with the lowest botanical knowledge (Table 1).

If we plot the collection localities from the 23,517 specimen records (Fig. 1) we observed that plant-collecting efforts are geographically biased and some inaccessible

**Table 1.** Collection Density Index (CDI) of Río Muni and its provinces.

Territory	N° collections	Area km <sup>2</sup>	CDI
Centro Sur	4,065	9,931	40
Kie Ntem	1,019	3,943	27
Litoral	4,953	6,665	74
Wele Nzás	1,295	5,478	23
Unknown territory	217	-	-
Total Río Muni	11,549	26,017	44



**Fig. 1.** Locations of the plant collections (white circles) from Río Muni across its four provinces, based on 23,517 georeferenced specimen records. Protected areas are highlighted in green (see Fig. 3).

places remain poorly known, thus botanical exploration in Río Muni is still one of the main tasks for future biodiversity studies.

#### MATERIAL AND METHODS

We built a checklist (Appendix 1) based primarily on both herbarium specimens and bibliographic references. We studied 11,549 specimens collected in Río Muni, mainly from the herbaria BATA, BRLU, HBG, K, LBV, MA, and WAG; although to a lesser extent, also from BM, BR, G, MO, NY, P, and S. For comparative purposes specimens from Cameroon, Gabon, São Tomé and Príncipe, and other territories of Equatorial Guinea kept in those herbaria were also studied.

Of the 11,549 specimens compiled, only 6,850 could be identified to species, this is, assigned to an accepted name. Bibliographic references for all families of vascular plants were also checked. In total 7,985 species records from bibliographic sources were compiled from Alston (1956, 1959), Arends (1992), Aubréville (1961), Aubriot (2020), Bamps (1970, 1974), Barberá & al. (2013, 2014, 2015),

Bauters & al. (2018), Bidault & van der Burg (2019), Bissengou & al. (2013), Biye *et al.* (2014), Bos (1984), Bourobou (2018), Brennan (1953a, 1953b, 1953c, 1968), Brennan & Exell (1957), Breteler (1999, 2010, 2011, 2013, 2016, 2017, 2018), Breteler & Smisjaert-Houwing (1977), Cabezas & al. (2004, 2005, 2009), Cebolla-Lozano & Rivas-Ponce (1995a), Chatrou & Repetur (1998), Couvreur (2008, 2009), Cufodontis (1953, 1955a, 1955b, 1970), Damen & al. (2018), De Kok (2022), Dekker (1983), Del Val (1942), Dhetchuvi & al. (2011), Diels (1910), Dilt (1995), Dilt & Leeuwenberg (1991), Droissart & al. (2009), Eimunjeze (1976, 1989), Engler (1912), Estrella & al. (2005, 2006, 2010a, 2010b), Fernández-Casas (1992), Fero (2012), Fero & al. (2003, 2014), Figueiredo (1995), Fischer & Lachenaud (2013), Galán Cella & al. (2018), Gauthier & al. (2016), Geerinck (1980), Ghogue & al. (2017), González Gómez & Pereira (1946), Guinea (1945, 1946, 1951), Harris (1995), Harris & Wortley (2018), Harris & al. (2021), Hauman (1951), Heine (1966), Hepper (1954, 1958, 1963, 1968a, 1968b, 1968c, 1972), Holttum (1981, 1986), Hooker (1864), Hooper & Napper (1972), Hutchinson & Dalziel (1927, 1928, 1931, 1936), Ikabanga & al.

