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Floristic Diversity and Conservation Status of Guineo-Congolese Species in Southeastern Cameroon: The Case of the Gari-Gombo Communal Forest

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Abstract

The conservation of plant biodiversity has become one of the most important objectives in the sustainable management of Guinean-Congolese ecosystems. However, in the south-east zone of Cameroon, there is a lack of rigor in the management of these forests, which can result in the loss of species of high conservation value. The study was carried out in communal forests in the south-east zone of Cameroon. Its aim was to carry out a floristic inventory and then compare the list of species with the IUCN catalog. Twenty-four plots, each with a surface area of 0.2 ha, were set up in the Gari-Gombo communal forest. All timbers with a DBH ≥ 5 cm were systematically counted. A total of 176 species, belonging to 144 genera and 45 families, were surveyed. Fabaceae (42.08%), Malvaceae (39%), Euphorbiaceae (24.64%), Moraceae (20.92%), Apocynaceae (18.64%), Cecropiaceae (16.60%), Ulmaceae (14.76%), Meliaceae (14.61%), Violaceae (14.08%), Combretaceae (12.67%), *Theobroma cacao* (21.17%), *Baphia leptobotrys* (18.06%), *Rinorea* sp. (14.09%), *Musanga cecropioides* (12.18%), *Terminalia superba* (10.32%), *Neosloetiopsis kamerunensis* (10.14%), *Celtis zenkeri* (8.29%) and *Alstonia boonei* (7.77%) were the most important taxa. Nearly 90% of the species in this forest are Guinean species, with a dominance of Guinean-Congolese species (66%). Fourteen (14) threatened species have been identified in the FCGG. This study, which highlights the rich biodiversity of communal forests, is important for guiding biodiversity conservation policies in ecosystems used for production.

Keywords

Communal Forest, Conservation Status, Cameroon Floristic Diversity

1. Introduction

African rainforests are among the most important and richest ecosystems on the planet (Wilson, 1995). The Guinean-Congolese region, covering 2.8 million km^2, is home to Africa's main rainforest massif, with more than 80% of its endemic plants (White 1983). The Guinean-Congolese forests contain a rich and varied diversity of flora. The forests of Central Africa present a remarkable diversity of flora and fauna (Megevand, 2013).

However, the rate of deforestation of these forests has increased in recent years. Between 2015 and 2020, the annual rate of deforestation was estimated at 1.79 million hectares of forest per year, compared with 1.39 million hectares between 2010 and 2015 (Vancutsem et al., 2020). Forest deforestation is a serious problem for biodiversity conservation. The current loss of biodiversity is a major problem that will have irreversible consequences for mankind. Based on this observation, Central African countries have created several protected areas over the past two decades (Bowler et al., 2020). The question of the effectiveness of protected areas in conserving floral and faunal biodiversity is at the heart of many reflections (Bowler et al., 2020; Vancutsem et al., 2020). Numerous factors, such as lack of funding, limited technical and human resources, size and accessibility, all point to the ineffectiveness of protected areas in combating biodiversity loss. However, if sustainably managed, production forests can play a crucial role in biodiversity conservation (Duveiller et al., 2008).

The winds of decentralization blowing through several African countries have led them to integrate forest governance by sub-state public authorities. Communal forestry is a model of forest resource management that has been deployed in Central Africa for over a decade. This concept reflects the ambition of governments to involve decentralized local authorities in the management of natural resources. A communal forest is a forest that is part of the permanent forest estate and is classified on behalf of the decentralized community concerned. In 2018, Cameroon had sixty - four (64) communal forests representing an area of 1,812,150 ha or 8% of the country's forest area (MINFOF, 2018). Communal forests are production forests, so the main activity is logging. Logging regularly leads to the loss of floristic biodiversity in ecosystems if certain prerequisites are not respected. The exploitation of a communal forest is conditional on the existence of a development or management plan approved by the administration in charge of forests, which is an essential tool for the biodiversity conservation. However, most studies carried out in CFs have concluded that conservation aspects are neglected in favor of marketable timber (Tchouto et al., 2006; Zekeng, 2020).

