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(RESEARCH ARTICLE)

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Botanical characteristics and assessment of the diversity of ornamental plants in Man city, Côte d'Ivoire

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Abstract

Introduction: This study focuses on the characteristics and diversity of ornamental plants in the city of Man, Côte d'Ivoire, an area where these plants are poorly documented. Its main objective is to promote these plants by assessing their diversity and highlighting their botanical characteristics.

Methodology: The method consisted of a traveling inventory conducted in 17 randomly selected neighborhoods of the city. This survey resulted in the identification of 99 species of ornamental plants. These plants were identified at the National Floristic Center of the Félix Houphouët-Boigny University in Abidjan, where they were characterized.

Results: The study identified 99 plant species divided into 18 genera and 46 botanical families. The Euphorbiaceae family is the majority (26.1%), followed by the Arecaceae family with 23.9% of the plant species listed. Regarding the diversity assessment, the calculated Shannon, Simpson, and Pielou indices showed a good diversity of ornamental plants in the city of Man, but not evenly distributed throughout the city.

Conclusion: This study contributes to filling the scientific gap concerning ornamental plants in Man and paves the way for their use in sustainable development and conservation programs.

Keywords: Ornamental plants; Botanical characteristics; Diversity; Man; Côte d'Ivoire

1. Introduction

Humans have relied on plants for survival since ancient times [1]. This is explained by their use in various areas of life, such as shelter, food, and health [2]. The relationship between humans and plants has led to the emergence of a new branch of botany called ethnobotany. This discipline is a science that studies the use of plants by humans throughout the history of a society and within a given geographical framework [3]. It aims to inventory the different uses of plants by diverse populations, analyzing and interpreting similarities as well as differences, moving from one population to another [4]. It is these constant interactions between humans and the plant world that determine the field of ethnobotany [5].

One of the areas of human use of plants is horticulture. Ornamental horticulture emerged in Côte d'Ivoire since its independence in 1960 [6]. Horticulture encompasses a set of agricultural sectors concerned with garden production. It

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includes the production of flowers, fruits, ornamental trees, lawns, and any other organ used to beautify the living environment. Although it is a sign of affluence, associating green spaces and flowers with housing has become a custom today, regardless of social status. Horticulturists can be found almost everywhere: around major cities and along major roads. The number of plant species used in decoration is therefore increasing [7].

Floristic inventories carried out in Abidjan and San Pedro resulted in the identification of 288 plant species used as ornamental plants in these two cities. The botanical characteristics of these plants have been provided [8].

However, while these data are available for some cities in Côte d'Ivoire, this is not the case for the city of Man. No scientific documentation is currently known regarding the plants that beautify the city of Man. This study is part of this approach. Its objective is to promote the plant species used in the ornamentation of the city of Man.