(2019), Jacques-Félix (1976, 1981), Jeffrey (1966, 1986, 1997), Johnson & Murray (2018), Jongkind & Lachenaud (2019), Jongkind (1989a, 1989b, 1989c, 2022), Keay (1952), Kenfack & al. (2015), Koechlin (1965), Kruif de (1985), Lachenaud (2016a, 2016b, 2019), Lachenaud & Breteler (2011), Lachenaud & Jongkind (2010), Lachenaud & van der Maesen (2016), Lachenaud & al. (2013, 2017, 2018), Le Thomas (1969), Leal (2007), Leeuwenberg (1961a, 1961b, 1969, 1985), Lejoly & Lisowski (1998, 1999a, 1999b, 2000), Lemmens (1989a, 1989b), Léonard (1951, 1955, 1961, 1988, 1995, 1996), Léonard & Voorhoeve (1964), Lissambou & al. (2018), Lock (1978, 1980, 1989), Maas & Maas-van de Kamer (2020), Maas-van de Kamer & al. (2016), Maesen & Sosef (2016), Manktelow (1996), Mas-Guindal (1944), Milne-Redhead (1950), Morales (1993, 2011), Moran & Smith (2001), Morton (1978, 1979), Moutsamboté (1990), Nelmes (1955, 1956, 1957), Ntore (2008), Oliver & Hanbury (1864), Oliver (1865, 1868, 1871), Parmentier (2001), Parmentier & Geerik (2003), Parmentier & al. (2001), Paton & al. (2022), Pax & Hoffmann (1911, 1912, 1914), Poncy (1978), Prain (1911), Prance & Jongkind (2015), Quintanar & al. (2022), Rial (2002), Robbrecht & al. (1993), Sanford (1971), Schaefer (2021), Senterre (2005), Simons (2021), Sleumer (1971, 1972a, 1972b, 1972c, 1973, 1974a, 1974b, 1974c), Sonké (2007), Sosef & Bissiengou (2016), Sosef & Dauby (2013), Sosef & Nguema Miyono (2010), Stévant & al. (2010), Stévant & Oliveira (2000), Stewart (1979), Szlachetko (2008), Thiselton-Dyer (1913), Townsend (1975), Troupin (1950, 1962), Van der Burg (2013), Van der Burg & Bidault (2020), Velayos & al. (2001, 2008, 2014, 2015, 2018), Veranso-Libalah & al. (2019), Verdcourt (1996), Vermeulen (1987), Verstraete & al. (2013), Villiers (1990), White (1963, 1976, 1978), Whitmore (2008), Wieringa (1999), Wilde (1968, 1971), Wilks & Issembé (2000), Zemagho & al. (2017, 2018). Names were updated according to the African Plant Database (<https://africanplantdatabase.ch/en>), or in the cases where supporting specimens were mentioned, the corresponding accepted names were assigned. Names of localities were also updated and standardized. Complementarily, 10,109 records from GBIF (2022) and 8,897 records from RAINBIO (Dauby & al. 2016) databases were also checked and updated, building a dataset of 36,984 species occurrence records from Río Muni, of which 23,517 were georeferenced.

The checklist was arranged in four main plant groups: Pteridophytes, Magnoliids, Monocotyledons and Eudicotyledons. Within each group, families, genera, and species were arranged alphabetically. Family classification follows PPG I (Schuettelpelz & al. 2016) for Pteridophytes and APG IV (Byng & al. 2016) for Angiosperms. When a discrepancy with the classification of *Flora de Guinea Ecuatorial* (Velayos & al. 2008) was found we indicated it in brackets. Authors of plant names were abbreviated according

to Brummit & Powell (1992), and to the updated version available at [http://www.ipni.org/ipni/query\\_author.html](http://www.ipni.org/ipni/query_author.html).

Under each accepted name, we included the following information: i) the updated IUCN category (<https://www.iucnredlist.org/> accessed September 2022) (NE indicates the species has not been evaluated); ii) distribution information, indicating if the species is native, endemic, sub-endemic (considering subendemic plants with a reduced distribution area in which most of the localities are in Río Muni), introduced, naturalized, or cultivated and also the complete distribution range with the biogeographical divisions of Takhtajan (1986); and iii) a list of the studied specimens arranged by provinces. References from the most relevant literature were also included, but these were not considered in the floristic analysis. Taxa marked with a question mark are doubtful because of imprecise information and must be corroborated in the future.