The Gari-gombo forest is a production forest with a management plan. However, it appears that no priority is given to biodiversity conservation. Intense and sustained logging activity in this forest can lead to a considerable loss of biodiversity. Several studies carried out in Cameroon's production forests (Doumé; Dimako) show that these ecosystems are home to species of high conservation value. These studies provide ample evidence that production forests are not only intended for timber production, but can also constitute biotopes for biodiversity conservation.

The aim of this study is to demonstrate that the Gari-gombo communal forest is not only a production forest, but can also be home to numerous species of high conservation value with the aim of encouraging forest managers to place particular emphasis on conservation.

2. Materials and Methods

2.1. Study Site

This study was carried out in the FCGG, located in the Subdivision of Gari-gombo, Division of Boumba and Ngoko, East Region of Cameroon, Figure 1. It is a semi-deciduous forest of the Guinean-Congolese domain (Letouzey, 1985). The Gari-gombo communal forest covers an area of 39,199 ha and locates between longitudes 15˚08'18"E and 15˚24'25" and latitudes 03˚37'92"N and 03˚29'8"N. The climate in this area is equatorial, with 4 unevenly distributed seasons. The average annual temperature is 25˚C, with annual rainfall of 1471 mm/year. The area is underlain by red and yellow ferralitic soil formed from micaschists and chlorous schist. Its relief is relatively flat, with an average

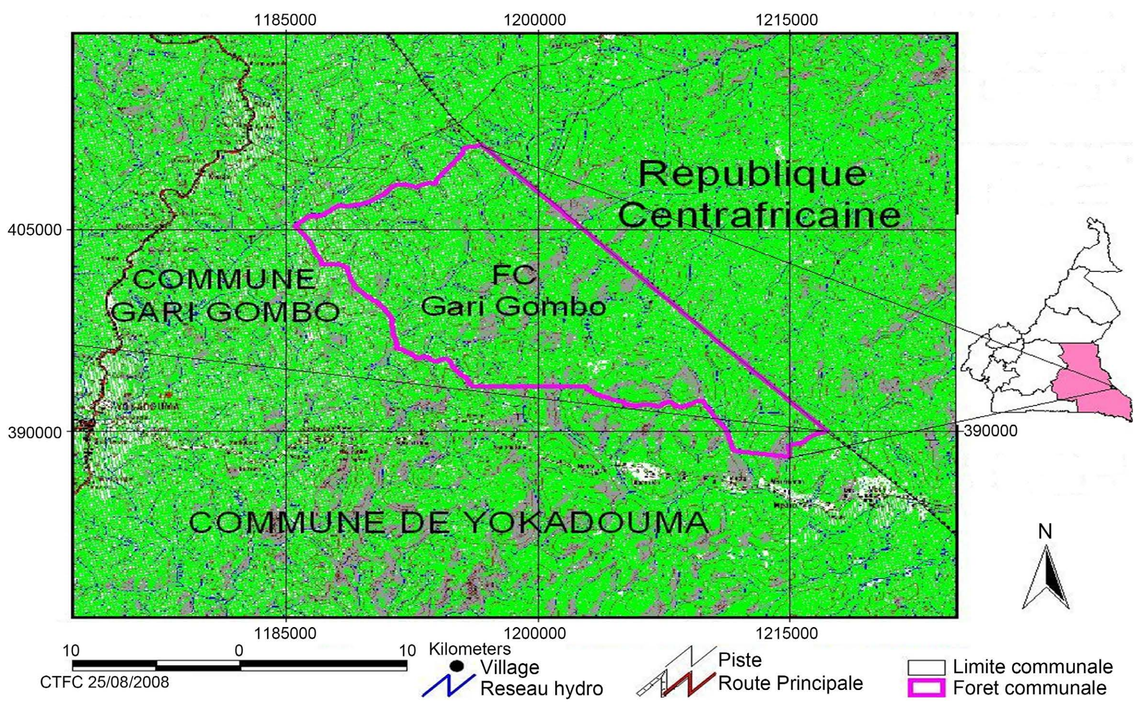

Figure 1. Location map of the Gari-Gombo communal forest.

altitude of around 600 m. Its hydraulic network is made up of several watercourses.

