Floristic Diversity and Conservation Value of Tanoe-Ehy Forest in South-Eastern (Cote d'Ivoire)

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Abstract

The Tanoe-Ehy Forest, located in the South-Eastern of the Côte d'Ivoire is one of the rare forest cover of this type that still exists in the Country. These Forest was identified as a top priority site for conservation in West Africa. However, this important forest is subject to strong anthropogenic pressures which through poaching, uncontrolled takeoffs of natural resources and some agricultural clearing. A Botanical study based on plots, itinerant and linear inventory conducted in this forest intends to assess the plant species diversity and the conservation value for biodiversity of this forest. At the end of the study, 432 plant species were recorded. Among them, 14 are listed on endemic of Upper Guinea and 16 threatened and endangered list of species. Concerning the species threatened and endangering, 3 species are really in endangering (*Hemandradenia chevalieri, Tieghemella heckelii, Irvingia gabonensis*) and 13 others are a category of vulnerable species. A Sassandrian species of type II (*Piptostigma fugax*) was also observed. The dominant species of the forest are *Symphonia globulifera* and *Uapaca paludosa*. Concerning the vegetation condition, the swamp forest, the dry land forest and the raphiale vegetation have a high conservation value.

Keywords: Diversity, endemic, endangered, Côte d'Ivoire.

Introduction

In Côte d'Ivoire, the rate of deforestation is one of the highest in the world, it is estimated to 6,5 **%** (Myer, 1989). If the development of cocoa and coffee cultures is responsible for the disappearance of dry land forest. It is rather of the banana and oil palm crops that have contributed to the reduction of swamp forests. Vast areas of this type of forestry training have been transformed into large plantation of banana tree and oil palm by mighty

agricultural societies. This has involved the rarity of this type of vegetation formation in the rural domain (Kouamé, 2012).

The Tanoé-Ehy Forest is located in the South-Eastern of the Côte d'Ivoire is one of the rare forestry formations of this type to exist. This swamp forest is located at the interface of the Tanoé river and Ehy lagoon. The first multidisciplinary investigations, in primatology, socio-anthropology, ichthyology, in ornithology, have demonstrated the exceptional character of these forests by its wealth and its diversity faunic. Because of the presence of some threatened species, this forest has been identified as a high value site for conservation (Koné *et al*., 2008). However from the floristic point of view no study has shown its conservation value. This forest is threatened by the harvest of medical plants, heat-seeking wood and by the palm-ci, a powerful agricultural society in research of Marshland for extension of its oil palm plantations (Zadou *et al*., 2011).A sustainable management of this vegetation formation turns out so indispensable for its survival. This goes by knowledge of its biodiversity also animal as floristic. The inventory conducted in this forest intends to characterize the floristic and structural aspect. In order to determine the conservation value for biodiversity of this forest.

Methodology

Study site

The Tanoé-Ehy Forest (approximately 12,000ha) is an unprotected forest in south-eastern Côte d'Ivoire, at the boarder of Ghana, between the latitudes 5°05' and 5°15' and the longitudes 2°45' and 2°53' (Figure1). The land is owned by all the villages surrounding the forest and each of these communities hold native rights to exploit the forest. It is located in the Ivorian littoral sector. She covers a superficies of 12000 ha.

The climate of the region, which is a sub-equatorial type comprise 4 seasons (Avenard *etal*.,1971; Lauginie, 2007) a great rainy season (end of April to half July) and one dry season (from December to April) alternating with one short rainy season (from half September to the end of November) and one small dry season (half, July-half, September).

The study area is characterized by the one of the Guinean domain (littoral sector). This forest is rich of species from lagoons and avifauna species of swamping ecosystems (Goliath, heron, eagle fisher, etc.). This fauna is adapted to the swampy conditions of the area, which protect it. The habitat decreases with increasing area of industrial plantations some primates (*Cercopithecus Diana roloway* Von Schreber, 1774, *Cercopitheques campbelli* Thomas, 1923 and *Colobus velleosus* Geoffroy Saint Hilaire, 1834 are also found in the forest.

Field method

For the collect of data, we chose the linear method of Gautier *et al.*. (1994). This method had been already used, for several studies in tropical forests (Bakayoko *et al*., 2001; Chatelain, 1996; Kouamé *et al*., 1998). The method consists in counting all the points of contact of the vegetation along an imaginary vertical line, placed in an equidistant way along a graduated ribbon. The standard length of transect is 200 meters. Because of the nature and humidity of soils observed in swamp areas where it is difficult to move without sinking and the small size of the dry land forests we have used a length of 100 meters. In these forests, measurement is made each 1 meter. The minimal and maximum height of each contact with the vegetation is measured using a stake of 8 meters. This stake is drawn up vertically. The values beyond 8 meters heights are estimated. For each contact, the species and the distance to which each individual is met on transect are noted.