A map (Fig. 1) and an updated and standardized list of collection localities of Río Muni is also provided (Appendix 2). A list of 665 localities was gathered, checked, and correctly spelled, and 450 localities were revised and georeferenced.

The conservation status of threatened species was assessed using the IUCN criteria (IUCN 2019). A preliminary risk of extinction assessment using the IUCN Red List categories and criteria (IUCN 2019) was carried out for the endemics and subendemic species that have not yet been published in the IUCN. Area of Occupancy (AOO) and Extent of Occurrence (EOO), estimated using a  $2 \times 2$  km grid, were calculated using GeoCAT (2020).

## RESULTS AND DISCUSSION

### *Floristic Analysis*

Due to their biological importance, floristic inventories of tropical African underexplored areas are an urgent need. Despite of the huge development of communication infrastructures in the continental region of Equatorial Guinea, a large percentage of its territory is still inaccessible (Fig. 1). Besides, some of the published data are not supported by herbarium specimens, thus so much of the information available is not reliable. Many of the analyses, conservation plans, or management strategies that have been developed in African countries have been made with outdated bibliographic data and assuming complete biodiversity inventories, which are far from being so. Thus, it is quite common in these regions (tropical Africa) that when new collections are added, species numbers change drastically. Similar results are usually observed with new taxonomic treatments or systematic analyses. Endemic or threatened species are usually known from a few collections, which require new data to properly evaluate their real taxonomic status or threat level.

The Río Muni Vascular Plants catalogue is a compendium of numerous cases of the above-mentioned problems.

The checklist of Vascular Plants from Río Muni comprises 178 families, 1,020 genera and 2,707 species and infraspecific taxa (Appendix 1). Pteridophytes represent the 5% of the species (142) and the 12.35% of the families of Río Muni (22). With these figures, the floristic knowledge of Río Muni, in terms of number of species, increases in 26.14% from the most recent studies (Table 2). The number of taxa considered as native is 2,411 (89.96%), 32 species (1.2%) are introduced, 36 cultivated (1.35%), and 158 (5.92%) should be considered as naturalized since they are able to establish new populations.

**Table 2.** Number of Río Muni vascular plants species compared with the main previous works.

	Guinea 1946	Lejoly & Lisowski 1998	Sosef & al. 2017	This work
Pteridophyta	52	53	133	142
Spermatophyta	1,064	1,141	2,013	2,565
Total	1,116	1,194	2,146	2,707

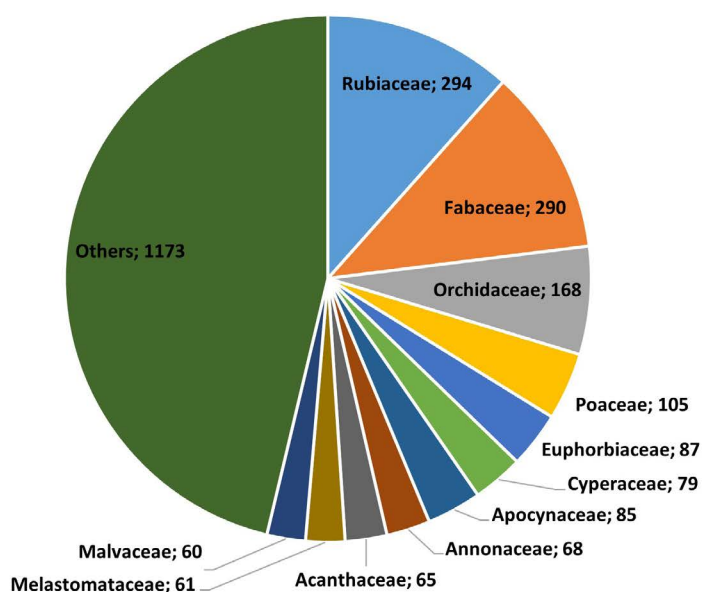
The most diverse families are Rubiaceae (294 species), Fabaceae (290), Orchidaceae (168) and Poaceae (105). The 10 most species-rich families are completed by Euphorbiaceae (87), Apocynaceae (85), Cyperaceae (79), Annonaceae (68), Acanthaceae (65) and Melastomataceae (61). These 10 families alone comprise about half of the species (49.22%) of Río Muni (Fig. 2).