2.2. Data Collection Methods

Sampling system

Plots measuring 50 m × 40 m were selectively installed in the strata previously identified in the Gari-gombo communal forest. A total of 24 plots covering 4.8 ha were sampled.

Botanical inventory and data collection

The botanical inventory was carried out in each plot and covered all woody species with Dbh ≥ 5 cm. Species identification was based on obvious diagnostic characters of organs such as leaves, flowers and tree habit. The scientific names of each timbers were homogenized to resolve synonymy and spelling issues, thus, the Plant list database was used (Hassler, 2018). Angiosperm Phylogeny Group IV (APG IV, 2016) was used for botanical nomenclature of families. Specimens were collected for identification at the Yaoundé national herbarium for certain timbers.

2.3. Membership to Centers of Endemism

Chorological subdivisions of Africa have been made by several authors: Lebrun (1947), Robyns (1948), Duvigneaud (1949, 1953), Monod (1957), Aubreville (1949) and (Sonké, 1998). For the purposes of this study, the works of White (1983, 1986), Sonké (1998) and Tchouto (2004) were used for the distribution of species to center of endemism. The following centers of endemism corresponded to those of the surveyed species in the two parks. These are: AA = African-American; CaGab = endemic to Cameroon and Gabon; Ca-Ni = endemic to Cameroon and Nigeria; Gc = endemic to the Guineo-Congolese region; G-SZ = Guinean and Sudano-Zambézian link species; Gu = endemic to the Guinea zone; In = introduced species; Ind = indeterminate zone of endemism; Lg = Lower Guinea endemic; Pal = Paleo tropical; Pan = Pantropical; s-sa = Sudano-Zambézian endemic; Sw-Cam = Southwest endemic; Tra = Tropical African endemic; WG = Western Guinean endemic; Zam = Zambézian endemic.

2.4. Overall Conservation Status of Species

In order to determine the IUCN status of each surveyed species, the IUCN Red List website (www.redlist.) was consulted and the status of each species was recorded.

2.5. Data Analysis and Statistical Processing

Data analysis focused on floristic and structural parameters. Floristic parameters were assessed by calculating the following diversity indices:

- Species richness (S) (Ramade, 1994).
- The Shannon index, $H' = -\Sigma(Ni/N)\log2(Ni/N)$, where Ni is the number of

species of rank i and N is the total number of all species. This index varies from 0 when only one species is present, to log S when all species have the same abundance (Dajoz, 2008).

- Piélou's equitability index provides information on how individuals are distributed within species. Its formula is as follows E = H'/log2(S). Equitability tends towards 0 when almost all individuals belong to the same species, and is equal to 1 when all species have the same abundance (Dajoz, 2000).

- Simpson's index gives the probability that two randomly selected individuals in a population belong to the same species. The formula used to calculate it is: D = 1 − Σ(Ni/N)2. It is a diversity index that varies between 0 and 1. It tends towards a value of 0 to indicate minimum diversity, and a value of 1 to indicate maximum diversity (Schlaepfer, 2002).

- Curtis and McIntosh's (1950) importance value index (IVI) is the sum of relative density (Dr), relative dominance (Gr) and relative frequency (Fr). It is calculated by the formula: IVI = Dr + Gr + Fr. This index highlights the ecological importance of species and families (Kabore et al., 2013). The IVI provides information on the place each taxonomic group occupies in relation to all species within a plant community. The family importance value (FIV) is the sum of the relative diversity, relative dominance and relative frequency of each family (Mori et al., 1983). The relative values of density, dominance, frequency and diversity were calculated for species and families according to the formulas of Cottam & Curtis (1956) and Mori et al. (1983).