The plot method was usually use for forest inventories in tropical zone (Spichiger *et al*., 1996; Hawthorne, 1996; Adou Yao *et al*., 2007).In order to record a maximum representative species of the inventory zone, for the study, the Tanoé-Ehy Forest has been divided into 110 squares of 20 m by side. The position (altitude/longitude) of each plot was recorded by a GPS. In each plot all vascular plant species (trees, shrubs, grass, and lianas) were recorded. A sub-plot of 10 $m^2$was selected in which, some details data were recorded (DBH individuals numbers) for individuals with diameter equal or more than 5 cm at 1m 30 high. To get a more accurate estimation of species richness and composition, additional species were added thanks to itinerant prospection.

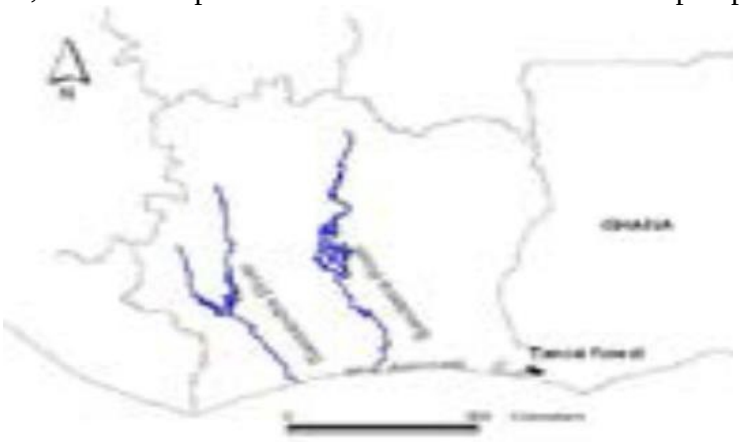

Figure I: Map of Tanoé-Ehy area, the geographical framework of this study

Data analysis

After establishing, species were examined to identify and count endemics, referring to previously checklist established by Poorter *et al*. (2004), for Upper Guinea endemic species. The list of threatened and endangered species was established according to the IUCN checklist of 2018.In order to appraise the floristic diversity in the Tanoé -Ehy Forest and to compare the diversity of the biotope, the Shannon (1948) diversity index has been calculated. This index is usually used in ecological studies (Huston, 1995) as measure of heterogeneity and takes into account the regularity of species abundance (Peet, 1974). It's calculated as the following formula:

$H = - \Sigma (Ni/N) \times Ln (Ni/N)$

Ni is individuals number for species i and N is the total numbers of all species.

In order to appraise the preponderance of species of the forest swamp of Tanoé-Ehy flora the Importance Value Index (IVI) has been calculated. It has been used in different tropical forest by different authors (Curtis and McIntosh, 1951; Bakayoko, 1999 and Adou Yao *et al*., 2007). Importance Value Index (IVI) was calculated for each species (i) as:

IVI = RDeni + RDomi + R Frqi.

RDeni is relative density, RDomi is relative Dominance, and RFrqi is relative frequency of species (i).

Species richness, species with special status, density and basal area of woody trees (> 5 cm), disturbance index, overlap, number of gaps, gap width and regeneration rate are criteria that we have taken into account to show the importance of this forest for the conservation of biodiversity.

To determine the conservation value of each biotope we have summed the crosses of these criteria. The crosses symbolize scales of value for each criteria. The sum of all the crosses being 48, we chose to vary the sum from 0

to 40. A biotope with the number of crosses between 0-10 at a very low value of conservation. Between 10-20 a low conservation value, 20 and 30 an average conservation value, between 30 and 40 a great value conservation and more than 40 and above a very high conservation value.

To appreciate vegetation condition, gap width, and biotope recovery were used. The recovery of each biotope was built from averages of the strata of different survey.