This floristic pattern of family diversity is similar to the one found in Annobon island (Velayos & al. 2014). Such pattern is observed even when total species-richness figures are 10-times bigger (Annobon 24 species of Fabaceae, Río Muni 290) and it highlights the importance of the flow of species across the territories of the Gulf of Guinea. This idea is supported by the low number of endemic species observed in these territories.

Although the botanical exploratory level of Río Muni is relatively high when compared to the Central African countries, the number of species recorded so far is still far from the observed in neighboring Cameroon or Gabon, with 6,883 and 5,236 species respectively (Sosef & al. 2017). Besides the differences in area among the three of them, these figures are pointing out the need of continuing with the collection effort in Río Muni. The number of species in the continental region and the entire Equatorial Guinea would likely increase if plant collecting efforts were extended to the poorly explored areas in the near future.

#### Threatened status and endemism

The number of threatened taxa (VU, EN and CR) is 144 (5.31% of the total taxa) of which 48 are under extinction risk, i.e., considered Endangered or Critically Endangered (Table 3). Two endemic species, *Polyscias aequatoguineensis* and *Scleria mongomoensis* are categorized as Endangered and should be regarded as priority species for Conservation plans and strategies. Nonetheless, a reevaluation of the real situation of these species should be even more important to do since preliminary data indicate that the real threatened



**Fig. 2.** Diversity of species per family in Río Muni. The eleven most speciose families ( $\geq 60$  spp.) are highlighted. The “Others” category includes 167 families with fewer than 60 species.

**Table 3.** Number of taxa per conservation status for each major plant group in Río Muni. Percentages were calculated considering the total number of taxa in each plant group.

	NE-DD		LC		NT		VU		EN		CR	
	N°	%	N°	%	N°	%	N°	%	N°	%	N°	%
Pteridophyta	132	92.96	9	6.34	0	0	1	0.7	0	0	0	0
Gymnospermae	1	50	0	0	1	50	0	0	0	0	0	0
Magnolioids	42	43.75	43	44.79	3	3.12	6	6.25	1	1.04	1	1.04
Monocots	389	65.79	177	31.21	1	0.17	8	1.41	11	1.94	1	0.17
Eudicots	1,082	57.55	652	34.68	31	1.65	81	4.3	30	1.6	4	0.21
Total	1,646		881		36		96		42		6	

status of Vascular Plants in Equatorial Guinea is far from well known. As an example, we focus our discussion below on endemic or subendemic plants from Río Muni.

Of all threatened taxa, only three are non-native to Río Muni namely *Terminalia neotaliala*, *Gossypium hirsutum* (both naturalized) and *Memecylon erythranthum* (introduced); and only 11 species could be considered as strictly endemic to Río Muni (Table 4). This low number of endemic taxa is reflecting the absence of natural barriers in the territory.

From the 13 endemic/subendemic species, three of them (*Scleria mongomoensis*, *Polyscias aequatoguineensis*, and *Grossera angustifolia*) have been recently evaluated by the IUCN as EN (Larridon & Bauters 2020; Paradis & al. 2021; Ruiz de Diego & al. 2022). *Guyonia obamae* records from Río Muni have been identified as *G. arenaria*, and the species was preliminary assessed as NT (Lachenaud & al. 2018), nonetheless its taxonomic situation is still unclear.

