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Contribution to the Systematic Study of the Ornamental Flora of Gorée Island (Dakar-Senegal)

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Abstract

Gorée Island, located approximately 4.5 km off the coast of Dakar, is both an island in the North Atlantic Ocean and one of the 19 boroughs of Senegal's capital city. This emblematic site has been widely studied in fields such as archaeology, geology, history, and tourism. However, its ornamental flora has received very little scientific attention. This is particularly concerning given that recent decades have been marked by the depletion of its natural resources due to numerous human activities combined with urban expansion and climate change. It is therefore crucial to improve scientific knowledge of Gorée Island's ornamental flora to support sustainable and

participatory management. This study, conducted in September 2021, aims to contribute to a broader understanding of Gorée's ornamental flora. More specifically, this study aims to establish the taxonomic, biological, and chorological profiles of the ornamental flora of Gorée. The methodological approach consisted of conducting a field survey in the three gardens (Canary Garden, Public Garden, and Succulent Plant Garden) and the flowerbeds of the municipality. The results showed that 55 plant species belonging to 49 genera, grouped into 31 families, were identified. Of these species, 36 are already listed in the flora of Senegal, while the remaining 13 have not been recorded and could be introduced to Senegal. This flora is composed exclusively of angiosperms, with three dominant families: Apocynaceae (9.09%), Acanthaceae (7.27%), and Asparagaceae (7.2%). In terms of biological types, Phanerophytes are the most represented (50.91%), followed by Chamaephytes (20%). Chorologically, the flora is dominated by pantropical species, which account for 34.55% of the species mentioned, compared to 21.82% for other African-American species.

Conclusion and application: This work has allowed us to characterize the ornamental flora of Gorée Island. Indeed, the structure of the flora, as well as its taxonomic, biological, and chorological spectra, has been determined. The results of this study can be used to develop tools for taxon identification (identification key).

Keywords: Flora, Ornamental, Characterization, Management, Gorée

Introduction

Gorée Island, located approximately about 4.5 km off the coast of Dakar, is both an island in the North Atlantic Ocean and one of the 19 boroughs of Senegal's capital city. It is a symbolic site of remembrance for the slave trade in Africa. The island was declared a historical site in 1944, with safeguarding measures adopted in 1951 (during the colonial era). It was subsequently inscribed on the national heritage list in 1975 (Decree No. 012771 of November 17, 1975) and on the UNESCO World Heritage List in 1978 (DEEC, 2022).

This iconic Senegalese territory has been the focus of numerous studies spanning archaeology, history, and tourism. Furthermore, despite centuries of conquest, pillaging, and urban redevelopment (18th century), the area currently occupied by the Adanson Public Garden has remained largely intact. This garden has nonetheless evolved, adapting to different configurations and functions throughout more than three and a half centuries of documented urban development on Gorée Island.

However, the ornamental flora of Gorée Island has been the subject of little scientific investigation. Recent decades have been characterized by

the depletion of its natural resources due to numerous human activities combined with urban expansion and climate change (MEED, 2014). The impact of these constraints is clearly visible today with the scourge of climate change. Thus, the quality of the living environment is now recognized as crucial to the physical and psychological well-being of populations, hence the importance of ornamental plants, which also play a significant role in improving the living environment. It is therefore essential to enhance scientific knowledge about the ornamental flora of Gorée Island in order to support a sustainable and participatory management.

This study was undertaken to enhance the overall understanding of the ornamental flora of Gorée Island. Specifically, it aims to characterize its taxonomic, biological, and chorological spectra.

Materials and Methods

Presentation of the study area

The studies were conducted in three gardens (the Canary Garden, the Public Garden, and the Succulent Garden) and other pathways on Gorée Island, located in the Bay of Dakar. These themed gardens contribute to the beautification of the living environment and also provide spaces for recreation and community gatherings. Gorée is one of the 19 boroughs of the capital of Senegal. It is a symbolic site of remembrance for the slave trade in Africa, officially recognized by the United Nations (UN) in 1978. Gorée, the "memory island" of this tragedy, was thus one of the very first sites to be inscribed on UNESCO's World Heritage List.