2. Materials and methods

2.1. Study area

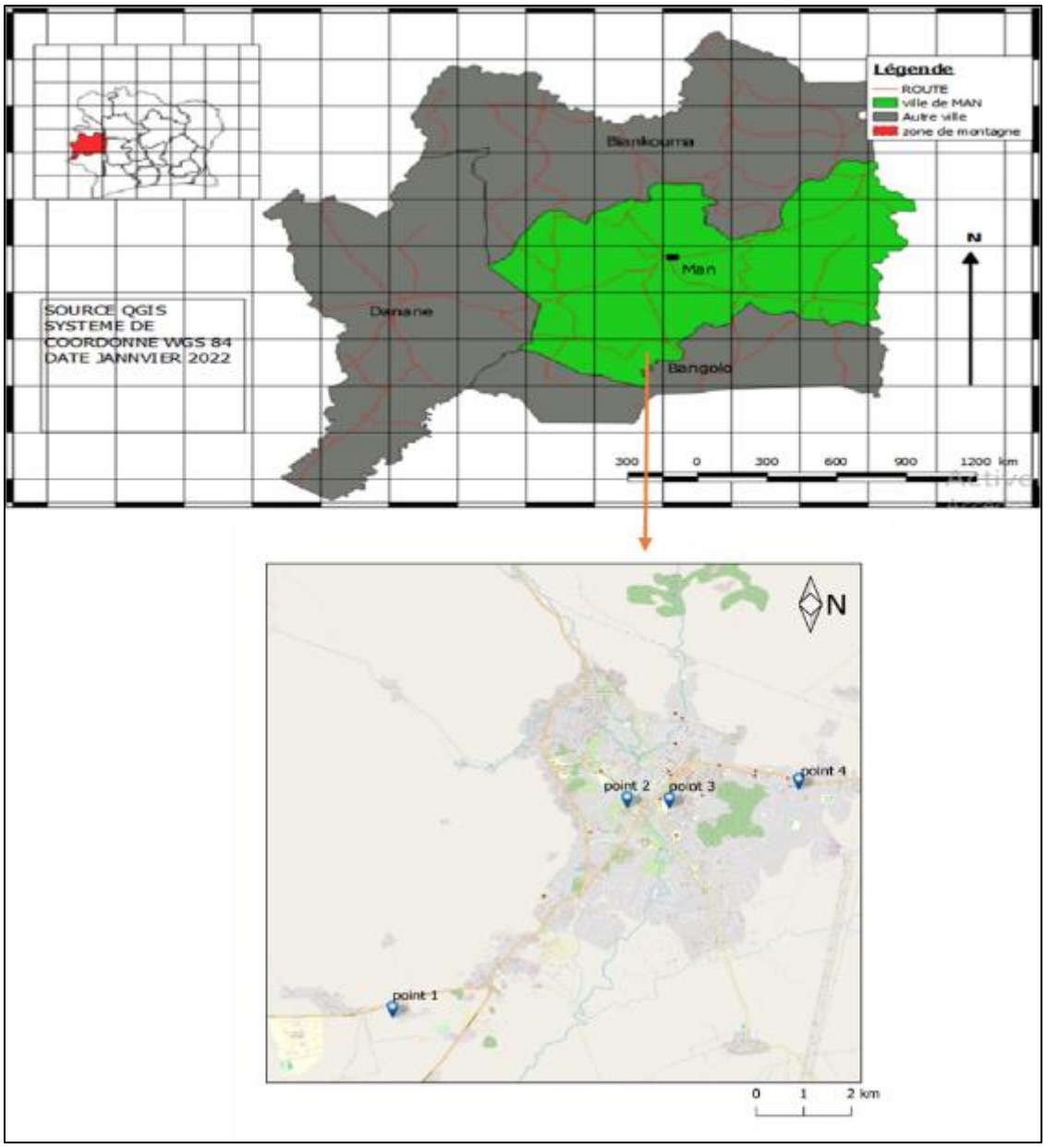

Figure 1 Geographic location of the city of Man and inventoried sites

A city covering 4,140.7 km^2, the city of Man is located in western Côte d'Ivoire, nearly 600 km from Abidjan. The city of Man is the capital of the Tonkpi region and the capital of the Montagnes District. It is also called the "City of 18 Mountains" because of the numerous mountain ranges that surround it, thus placing the city within a basin. The city of Man is one of the largest cities in West of Ivory Coast. It is located at 7°24'0''N latitude and 7°33'0''W longitude (Figure 1).

2.2. Materials

The biological material consists of all the plant species involved in ornamentation in the city of Man. The technical equipment used during this study consisted of a survey sheet for collecting information, pruning shears for collecting specimen samples, black plastic bags, old newspapers for preserving the samples, and cardboard to spread the samples evenly in the newspapers. A notebook was required to record additional information. A GPS was used to obtain the coordinates of the various sites. Photographs were taken using a digital camera. A laptop was also required to enter and analyze the collected data.

2.3. Botanical data collection and characterization

2.3.1. Traveling inventory

The traveling inventory was carried out along a route that crossed the city of Man. On this route, four sites were randomly selected and inventoried. These four sites each have an area of 10,000 m2 (100m x 100m) and are coded: Point 1, Point 2, Point 3 and Point 4 (Figure 2). Point 1 corresponds to CNRA, Zélé, Municipal, CAFOP, Maindeba neighborhoods; Point 2 is the part of Man including the Beau Séjour, Focolary, Domoraud, Campus, Saari hotels; Points 3 and 4 respectively group together Préfecture, Camp Séa, Lycée, district 13 and Air France, Grand Gbapleu, Mustro neighborhoods. In each area, data collection was done using the itinerant method, which consists of moving in several directions of the area [9]**.** Samples of all the ornamental plants encountered in these 17 neighborhoods visited were taken and photographs were immediately taken.

2.3.2. Species identification and typology

The plant species identified were identified using botanical references and validated by taxonomic experts at the National Center for Floristics at Félix Houphouët-Boigny University. It is based on the Angiosperm Phylogeny Group III classification [10], ensuring rigorous scientific nomenclature. Each species was characterized according to several fundamental criteria. First, morphological characteristics were analyzed based on the size, structure, and consistency of plant organs. Next, biological typology was determined based on Raunkiaer's classification [11], which defines plants according to the position of their growth buds relative to the ground. Furthermore, phytogeographic distribution was established, allowing each species to be assigned a specific ecological area [12].