We confirm that 12 out of 13 of the endemic species evaluated should be considered as threatened (Table 4). Only

for the subendemic *Polystachya riomuniensis*, since the distribution range of the species is quite large, the Extent of Occurrence (EOO) criteria states it as Least Concern while the Area of Occupancy (AOO) indicates the taxon as EN. We consider a more realistic conservative approach until taxonomic studies confirm the identity of these 12 species or new collecting campaigns confirm the presence of these taxa beyond the current distribution ranges.

#### Preliminary assessments of NE taxa

*Scaphopetalum obiangianum* is a shrub 20-150 cm tall, known from the understory of rain forest, at around 700 m in elevation (Leal 2007). The species is endemic to Equatorial Guinea and is only known from one collection made by Leal in 2005 in Monte Mitra, which thus represents a single occurrence in the Litoral Province. The AOO is estimated as 4 km<sup>2</sup>, below the upper threshold for Critically Endangered status under subcriterion B2. The EOO is the same as the AOO. This occurrence therefore represents the entire known population of the species. It

**Table 4.** Endemic and subendemic species from Río Muni. Accepted Name, threatened category according to the IUCN, or preliminary assessments already published or preliminary assessed here. Preliminary risk of extinction assessments using the IUCN Red List categories and criteria (IUCN 2022) are provided for the endemic and subendemic species that have not yet been published in the IUCN.

Family	Species	IUCN category	Preliminary assessment
Araliaceae	<i>Polyscias aequatoguineensis</i> Lejoly & Lisowski	EN (2021)	-
Aspleniaceae	<i>Asplenium carvalhoanum</i> Herrero, Aedo, Velayos & Viane	NE	CR (here)
Begoniaceae	<i>Begonia aequatoguineensis</i> Sosef & Nguema	NE	VU D2 (here)
Begoniaceae	<i>Begonia monte-alenensis</i> Sosef	NE	VU D2 (Sosef 2014)
Cyperaceae	<i>Scleria mongomoensis</i> Bauters	EN (2020)	-
Euphorbiaceae	<i>Grossera angustifolia</i> Barberá & Riina	EN (2022)	-
Malvaceae	<i>Scaphopetalum obiangianum</i> M.E. Leal	NE	VU D2 (here)
Melastomataceae	<i>Guyonia obamae</i> (Lejoly & Lisowski) Veranso-Libalah & R. D. Stone (= <i>G. arenaria</i> (Jacq.-Fél.) Verano-Libalah & R.D. Stone	NE	NT (Lachenaud & al. 2018)
Melastomataceae	<i>Nothodissotis alenensis</i> Veranso-Libalah & O. Lachenaud	NE	VU D2 (Veranso-Libalah & al. 2019)
Orchidaceae	<i>Polystachya riomuniensis</i> Stévant & Nguema	NE	LC/EN
Orchidaceae	<i>Rhipidoglossum montealenense</i> Descourvières, Stévant & P.J. Cribb	-	EN (Descourvières & al. 2013)
Orchidaceae	<i>Vanilla chalongii</i> Finet	NE	VU/EN
Podostemaceae	<i>Macropodiella uoroensis</i> Rial	NE	CR (here)