The structural composition of the forest was studied using the following parameters: basal area (m^2/ha); stem density per hectare. The basal area (Ba) is the cross-sectional area of a timber trunk; it is calculated using the formula: ∑ (π/4 × DI^2); D is the diameter of timber and expressed in metre. The density is the numbers of individuals belonging to a specie obtained in a area. It is calculated by the formula: D = N/S; D is the total number of individual and S is the total sampling area. Data were processed and analyzed using Excel and Statgraphics softwares.

3. Results

3.1. Species Richness and Communal Diversity Indices for Gari-Gombo

Compilation of the lists of the surveyed species in the various plots revealed 176 species, belonging to 144 genera and 45 families. The most important families according to Family Importance Value (FIV) were: Fabaceae (42.08%), Malvaceae (39%), Euphorbiaceae (24.64%), Moraceae (20.92%), Apocynaceae (18.64%), Cecropiaceae (16.60%); Ulmaceae (14.76%), Meliaceae (14.61%), Violaceae (14.08%) and Combretaceae (12.67%). Fabaceae (20 species), Euphorbiaceae (18 species), Rubiaceae (14 species), Malvaceae (10 species), Meliaceae (10 species), Annonaceae (9 species), Apocynaceae (7 species) and Olacaceae (7 species) represent 60.79% of the total number of species recorded throughout the study area.

Diospyros (4 species), *Cola* (4 genera), *Entandrophragma* (4 species), *Strombosia* (3 species), *Zanthoxylum* (3 species) and *Celtis* (3 species) were the most diversified genera. Whereas, *Theobroma cacao* (21.17%); *Baphia leptobotrys* (18.06); *Rinorea* sp. (14.09%); *Musanga cecropioides* (12.18%) and *Terminalia superba* (10.32%), *Neosloetiopsis kamerunensis* (10.14%); *Celtis zenkeri* (8.29%) and *Alstonia boonei* (7.77%) were the most important species.

Shannon's index was 4.27 while Piélou's equitability index was 0.82 and Simpson's index 0.82. The density and basal area of the FCGG were 657 ± 213 stems/ha and 47 ± 14 m^2/ha respectively.

3.2. Center of Endemism

Analysis of the distribution by center of endemism of the species recorded in this study reveals 6 types of distribution, grouped into 2 main categories:

Group1: Broadly distributed species: Pantropical (Pan); Paleotropical (Pal); African-American (AA) and Tropical African (Tra).

Group2: Guinean species: GC: endemic to the Guinean-Congolese region; CG: endemic to Cameroon and Gabon; Lg: endemic to lower Guinea; WG: endemic to western Guinea.

Figure 2 shows the distribution of species by center of endemism for stems of Dbh ≥ 5 cm. The flora of the Gari-gombo forest is predominantly made up of Guinean species. More specifically, Guinean-Congolese (GC) species are the most dominant in this forest, with 116 species, i.e. 66% of the forest's total species, followed by species endemic to Cameroon and Gabon (CG) with 44 species, i.e. 25% of the forest's species, while species from the western Guinean zone account for 4.54% of species. Wide-ranging species are the least represented, with African-American species (AA) at 1.7% and tropical African species (Tra) at 1.13%.