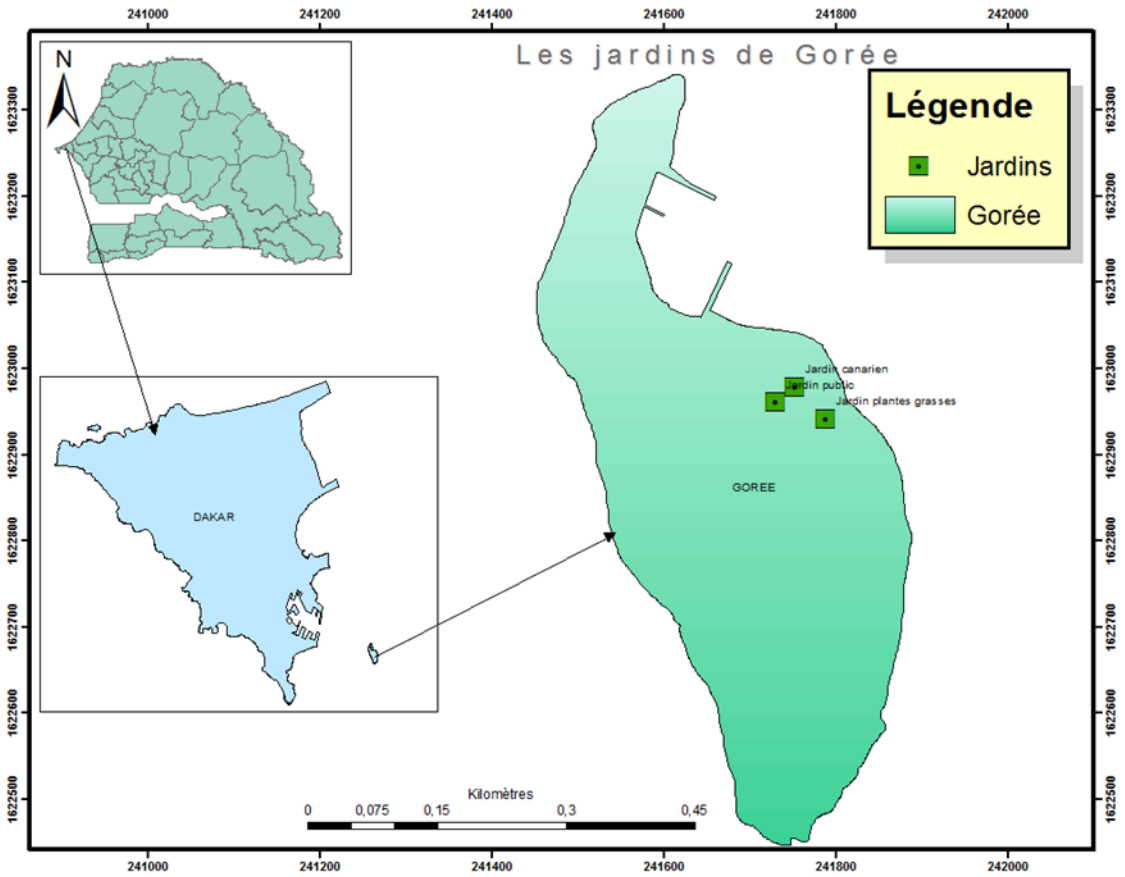


Figure 1: Map showing the location of the study site

Equipment

The following equipment was required to complete this work:

- A GPS to get the geographical coordinates of the gardens;
- Floristic inventory sheets to inventory the species present in the different gardens;
- Notebooks, pencils, erasers for taking notes;
- Pruning shears for collecting samples;
- A press for preserving and drying samples;
- A digital camera for taking pictures of ornamental plants

The following books and websites were used for species identification:

- Flora of Senegal (Berhaut, 1967),
- Flora of West Tropical Africa (Hutchinson & Dalziel, 1954, 1958, 1963, 1968, 1972)

- Catalogue of vascular plants of Burkina Faso (Thiombiano et *al*., 2012).
- Master's and PhD thesis from the Laboratory of Botany and Biodiversity: Photo libraries of Dieng (2014 and 2019).