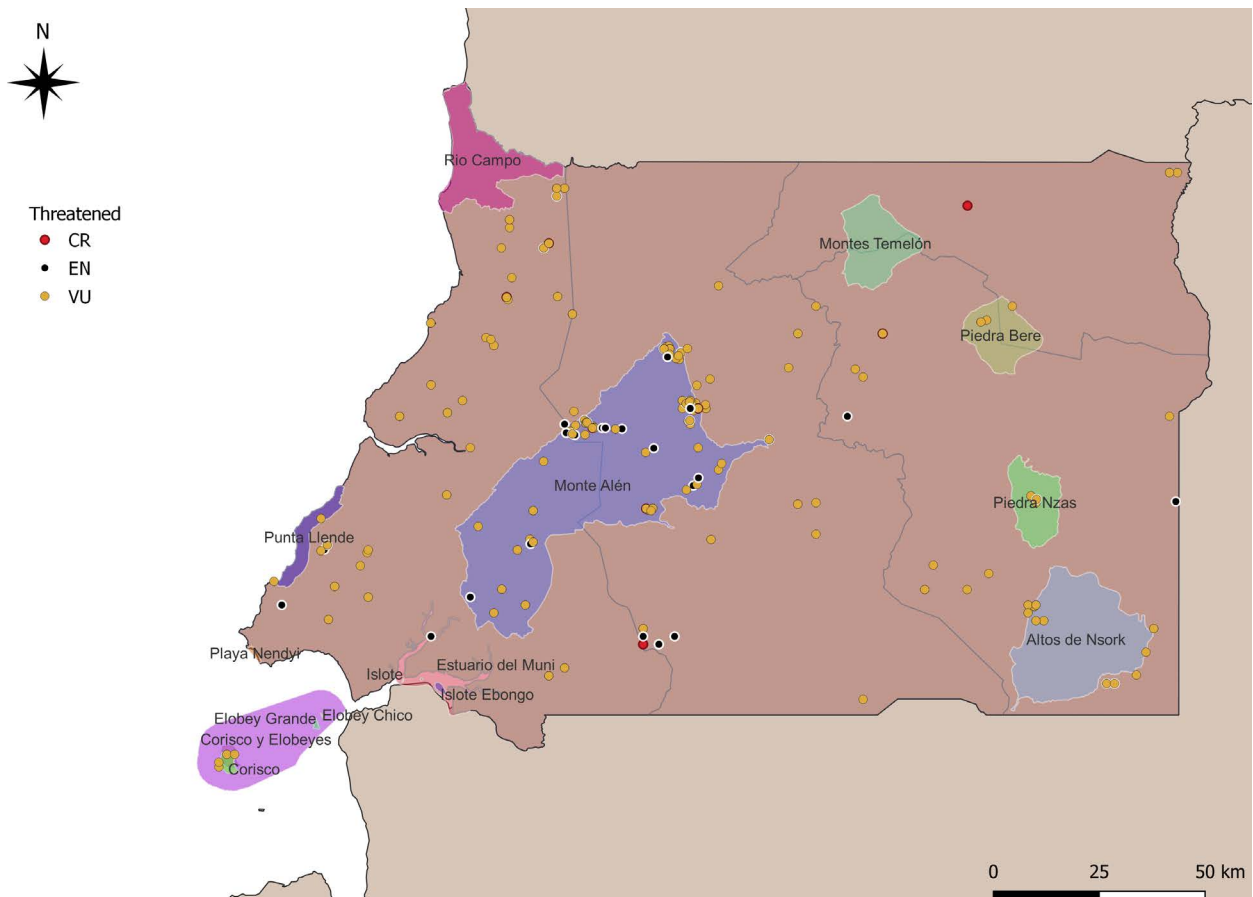
is located within a protected area (Monte Alén National Park), and no specific threats have been identified at the present time. Therefore, *Scaphopetalum obiangianum* is assigned a preliminary status of VU D2.

*Begonia aequatoguineensis* is an herb up to c. 5 cm high, known from primary forest at c. 450 m altitude (Sosef & Nguema Miyono 2010). The species is endemic to Equatorial Guinea and is only known from one collection, which thus represents a single occurrence, made by Nguema Miyono at West of Mendung, in the Centro Sur Province. The AOO is estimated as 4 km<sup>2</sup>, below the upper threshold for Critically Endangered status under subcriterion B2. The EOO is the same as the AOO. This occurrence therefore represents the entire known population of the species. It is located within the protected area Monte Alén National Park and no specific threats have been identified at the present time. Therefore, *Begonia aequatoguineensis* is assigned a preliminary status of VU D2.