2.4. Plant diversity assessment indices

Three indices were used to determine the quantitative diversity of each ornamental species found in the study areas of the city of Man. These are: The Shannon & Weaver (H) index, the Simpson index, and the Piélou Equitability index.

2.4.1. Shannon & Weaver index

The Shannon & Weaver index is widely used in vegetation studies. It provides information on the number of species and their abundance, and quantifies the diversity of an area's flora [13]. Its mathematical expression is as follows:

$$H' = -\sum_{i=1}^{S} Pi \times \ln Pi$$

The values of this index range between 0 and ln (S), which is the maximum diversity (S being the total number of species at a site). When the stand is composed of a single species, it is equal to 0, while for a flora with a large number of plant species, it tends towards ln of S. When biodiversity is good and can be maintained sustainably, H′ tends towards S [14].

2.4.2. Simpson index

The Simpson index also measures the species composition of a stand by taking into account species richness. This is a dominance index. It confirms the results of the Shannon index. It takes into account the measured frequency of species. Its mathematical expression is:

$$D = 1 - \sum_{i=1}^{S} Pi^2$$

With pi being the proportion of individuals of species i. It is interpreted as the probability that two randomly selected individuals are of different species. It ranges from 0 to 1.

2.4.3. Piélou's equitability index

The Piélou's equitability index (E) represents the ratio of H' and the theoretical maximum diversity (lnS) in the stand. This index ranges from 0 to 1. The closer E is to 1, the more evenly the species in the environment are distributed among the individuals that compose it. On the other hand, low values reflect the presence of a number of rare species [15]. This index is calculated using the following mathematical formula:

$$E = H'/\ln S$$

With E being the Piélou's equitability index, H(1) being the Shannon index, S being the total number of species recorded, and ln(S) being the maximum species diversity in the area concerned.

2.5. Statistical Analysis

The Shannon & Weaver (H), Simpson, and Piélou's Equitability indices were calculated and analyzed using Estimate 22.0 software. The histograms were created using Excel 2016.

3. Results

3.1. Botanical characteristics

3.1.1. Taxonomic groups

The inventory of ornamental plants in the city of Man identified 99 plant species divided into 18 genera and 46 botanical families. The Euphorbiaceae family is the majority (26.1%). Codiaeum variegatum (Figure 2 a) and *Euphorbia milli* (Figure 2 b) are the regularly encountered plant species in this family. The Arecaceae family follows the Euphorbiaceae family with a proportion of 23.9% of the listed plant species. Annonaceae, Piperaceae, Bromeliaceae, Oleaceae, Costaceae, Cleaceae, Cactaceae, Lythraceae, Malvaceae, and Meliaceae are poorly represented.

Codiaeum variegatum	*Euphorbia milli*

Figure 2 Two ornamental plant species of the Euphorbiaceae family in Man

3.1.2. Typologies

Morphological types of listed ornamental plants

Ornamental plants in the city of Man are divided into four morphological types: shrubs (41%), herbs (32%), trees (19%), and vines (7%). These morphological types are represented in Figure 3.

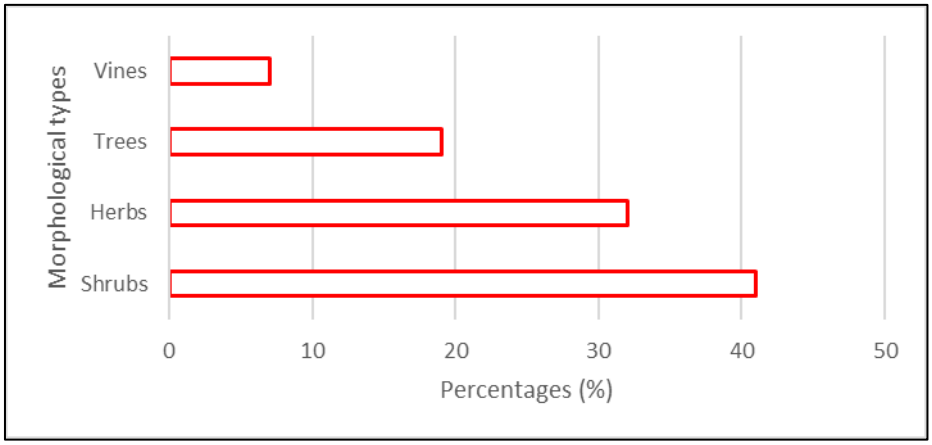

Figure 3 Distribution of listed plants according to morphological types

3.1.3. Phytogeography types

The phytogeography typology of our species includes (63%) Introduced species (I) and 27% GC-SZ species from the Guinean-Congolese and Sudano-Zambesian regions. The listed plants are therefore divided into two groups: 63% introduced species and 27% species from the Guinean-Congolese and Sudano-Zambesian regions (Figure 4).