Methods

Data Collection

The floral inventory

The inventory was conducted through a field survey, which consisted of traversing the area in all directions, noting all plant species encountered. For each plant, its botanical characteristics were described on site and its common name recorded. Once in the laboratory, the botanical characteristics of each plant were compared to those described in available documentation. After identification, each species was assigned its scientific name, and the description of its botanical characteristics was completed.

Data Processing

Analysis of the flora structure

To analyze the structure of the ornamental flora of Gorée Island, taxonomic, biological and chorological spectra were developed.

Taxonomic spectrum

After compiling the floristic list, the taxonomic spectrum shows the distribution of species across the different taxonomic ranks (genus, family, class, etc.). Determining the taxonomic spectrum made it possible to define the number of species, genera, and families of the recorded species and to identify the dominant taxa for each taxonomic rank.

The nomenclature used follows the database managed at the Conservatory and Botanical Garden (CJB) of Geneva; this database is based on the seminal work of Lebrun and Stork (1991-1997) and is accessible on the following regularly updated website:
http://www.ville-ge.ch/musinfo/bd/cjb/africa/index.php?langue=fr
The taxonomic classification used is that of APG III (2009).

Biological spectrum

The biological spectrum shows the distribution of species among different biological forms. These forms refer to "the set of morphological characteristics that play a role in resistance to adverse conditions, and therefore in the localization of plant species" (Serge et al., 2015). Raunkier's (1934) biological types are adapted to the intertropical zone where the

unfavorable season corresponds to the dry season (Lebrun, 1966). This classification distinguishes eight biological forms, which are:

- phanerophytes (Ph): woody plants whose buds are located more than 50 cm above the ground;
- chamaephytes (C): perennial woody or herbaceous plants, rooted, whose regenerative buds are located near the ground, below 50 cm;
- hemicryptophytes (He): rooted plants whose bud is located on the surface of the soil, and whose aerial part dies during the unfavorable season;
- geophytes (Ge): plants whose bud is well buried in the soil;
- therophytes (Th): plants that survive the unfavorable season in the form of seeds;
- Parasites (Par): plants that draw water, mineral salts and/or sugars from photosynthesis from other plants (functional parasitism).

The distribution of the recorded species according to Raunkier's (1934) biological types was a synthesis of information on species biological types from the work of Berhaut (1971; 1988), Hutchinson et *al*. (2014), and Thiombiano et *al*. (2012). Thus, the biological spectrum was first established globally, without considering individual sites, and then further defined for each site.

For the evaluation and interpretation of the results, the percentage proportion of each biological type is calculated using the following formula:

$$\text{Frequency of a given biological type} = \frac{\text{number of species of the biological type in question} \times 100}{\text{total number of species}}$$

Chorological spectrum

The chorological spectrum shows the distribution of recorded species across the various regions of the biosphere. To establish it, each species was assigned to a phytogeographical type based on the regions where it was recorded. The phytogeographical types used are based on the major chorological subdivisions established for Africa by White (1986), the main ones being:

- Cosmopolitans (Cos): species found in both tropical and non-tropical regions;
- Pantropical (Pt): species widespread in Africa, America, tropical Asia and Australia (intertropical regions);
- Paleotropical (Pal): species found in Africa and tropical Asia as well as in Madagascar and Australia (tropical zones of the Old World);

- African American (Am): species found in Africa and tropical America;
- African American and Australian (Amu);
- Afro-Asians (As);
- Afro-Asian and Subtropical (AsT);
- Afro-tropical (AT): species distributed throughout tropical Africa;
- Pantropical and Mediterranean (Pt-Me);
- Afro-Malagasy (AM): species distributed in Africa and Madagascar;
- Afro-Malagasy and Asian (Mas);