3.3. Special-Status Species

Figure 3 shows the number of species by IUCN category of Dbh ≥ 5 cm obtained in the Gari-gombo forest. Of the 179 species recorded in the Gari-gombo forest, there are 14 species threatened with extinction; 04 species in the category minor

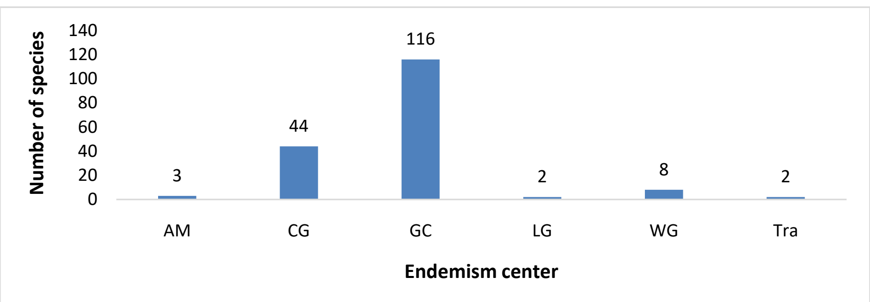

Figure 2. Region of endemism of Dbh ≥ 5 cm species in the Gari-gombo forest.

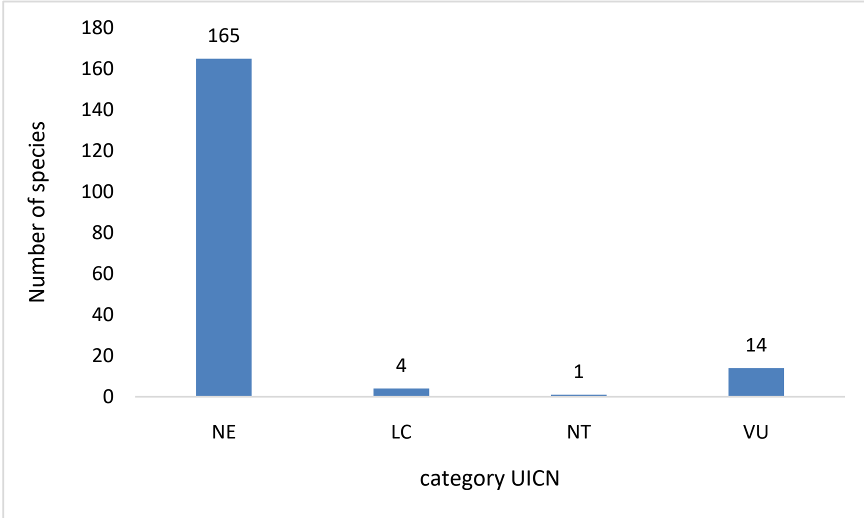

Figure 3. Number of species by IUCN category for trees with dhp ≥ 5 cm; (LC = Least Concern; NE = Not Evaluated; NT = Near Threatened; VU = Vulnerable) in the Gari-gombo Communal Forest.

risk (LC), and 1 species in the category little threatened (NT). Endangered species were *Albizia ferruginea* (Fabaceae), *Allanblackia floribunda* (Clusiaceae), *Entandrophragma candollei* (Meliaceae), *Eribroma oblongum* (Malvaceae), *Guarea thompsonii* (Meliaceae), *Pterygota baquaertii* (Malvaceae), *Entandrophragma cylindricum* (Meliaceae), *Entandrophragma utile* (Meliaceae), *Garcinia mannii* (Clusiaceae), *Khaya ivorensis* (Meliaceae), *Afzelia bipindensis* (Fabaceae), *Diospyros crassiflora* (Ebenaceae), *Drypetes preussi* (Euphorbiaceae), *Nesogordonia papaverifera* (Malvaceae).

4. Discussion

Floristic inventories remain one of the most important methods for assessing species composition, forest diversity and forest condition (Phillips et al., 2003). They also provide the information needed for ecosystem conservation (Gordon & Newton, 2006). Species richness and diversity are key features of tropical forests (Tarakeswara et al., 2018). Several inventory studies of floristic diversity in tropical forests in Africa have been limited to trees of Dbh ≥ 10 cm, reflecting the floristic composition and physical structure of these forests (Gonmadje et al., 2011). The aim of this study was to determine the floristic diversity and conservation status of Dbh ≥ 5 cm trees.