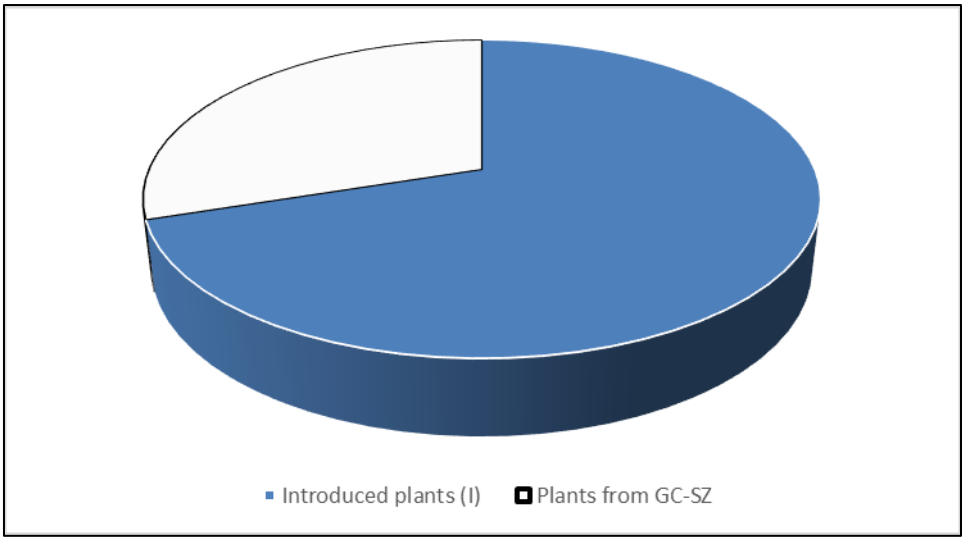

Figure 4 Distribution of phytogeography types of the recorded species

3.2. Biological types

The recorded ornamental plants fall into five biological types: Phanerophytes (70%), Hemicryptophytes (19%), Geophytes (6%), Chamaephytes (4%), and Terophytes (1%). Phanerophytes are the majority of ornamental plants in the city of Man (Figure 5).