The phytogeographic distribution of the species identified was a work of synthesis of the chorological information of the species from the works of Berhaut (1971-1988), Hutchinson et *al*., (2014) and Thiombiano et *al*., (2012).
It was established using the following formula

$$\text{Frequency of a given phytogeographical type} = \frac{\text{number of species of the phytogeographical type in question} \times 100}{\text{total number of species}}$$

Results and Discussion

Qualitative Analysis

Overall structure of the flora

Table 1 summarizes the results on the list of species inventoried in the three (3) gardens. For each species, its presence or absence in the flora of Senegal, its geographical distribution, and its biological type were noted.

Fifty-five (55) species belonging to 49 genera grouped into 31 families were recorded in the gardens of Gorée island. Among these ornamental species, 36 have already been cited in the flora of Senegal, while the remaining 19 have not been listed and could be introduced to Senegal.

Family	Sub-family	NG	NS	*Espèces*	FS	BT	GR
Acanthaceae (D)		3	4	*Pseuderanthemum carruthersii* (Seem.) Guillaumin	-	C	As
				Pseuderanthemum carruthersii var. reticulatum (W.Bull) Fosberg	-	C	Pt
				Ruellia tuberosa L.	-	C	Am
				Asystasia gangetica (L.) T. Anderson	+	C	Amu
Agavaceae (M)		1	1	*Agave sisalana* L	+	P	Pt
Aloeaceae (M)		1	1	*Aloe vera* (L.) Burm.f	+	H	Cosm
Amaranthaceae (D)		1	1	*Alternanthera brasiliana(L.) Kuntze*	-	C	Pt
Amaryllidaceae (M)		2	2	*Crinum amabile* Donn ex Kew Gawler.	-	G	Pt
				Hymenocallis speciosa (L. f. ex Salisb.) Salisb.	-	G	As
Apocynaceae (D)	Apocynoideae	4	4	*Catharanthus roseus* (L.) G. Don	+	C	Pt

Family	Sub-family	NG	NS	*Espèces*	FS	BT	GR
				Nerium oleander L.	+	P	Pt
				Saba senegalensis (A. DC.) Pichon	+	P	Af
				Thevetia neriifolia Juss. Ex Steud.	+	P	Pt
	Asclepioideae	1	1	*Calotropis procera* Ait	+	P	Pt
Araceae (D)		1	1	*Philodendron lacerrum* (Jacq.) Schott.	-	Np	Am
Araliaceae (D)		1	3	*Polyscias balfouriana (André) L.H.Bailey*	-	Np	Mas
				Polyscias guilfoylei Cogn.et March.	+	P	Pt
				Polyscias guilfoylei. Var.laciniata L.H. Bailey.	+	P	Mas
Arecaceae (M)		3	3	*Phoenix dactylifera L.*	+	P	As-T
				Pritchardia pacifica Seem. Et Wendl.	+	P	Af-Poly
				Washingtonia filifera (Linden ex André) H.Wendl.	+	P	Am
Asparagaceae (M)		2	4	*Sansevieria cylindrica* W.B	-	G	Af
				Sansevieria trifasciata Prain.	-	G	Af
				Sansevieria trifasciata (De Wild.) NEBr. *Var laurentii*	-	G	Af
				Yucca elephantipes Lem.	-	P	Am
Boraginaceae (D)		1	1	*Cordia sebestena* L.	-	P	Pt
Cacataceae (D)		3	3	*Echinocactus grusonii* Hildm.	-	Np	Am
				Nopalea cochenillifera (L.) Salm - Dyck	+	C	Am
				Opuntia tuna (L.) Mill	+	P	Amu
Casuarinaceae (D)		1	1	*Casuarina equisetifolia* L.	+	P	Pt
Combretaceae (D)		1	1	*Terminalia catapa* L.	+	P	Pt
Commelinaceae (M)		2	2	*Tradescantia pallida* (Rose) D.R. Hunt	-	C	Am
				Tradescantia spathacea SW.	+	C	Am
Cyperaceae (M)		1	1	*Cyperus alternifolius* L	+	G	Cosm
Euphorbiaceae (D)		3	3	*Elaephorbia drupifera* (Thonn.) Stapf	+	P	Af
				Euphorbia lactea Haw	+	Np	As
				Pedilanthus tithymaloides (Linn.) Poit.	+	C	Am
Heliconiaceae (D)		1	1	*Heliconia bihai (L) L.*	-	P	Am
Lamiaceae D)		2	2	*Ocimum basilicum* L.	+	T	Cosm
				Volkameria inermis L.	-	Np	As
Lythraceae (D)		1	1	*Punica granatum L.*	-	P	Pt-Me
Malvaceae (D)	Bombacoideae	1	1	*Adansonia digitata* L.	+	P	Ma
	Malvoideae	1	1	*Hibiscus Rosa sinensis* L.	+	P	Ma
Meliaceae (D)		1	1	*Azadirachta indica* L.	+	P	Pt
Moraceae (D)		1	1	*Ficus retusa* L.	+	P	Pt
Moringaceae (D)		1	1	*Moringa oleifera* Lam.	+	Np	Pt
Nyctaginaceae (D)		2	3	*Bougainvillea glabra* Choisy.	+	P	Pt
				Bougainvillea spectabilis Willd.	+	P	Pt
				Mirabilis jalapa L.	+	T	Cosm
Oleaceae (D)		1	1	*Jasminum sambac(Linn.), Aiton*	+	P	AsT
Passifloraceae		1	1	*Turnera ulmifolia* L.	-	C	Pt