Results

Floristic composition and diversity

This inventory of surface listing combined three methods (surface, linear and itinerant) constitutes the first one implemented in Tanoé-Ehy Forest. In total, 432 plant species have been listed in the Tanoé-Ehy Forest according to Angiosperm Phylogeny group (APG IV, 2016). This number shows a relatively high diversity in this forest (table 1). Among the species 51 have special status (Endemic species of Upper Guinea, of Cote d'Ivoire, threatened and endangered). For the threatened and endangered species, 16 have been recorded in the Marsh Forest Tanoé-Ehy (table 2). Among them, 3 species are really in endangering (*Hemandradenia chevalieri*, *Tieghemella heckelii*), 1 endangered species but with a minor concern (*Irvingia gabonensis*) and 13 others are a category of vulnerable species. A Sassandrian species of type II (*Piptostigma fugax*) was also observed. Concerning the IVI of the forest. *Symphonia globulifera* (43.10) and *Uapaca paludosa* (35, 03) have the highest IVI values (table 3).

Table 1: Shannon index and Pielou equitability

Floristic parameters	Tanoé- Ehy Forest	Dry land forest	Swamp forest	Raphiale
Shannon index	5,09	3,27±1,5	2,37±0,5	1,25±0,01
Pielou equitability	0,90	0,81±0,1	0,52±0,2	0,29±0,02

Table 2: Threatened and endangered species listed in the Tanoé-Ehy Forest according to IUCN (2017)

Species	Families	Status of conservation
Anopyxis klaineana (Pierre) Engl.	Rhizophoraceae	VU Ald ver 2.3 (1994)
Entandrophragmacandollei Harms	Meliaceae	VU Ald ver 2.3 (1994)
Garcinia afzelii Engl.	Clusiaceae	VU Ald ver 2.3 (1994)
Guarea cedrata (A. Chev.) Pellegr.	Meliaceae	VU Ald ver 2.3 (1994)
Hemandradenia chevalieri Stapf	Connaraceae	En B1 12C
Hallea stipulosa (DC.) J.-F.Leroy	Rubiaceae	VU Ald ver 2.3 (1994)
Hallea ledermannii (K.Krause) Verdc.	Rubiaceae	VU Ald ver 2.3 (1994)
Irvingia gabonensis (Aubry Le-comte ex O'Rorke) Baill.	Irvingiaceae	LR/ nt ver2.3(1994)
Lovoa trichilioides Harms	Meliaceae	VU Ald ver 2.3 (1994)
Lophira alata Banks ex C.F. Gaertn.	Ochnaceae	VU Ald ver 2.3 (1994)
Milicia excelsa (Welm.) C.C. Berg	Moraceae	VU Ald ver 2.3 (1994)

Milicia regia (A. Chev.) C.C.Berg	Moraceae	VU Ald ver 2.3 (1994)
Nauclea diderrichii (De Wild. & T. Durand) Merr.	Rubiaceae	VU Ald ver 2.3 (1994)
Piptostigma fugax A.Chev.ex Hutch.Dalziel	Annonaceae	VU Ald ver 2.3 (1994)
Tieghemella heckelii (A. Chev.) Pierre ex A. Chev.	Sapotaceae	En B1 12C
Tarrietia utilis (Sprague) Sprague	Malvaceae	VU Ald ver 2.3 (1994)

Table 3: Importance Value Index of the species in the Tanoé-Ehy Forest

SPECIES	Relative Dominance (%)	Relative density (%)	Relative Frequency (%)	IVI
Symphonia globulifera	14,91	15,11	13,08	43,10
Uapaca paludosa	13,02	12,01	10,00	35,03
Anthostema aubryanum	17,98	7,64	5,58	31,21
Tarrietia utilis	17,98	7,64	5,58	31,21
Hallea stipulosa	11,12	8,90	6,94	26,97
Xylopia rubescens	1,66	9,06	9,59	20,31
Raphia hookeri	8,12	4,20	4,16	16,48
Spondianthus preussii	4,26	6,47	4,23	14,96
Hallea ledermannii	6,86	2,43	2,71	12,00
Uapaca guinnensis	1,89	3,10	4,20	8,06
Syzygium rowlandii	0,14	1,84	1,85	4,80
Funtumia africana	0,42	1,45	1,00	2,87
Nauclea diderichii	0,06	0,98	1,76	2,81
Other	1,58	19,15	29,33	50,03
Total	100	100	100	300

Structure of vegetation

The observation of these coverings shows that at the level of the recovery, the raphiale middle, the strate of herbaceous and small shrubs less than two meters is very poorly occupied. Then a progressive increase of the percentage of recovery up to the stratum 8 at 16 meters is observed. This percentage falls at the level of the stratum. For the swamp forest, the strate base is very covered, the vegetation is dense in medium stratum from thee strate vegetation occupation decreases. Emerging stratum has a percentage of over 20% (Figure 2).