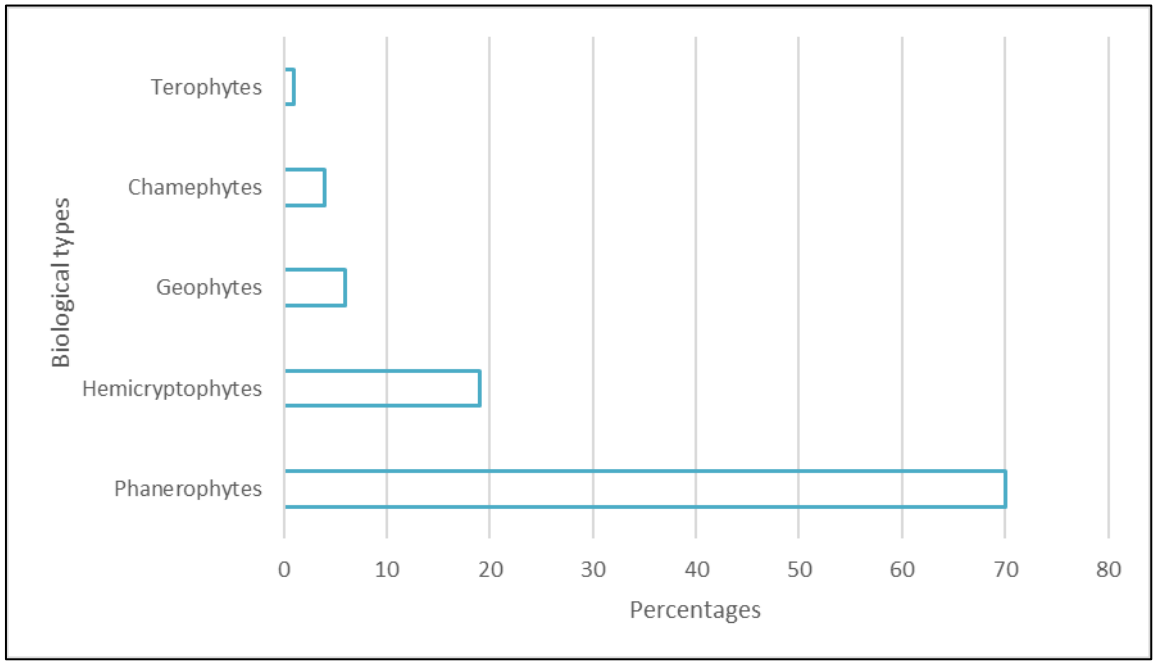

Figure 5 Distribution of plants identified by biological type

3.3. Plant diversity assessment

The diversity indices are shown in Table 1. This table shows that the Shannon index (H') for the entire city of Man is 2.52. Thus, the most diverse area in the city according to the Shannon index is Zone 2, which corresponds to the Beau Séjour, Focolary, Domoraud, Campus, and Sarri de Man neighborhoods. In contrast, the third zone is the least diverse, with a Shannon index value of 1.64, including the Préfecture, Camp Sea, Lycée, and Quartier 13 neighborhoods. The Simpson index confirms the Shannon index, with the highest value in Zone 2 (0.92). As for Pielou's Equitability index, it has an average value of 0.64 for the entire city. This index shows an average distribution of ornamental plant species in the city

Table 1 Diversity indices by inventoried area

	ZONE 1	ZONE 2	ZONE 3	ZONE 4	Mean
Simpson index	0.91	0.92	0.65	0.90	0.84
Shannon & Weaver index	2.85	2.95	1.64	2.64	2.52
Equitability index	0.64	0.66	0.46	0.82	0.64

4. Discussion

4.1. Botanical characteristics of ornamental plants in the city of Man

The study identified 99 plant species used in the ornamentation of the city of Man. These plants belong to 36 families, with a predominance of Euphorbiaceae (12%). These results corroborate those of Koné *et al*. [16], who indicated that the Euphorbiaceae family is the dominant family in the ornamental flora of Ivorian cities. Furthermore, this botanical family is one of the most represented plant groups in the Ivorian flora. In relation to morphological types, there is a strong representation of shrubs (41%). This is a finding already made by Tombouctou and Koné [17]. These authors reported the dominance of these morphological types in the ornamental flora of Côte d'Ivoire. The distribution of taxa by phytogeographic types, with a majority of introduced species (60%), is comparable to that established in Abidjan and San Pedro in previous studies. Regarding the biological types of ornamental plants inventoried in Man, there is a clear predominance of phanerophytes (70%), which reflects their central role in urban landscape architecture. Indeed, phanerophytes constitute 65% of the ornamental species recorded in their study [18]. This predominance of phanerophytes is explained by the capacity of these plants to provide shade, lasting aesthetics and resistance to urban climatic constraints [19]. Hemicryptophytes (19%), in second place, are mainly represented by herbaceous plants used as ground cover or as borders, a use also highlighted in the city of Bouaké [20]. The presence of geophytes (6%) and chamephytes (4%) illustrates a functional diversity appreciated in green spaces for their hardiness and their ability to flower in difficult conditions. Therophytes, which are very poorly represented (1%), are rarely used for ornamentation [21]. Thus, the biological distribution observed in Man is consistent with a national trend in which urban ornamentation choices are moving toward perennial, hardy species with high landscape value.

4.2. Diversity Assessment

The Shannon index (H') for the entire city of Man is 2.52. This demonstrates a good diversity of ornamental plants in the city. However, this diversity varies throughout the city, as zone 2 has a high value (H'=0.92). This zone 2 corresponds to the Beau Séjour, Focolary, Domoraud, Campus, and Sarri de Man hotel districts. The calculated Shannon, Simpson, and Pielou indices also demonstrate a good diversity of ornamental plants in the city of Man, but not evenly distributed throughout the city.

5. Conclusion

The study focuses on ornamental plants ornamental plants in the city of Man, Ivory Coast. It aims to promote these plant species that highlight the beauty of the city. It assesses the diversity of these plants by highlighting their botanical characteristics. The inventory of plants was carried out using the itinerant method in 17 districts of the city and their characterization was done at the laboratory of the National Center of Floristics in Abidjan. The study identified 99 plant species divided into 18 genera and 46 botanical families. The Euphorbiaceae family is the majority (26.1%), followed by the Arecaceae family with 23.9% of the listed plant species. In relation to the diversity assessment, the Shannon, Simpson and Pielou indices calculated showed a good diversity of ornamental plants but not distributed uniformly throughout the city. This study is a scientific basis for a good knowledge of the plant species involved in the ornamentation of the city of Man.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in this study.

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