Family	Sub-family	NG	NS	*Espèces*	FS	BT	GR
(D)							
Plumbaginaceae (D)		1	1	*Plumbago auriculata* Thunb.	+	H	Pt
Polygonaceae (D)		1	1	*Coccoloba uvifera(L.) L*	+	P	As-Am
Sapotaceae (D)		1	1	*Manilkara zapota* (L.) P. Royen	+	P	Am
Strelitziaceae (M)		1	1	*Ravenala madagascariensis* Gmel. J.F.	+	P	Ma
Total		**49**	**55**				

Legend: NG (Number of genera), NE (Number of species), FS (Flora of Senegal), + (presence) and - (absence), D (dicotyledons), M (monocotyledons); BT: Phanerophytes (P), Nanophanerophytes (Np), Chamaephytes (C), Hemicryptophytes (H), Geophytes (G), Therophytes (T); GR (Geographic Distribution), African (Af), African American (Am), American (Am), African American and Asian (Am As), Afro-Asian (As), Afro-Malagasy and Asian (Mas), and Pantropical (Pt). TB (Biological type), P (Phanerophytes), G (Geophytes), C (Chamaephytes), H (Hemicryptophytes), T (Therophytes)

Taxonomic spectrum

Table 2 provides information on the taxonomic spectrum of the ornamental flora of Gorée Island.

This flora is 100% dominated by angiosperms (Table 2). Among these angiosperms, dicotyledons are dominant with 70.97% of families, 75.51% of genera and 72.73% of species.

Table : 2 Taxonomic spectrum

Taxonomic Groups	Families		Genres		Species	
	Number	Proportion (%)	Number	Proportion (%)	Number	Proportion (%)
Dicotyledons	22	70.97	37	75.51	40	72.73
Monocotyledons	9	29.03	12	24.49	15	27.27
TOTAL	**31**	**100.00**	**49**	**100.00**	**55**	**100.00**

Nb = number

Table 3 shows the distribution of the species inventoried depending on the family in the three (3) gardens of Gorée island.