*Asplenium carvalhoanum* is an epiphyte, known from primary rainforest, endemic to Equatorial Guinea (Herrero

& al. 2001). The species is only known from one collection, made by Carvalho in Cogo, between Emangós and Ncó villages, in the Litoral Province, which thus represents a single occurrence. The AOO is estimated as 4 km<sup>2</sup>, below the upper threshold for Critically Endangered status under subcriterion B2. The EOO is the same as the AOO. This occurrence therefore represents the entire known population of the species. It is not located within a protected area and is threatened by logging and by small-scale harvesting. The most serious plausible threat is the logging. We infer a future decline in the extent and quality of its habitat, therefore *Asplenium carvalhoanum* is thus assessed as CR B2ab(iii).

*Macropodiella uoroensis* is endemic to Equatorial Guinea, known from the rapids of the Uoro river, at Centro Sur province. The species is only known from one collection made by Rial & Laso in 1994, representing a single occurrence. The AOO is estimated as 4 km<sup>2</sup>, below the upper threshold for Critically Endangered status under subcriterion B2. The EOO is the same as the AOO. This occurrence therefore represents the entire known population of



**Fig. 3.** Protected Areas of Río Muni here depicted in different colors. Dots indicate the occurrences of threatened species: CR (red), EN (black), VU (yellow).



the species. It is not located within a protected area and is potentially threatened by water pollution due to increase in urbanization. We infer a future decline in the extent and quality of its habitat hence, *Macropodiella uoroensis* is assessed as CR B2ab(iii).