Conservation value of Tanoé-Ehy Forest

Analysis of the table 4 shows that the swamp forest, the dry land forest and the raphiale have a high conservation value. The sum of the crosses representing the conservation value is 36; 32 and 34 respectively for marshy forest, raphiale and land forest. The marshy forest has a high conservation value due to the large number of species, the number of rare species according to Aké-Assi and the number of rarity and threatened species according to

IUCN. Concerning the raphiale and the dry land forest. The high conservation value observed in these biotopes is due to the low perturbation of these two areas.

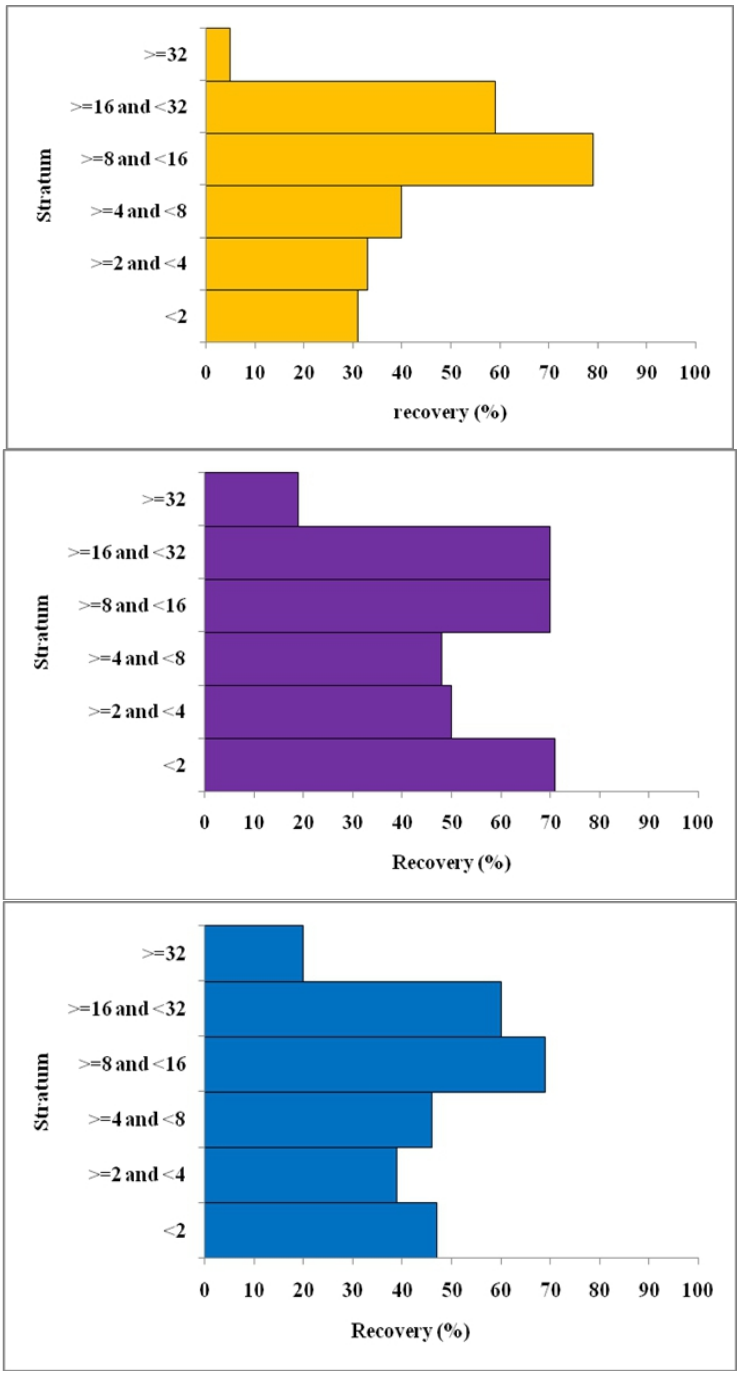

Figure 2: Recovery from the recovery stratum biotope Raphiale (A); Swamp forest (B); Dry land forest (C)