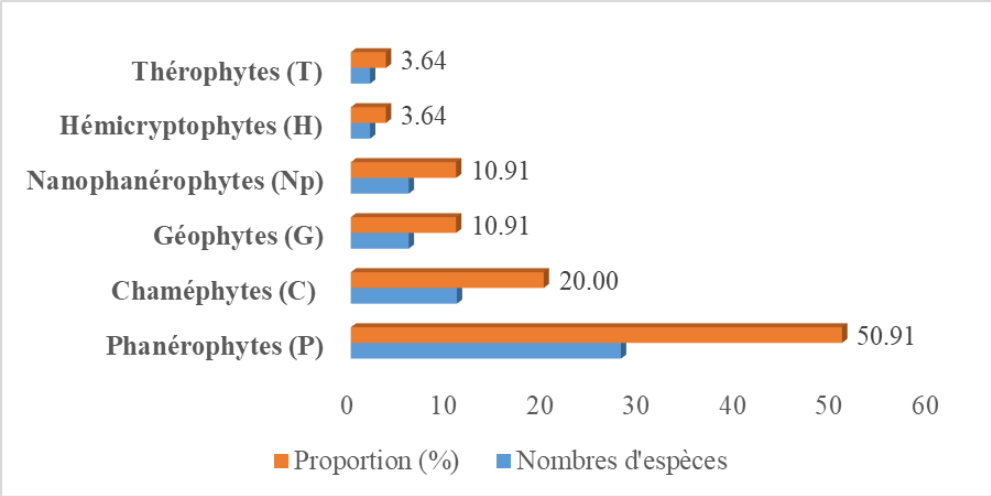
The analysis reveals that this flora is dominated by three families: Apocynaceae (9.09%), followed by Acanthaceae (7.27%) and Asparagaceae (7.27%), totaling 23.64% of the flora. However, five other families are also relatively well represented, each accounting for 5.45%: Araliaceae, Arecaceae, Cacataceae, Euphorbiaceae, and Nyctaginaceae (Table 3). The remaining 23 families comprise 49.09% of the flora.

Familles	Nombre d'espèces	Proportion (%)
Apocynaceae (D)	5	9,09
Acanthaceae (D)	4	7,27
Asparagaceae (M)	4	7,27
Araliaceae (D)	3	5,45
Arecaceae (M)	3	5,45
Cacataceae (D)	3	5,45
Euphorbiaceae (D)	3	5,45

Familles	Nombre d'espèces	Proportion (%)
Nyctaginaceae (D)	3	5,45
Amaryllidaceae (M)	2	3,64
Commelinaceae (M)	2	3,64
Lamiaceae D)	2	3,64
Malvaceae (D)	2	3,64
Agavaceae (M)	1	1,82
Aloeaceae (M)	1	1,82
Amaranthaceae (D)	1	1,82
Araceae (D)	1	1,82
Boraginaceae (D)	1	1,82
Casuarinaceae (D)	1	1,82
Combretaceae (D)	1	1,82
Cyperaceae (M)	1	1,82
Heliconiaceae (D)	1	1,82
Lythraceae (D)	1	1,82
Meliaceae (D)	1	1,82
Moraceae (D)	1	1,82
Moringaceae (D)	1	1,82
Oleaceae (D)	1	1,82
Passifloraceae (D)	1	1,82
Plumbaginaceae (D)	1	1,82
Polygonaceae (D)	1	1,82
Sapotaceae (D)	1	1,82
Strelitziaceae (M)	1	1,82
TOTAL	**55**	**100,00**

Biological Spectrum

Figure 2 represents the biological types of species in the three gardens on Gorée Island. Analysis of Figure 2 shows that Phanerophytes are the most represented, accounting for 50.91% of the flora, followed by Chamaephytes (20%). Geophytes and Nanophanerophytes each accounting for 10.91%. Hemicryptophytes and Therophytes each represent 3.64% of the recorded species.



Chorological spectrum

Data on the distribution of species according to their geographical affinities are recorded in Table 4. This ornamental flora is dominated by pantropical species, which account for 34.55% of the species listed. These are followed by Afro-American and African species, with respectively 21.82% and 9.09%. In contrast, the Afro-Asian and cosmopolitan species are relatively well represented, each accounting for 7.27% of the flora.