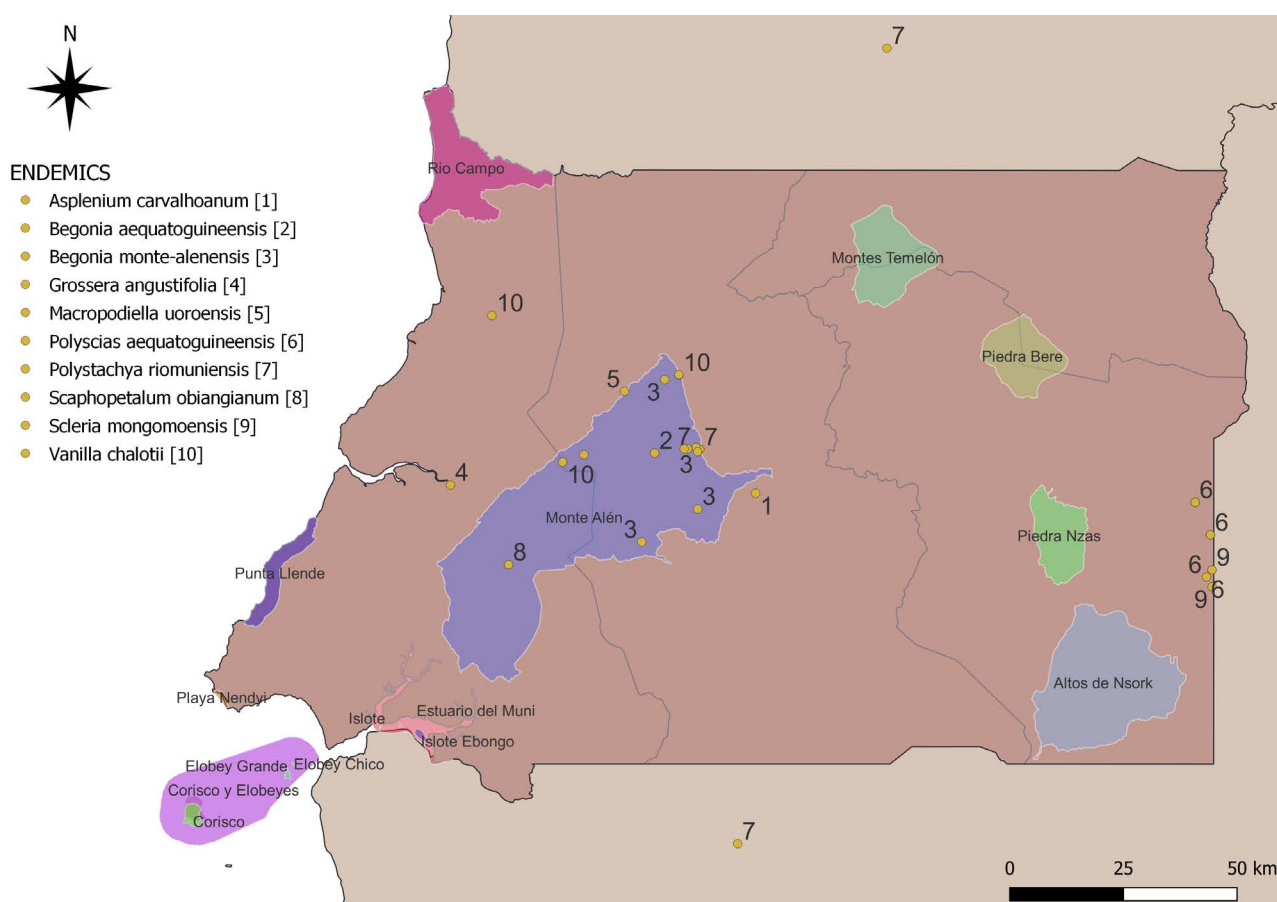
#### Priority conservation areas

The geographical analyses of threatened species from Río Muni revealed the value of the National System of Protected Areas of Equatorial Guinea (Fig. 3). A total of 618 records out of the 23,517 compiled correspond to threatened species (CR, EN or VU), 224 of them are outside protected areas, which means that 36.25% of the threatened plants of Río Muni do not have any protection at all. If we consider those Near Threatened taxa, there are 721 total occurrences, 276 outside protected areas (38.28%). Monte Alén National Park is by far the most important Protected Area in Río Muni, hosting 49.23% of the occurrences of threatened species in this continental region. Two protected areas, Río Campo, and Montes Temelón do not include any occurrence from threatened species (Fig. 3).

#### Endemicity and areas for conservation

The conservation relevance of the system of protected areas of Equatorial Guinea comes to the fore when we consider the endemicity of the flora. Figure 4 shows the spatial distribution of the 13 endemic and subendemic species. Twenty-one of these occurrence records (46.6%) are included in protected areas. In this sense, the situation of *Scleria mongomoensis*, *Macropodiella uoroensis*, *Polyscias aequatoguineensis*, *Grossera angustifolia* and *Asplenium carvalhoanum* is particularly delicate since none of their localities has any protection status. As aforementioned, all of them, but *Polyscias aequatoguineensis*, could be also threatened under the IUCN category of Critically Endangered.

Expanding the area of the Monte Alén National Park and establishing a monitoring program for these species to establish corridors between protected areas or new areas of special interest for the flora are necessary strategies to achieve a sustainable management of plant diversity in Equatorial Guinea. Connecting the different protected areas or increasing the surface area of some of them seems



**Fig. 4.** Distribution of endemic and subendemic species in Equatorial Guinea. Protected areas of Río Muni (8) are shown in different colors and endemics occurrences are indicated by colored dots and numbers.

to be the best alternative to include the greatest number of threatened species present in this region. Finally, we emphasize that coastal meadows are especially under protected from human impacts.

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The elaboration of the checklist of vascular plants of Río Muni would have not been possible without the contribution of many people along the last years. We assume that, if we try to mention all of them, we will surely forget some names. We apologize for not even trying. However, it is necessary to mention the main contributors: the authors of the Flora de Guinea project who, over the years, collected, identified and studied most of the specimens on which this checklist is based.

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**Appendix 1.** Checklist of the Vascular Plants of Río Muni (Equatorial Guinea) available at: <https://doi.org/10.20350/digitalCSIC/15141>

**Appendix 2.** Localities of Río Muni with geographic coordinates available at: <https://doi.org/10.20350/digitalCSIC/15142>