Table 4: Conservation value of each recognized biotope in the Tanoé-Ehy Forest

Indicators	Swamp forest	Raphiale	Dry land forest
Number of species	xxxxx	xxxx	xxx
Scarce number according Ake-Assi	xxxx	xx	xx
Number of species from Upper Guinea	xxxx	xxx	xxxx
Number of IUCN Species (2015)	xxxx	xxx	xxx
Number of West African endemic species	xxx	xxx	xxx
Density	xxx	x	xxx
Basal area	xxxx	xxx	x
Recovery	xx	x	xxx
Width of the gaps (15m)	x	xxxx	xxxx
Number of holes (15m)	x	xx	xx
Pioneer Index (PI)	xxx	xxxx	xxx
Regeneration rate	xx	xx	xxx
Total + Conservation Value	36: High conservation value	32: High conservation value	34: High conservation value

Discussion

Floristic composition and diversity

Concerning our study, to have arguments to heepher, we characterized the Tanoé-Ehy Forest generally and the various biotopes which make up her. Confronting the results of this study with the criteria recognized by the forest stewardship, some observations can get free. The first criterion recommend that the forest is to be protected. The Tanoé-Ehy Forest satisfied this criterion because the first ones measures of its protection were already taken. Then, the concept requires a concentration of vulnerable species, in or danger or threatened. The analyze of the general flora indicates that the Tanoé-Ehy Forest includes fifty-one botanical species with particular status. This proportion is superior for example to thirty-four botanical species with particular status for the forest of the site of the intended voluntary nature reserve.Among these species with particular status, we observe the presence of the endemic species, the botanical species rare and threatened according to Aké-Assi (1984). These observations confirm the peculiarity of this forest. Generally, a forest presenting good wealth, as well as strong rate of species with particular status such as the endemism, the rarity, deserves a priory attention for the conservation. This shows the membership this forest in one of the hotspots of high Guinea that is the south east of Côte d'Ivoire. In fact, besides the endemism which is considered as an important fact, the rarity holds an important place in the definition of the species to be kept. The presence of numerous endemic species and endangered (particular status species) is broadly a sign of a great biodiversity and a good level of conservation (Adou Yao & Roussel, 2007).The presence of a Sassandrian in the Tanoé-Ehy Forest goes with works of Adou Yao (2007). But Guillaumet &Adjanohoun (1971)

noted the absence of Sassandrian in the trainings degraded by human. Scieng this result we can say that Tanoé-Ehy Forest is altogether well kept the presence in the forest Tanoé-Ehy Forest of these species shows that the forest possesses a big diversity. In fact according to Myers *et al*. (2000); Tchouto (2004), the endemic species are the most sensitive to perturbations caused by human. Then, the risks of extinction are more important at these species enfeoffed in housing environments one the very particular conditions.

Concerning the biotopes which make up the Tanoé-Ehy Forest, the analysis of the importance of the species of every biotope showed that certain species which contribute strongly to the training of the vegetation one member of species of the red list of the IUCN. These species are mainly run by the populations resulting from Ghana country which is limited of the Tanoé-Ehy Forest by the Tanoé river. These observations show that if the flora and the vegetation of these biotopes are not protected, they will finish by disappear.

Conservation value

Considering conservation values we notice that the swamp forest has a great value of conservation. This biotope deserved so special attention. Results similar ones were made by Adou Yao *et al*. (2005) at the southern level of the National Park of Tai. It could be activities which have more negative impact in these biotopes. It is mainly the traces of old farms (tracks, tree trunks) that testify to these disturbances, major causes of the massive presence of pioneer species.The observation of the histograms of the profiles of average coverings of specie realized in the Tanoé -Ehy Forest show that the histogram of the dry land forest is similar to the type of Chatelain (1996) and to the H twice of Menzies (2000) characterizing the statements of primaries forest. This resemblance shows that this biotope would be the best kept environment.

Conclusion

This study showed that the Tanoé-Ehy Forest, the last forest relic in the south-eastern of Côte d'Ivoire includes 432 species. Among the species 51 have particular status species. The presence of numerous particular status species (endemic species and endangered) in this forest is broadly a sign of a great biodiversity and a good level of conservation. However, these species are mainly run by the populations resulting from Ghana country and the populations around this forest there is a composite population made up by the autochthons, the natives of Tanoé-Ehy areas, the allochthons which are nationals coming from other regions of Côte d'Ivoire and foreigners. Concerning the diversity, the Shannon index showed that the Tanoé-Ehy Forest is among the most diverse forests of swampy environments in particular and dense evergreen forests in general. Considering conservation values of the

biotope we notice that the swamp forest has a great value of conservation. However, the dry land forest would be the best kept environment.

Finally, we urge for the protection of these forests as they represent an important refuge for the forest flora in the South-Eastern of the Côte d'Ivoire, a region where only few forests persisted until today.

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