The characterization of the flora of a forest ecosystem is based on the interpretation of diversity indices (Sonké, 2004; Mbolo et al., 2016). A forest is considered rich and diverse if it has a Shannon diversity index greater than or equal to 3.5 (Kent & Coker, 1992). The Gari-gombo communal forest (FCGG) has a Shannon index of 4.26, so we can conclude that the FCGG is home to a rich and diverse flora.

A total of 176 species were surveyed in 24 FCGG plots. Mounmemi et al.,

(2020) sampled 171 species in the Dimako semi-deciduous forest in the same region. A total of 271 species were surveyed in the Doumé semi-deciduous forest by Zekeng (2020); while Chimi et al. (2018) surveyed 127 species in the semi-deciduous forest of eastern Cameroon. Some ecological factors such as rainfall, topography, disturbance and soil conditions could explain in these inventories conducted in the same region of Cameroon.

Throughout the sample area, the most common families were Fabaceae, Malvaceae, Euphorbiaceae and Moraceae. The families recorded in this forest are not specific to the semi-deciduous forests of the East Cameroon region. They are no different from those reported in the West African semi-deciduous forest belt (White, 1983; Vooren & Sayers 1992; Bakayoko et al., 2001); meaning that the floristic composition of the vegetation is the same in these forest areas. However, the presence of Euphorbiaceae and Fabaceae proved that this is a forest with modified tree stands. These families are rich in colonizing species whose role is to restore plant biodiversity to degraded environments. This observation is based on the presence of pioneer and heliophilous species that colonize disturbed sites: *Macaranga* spp.; *Musanga cecropioides*; *Alstonia boonei*. The abundance of these species in the FCGG could indicate a more advanced level of forest degradation. In fact, the FCGG was subject to normal and legal logging under the licence regime between 1960 and 1992. Some biotopes have experienced logging of varying intensity, reflecting the state of much of the Congo Basin's forests.

This study showed how important it is to determine the habitat and real threats to these species, which are considered to be of high conservation priority. It is important to know that the notion of sustainable management and biodiversity conservation is a major issue for communal forestry. Given the status of the Gari-gombo forest, it is imperative to ensure its proper management. Biodiversity loss in production forests is linked in most cases to non-compliance with the logger's management plan (Ferenc et al. 2018) and non-compliance with logging standards with minor impacts (Zekeng, 2020).

Agroforestry systems, including agricultural plantations, are the main drivers of forest conversion to non-forest land (Zekeng et al., 2019). This observation is a reality in the FCGG, as before this forest was classified as a communal forest, several villages had already settled there, so it is urgent to find a solution to this problem in order to avoid the loss of species of high conservation priority in this forest. Studies have shown that the species richness of an ecosystem increases its capacity to sequester above-ground carbon, and that these species could constitute a potential carbon sink (Zekeng, 2020). For this reason, management techniques that enhance carbon storage would be fundamental to enhancing carbon sequestration in the FCGG. Such techniques could contribute to the efficiency of sustainable production forest management. To reduce the impact of human activities on the Gari-gombo forest, we suggest that forest managers introduce incentives such as REDD+.

5. Conclusion

The importance of the Gari-gombo communal forest for biodiversity conservation in Cameroon has long been overlooked. The present study determined the floristic diversity of woody species with a Dbh ≥ 5 cm of this semi-deciduous forest. This research has shown that the Gari-gombo communal forest is rich and diverse; it shows that most of the surveyed species in this forest have a Guinean-Congolese distribution and that it also hosts threatened species. This study begins to fill the gap in our knowledge of the flora of several Cameroon's communal forests. The results obtained during this study give an idea of the plant diversity as well as the level of conservation of this communal forest. Further studies characterizing the floristic diversity and the living environment of threatened and rare species throughout the Gari-gombo forest. Other communal forests in Cameroon are important to support sound decision-making on the conservation and sustainable management of communal forests in Cameroon.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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