Table 4 : Chorological spectrum

Biogeographical affinities	Number of species	Proportion (%)
Pantropical species (Pt)	19	34.55
African American (Am) species	12	21.82
African species (Af)	5	9.09
Afro-Asian species (As)	4	7.27
Cosmopolitan species (Cosm)	4	7.27
Afro-Malagasy species (Ma)	3	5.45
Tropical Afro-Asian Species (AsT)	2	3.64
Afro-Malagasy and Asian species (Mas)	2	3.64
African and Polynesian (Af-Poly) species	1	1.82
Pantropical and Mediterranean (Pt-Me) species	1	1.82
African American and Australian (Amu) species	1	1.82
Afro-Asian and American (As Am) species	1	1.82
TOTAL	**55**	**100.00**

Discussion

The species diversity of the gardens and pathways of Gorée boasts 55 species. This figure is lower than that of Dieng (2019) and Sagna (2019), who recorded 225 and 160 ornamental species respectively in Dakar and Mbour. This difference in floristic richness can be explained by the fact that the 2019 inventory was conducted in 84 horticultural sites in the Dakar region, whereas, for this study, only three gardens and the small pathways of the Gorée municipality were visited. Furthermore, Dakar and Mbour are the

main cities where floral activity has been rising in recent years. However, this figure is higher than that of Fall (2023), who recorded 44 species in the green spaces of Gorée. Moreover, 34.54% of these ornamental species are not present in the vascular and illustrated flora of Senegal. This could be explained by the fact that floriculture is one of the main drivers of invasive plants introduction throughout the world (Reichard et al., 2001; Bell et *al*., 2003; Dehnen-Schmutz et *al*., 2007; Burt et *al*., 2007).

From a taxonomic diversity perspective, the ornamental flora of the Gorée commune is dominated by dicotyledons (70.97%) and monocotyledons (29.03%). These angiosperms comprise 49 genera belonging to 31 families. These results corroborate those of Dieng (2019), Sagna (2019), and Gaye (2018), who also noted a dominance of dicotyledons.63.11%, 65.63% and 78.94%. Furthermore, it should be noted that perennial species are by far the most common, representing 96.36% of the ornamental flora. Annual species, on the other hand, account for only 3.64% of the species recorded. These results are similar to those of Dieng (2019) and Sagna (2019), who also showed that perennial species are by far the most prevalent, at 93.33% and 94.38% respectively. This similarity could be explained by the fact that these perennial species are better adapted to local climatic conditions or better suited to landscaping needs. Moreover, seasonal ornamental plants are not widely cultivated by Senegalese nursery growers due to their high maintenance costs, and municipalities, hotels, and private clients also seek perennial ornamental species that offer year-round greenery and do not require seasonal maintenance.

Regarding biogeographical affinities, the ornamental flora of Gorée, like that of most Senegalese cities (Dakar, Mbour) and other African cities, is dominated by exotic taxa. Only 9.09% of the recorded species originate from the African continent, and approximately 36 species are reported in the flora of Senegal. The remaining 19 have not been recorded and can therefore be considered species newly introduced to Senegal through floriculture. The increased importance of pantropical species seems linked to Senegal's more westerly and oceanic geographical position (Dieng, 2014; Dieng, 2019). It is likely that these species are better adapted to Senegal's bioclimatic conditions than some strictly African species.

Conclusion

This study, aim was to contribute to a better understanding of the ornamental flora of Gorée Island, identified 55 species belonging to 49 genera of 31 families. This flora is dominated entirely by angiosperms, with dicotyledons representing the majority (70.97% of families, 75.51% of genera, and 72.73% of species). It is characterized by the predominance of three families: Apocynaceae (9.09%), Acanthaceae (7.27%), and

Asparagaceae (7.27%), accounting for 23.64% of the flora. Biologically, Phanerophytes clearly dominate the flora, accounting for 50.91% of the identified species, followed by Chamaephytes (20%). Regarding geographical distribution, pantropical species dominate with 34.55% of the species cited, followed by Afro-American and African species with 21.82% and 9.09% respectively.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

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