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SPECIES DIVERSITY AND NATURAL REGENERATION OF WOODY PLANTS IN NYÉ'ÉTÉ FOREST, SOUTH REGION OF CAMEROON

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This study was carried out in the tropical rainforest of Nyé'été (South Cameroon). The main objective was to contribute to the knowledge of potential floristic of woody plants for the sustainable management of Cameroonian tropical forests. Units selected for this study were Nkongo, Adjap and Akom 1 forest areas. Four transects of 20 m × 1000 m each were established in each collection unit and all plant species with diameter at breast height > 10 cm in the transects were inventoried. Meanwhile, juvenile plants were collected in 40 plots (20 m × 20 m each) established in prospected transects. Diversity and regeneration indices were then calculated. In total, 127 mature species belonging to 99 genera and 37 families and 130 juvenile species comprising 102 genera and 39 families were identified. Of the mature plants, Euphorbiaceae and Meliaceae were the most abundant families (13 species each) and the least abundant were Bignoniaceae, Ebenaceae and Sapindaceae (2 species each). Nyé'été tropical rainforest was characterised by a high species diversity (Shannon = 4.65; Simpson = 0.99; Pielou = 0.64). Density of juvenile individuals was 6820 individuals ha^{-1}, whereas density of adult individuals was 239.17 individuals ha^{-1}. Natural regeneration in the forest was generally good.

Keywords: Potential floristic, regeneration indices, sustainable use, Cameroonian tropical forests

INTRODUCTION

In Africa, tropical rainforest are located mainly in the Congo Basin covering the Democratic Republic of Congo, Cameroon, Equatorial Guinee, Central African Republic, Congo and Gabon (Tchatchou et al. 2015). In Cameroon, forest covers about 17.5 million ha, representing approximately 37% of the total surface area of the country (WRI 2012).

Forest ecosystems are highly important for human wellbeing, providing goods and services such as reliable clean water, climate regulation, fertile soils, timber and wood fuel production. However, these ecosystem services had already declined about 60% as a direct result of uncontrolled human activities (Martinez Pastur et al. 2020). Moreover, many species-rich ecosystems are disappearing before being studied. Recent studies revealed that Africa is losing forest cover about 4 million ha year^{-1} (Moon & Solomon 2018). The main human activities leading to the vegetation loss are intensive wood exploitation and forest clearing for intensive agriculture (CARPE 2005).

In the Congo basin, deforestation rate increased from 0.09% between 1990 and 2000 to 0.17% between 2000 and 2005 (Tchatchou et al. 2015). In Cameroon, the forests are of vital importance at the local, regional and global levels (WRI 2012) but deforestation rate range from 0.4 to 1% (Essama-Nssah & Gockowski 2000) and this rate is still increasing. At the same time, the construction of hydroelectric dams of Lom Pangar and Memve'le destroyed more than 3220 and 2010 ha of forest respectively (Tchatchou et al. 2015).

Since the establishment of a rubber plantation company in 1975, the number of villages around Nyé'été rainforest has increased drastically. As a result, anthropogenic activities increased in the rainforest. In addition to working for the rubber plantation company, migrant populations are clearing forest areas to establish villages and also carry out various activities such as agriculture, hunting, breeding and picking fruits to meet their needs. They are exploiting large forest surfaces to grow oil palm, banana, plantain, cassava, etc.

In this context, there is an urgent need to know the potential plant resources of forests in order to develop efficient strategies for in-situ conservation for a sustainable use. Thus, the main objectives of this study were (1) to assess the floristic composition, (2) to assess the specific diversity plants as well as (3) to assess the natural regeneration rate of the plant species.

MATERIALS AND METHODS

Study site

The Nyé'été forest is located in Nyé'été subdivision and covers an area of 2117 km^2. The forest belongs to the Ocean Division in the south region of Cameroon (Figure 1). The population is estimated at 40,894 people in 28 villages. The climate is humid tropical type, characterised by four seasons, i.e. two dry seasons and two rainy seasons (Suchel 1987). The average annual temperature is around 25 °C. Soils are mainly ferrallitic and hydromorphic (Gemerden & Hazeu 1999). Nyé'été forest belongs to the Atlantic basin area and it is crossed on both sides by two rivers, namely, the Kienké river in the north and the Lobé river in the south.

For this study, three forest stands (Adjap, Nkongo and Akome I) were chosen collection units related to three villages of the same names respectively. Adjap forest is located in the north of Nyé'été subdivision, between 2° 49' N and 10° 11' E. The Bulu people dominate the populations. The main activities carried out by the ethnic groups here are agriculture and logging. The most exploited timber species are *Pterocarpus soyauxii*, *Erythrophleum ivorense* and *Baillonella toxisperma*.

Akom I is also located in the north of Nyé'été subdivision, near Adjap forest, but between 2° 49' N and 10° 08' E (Figure 1). The populations in Akom I belong to Fang, Bulu, Bassa and Ngoumba ethnicities. The main anthropogenic activities carried out by these populations are agriculture and the exploitation of timber. The people here cultivate rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*) on small scales. They also take and use bark from certain plant species such as *Garcinia lucida* and *Alstonia boonei*.

Nkongo (4.73° S, 31.57° E) is located in the southern area of Nyé'été subdivision. The ethnicities of the populations in this area are pygmies, Fang, Boulou, Bassa and Ngoumba and the increasing populations of migrants from the northern regions of Cameroon. Due to the increasing population growth, intensive anthropogenic activities such as agriculture, exploitation of timber and illegal hunting are observed. Large forest areas are exploited for

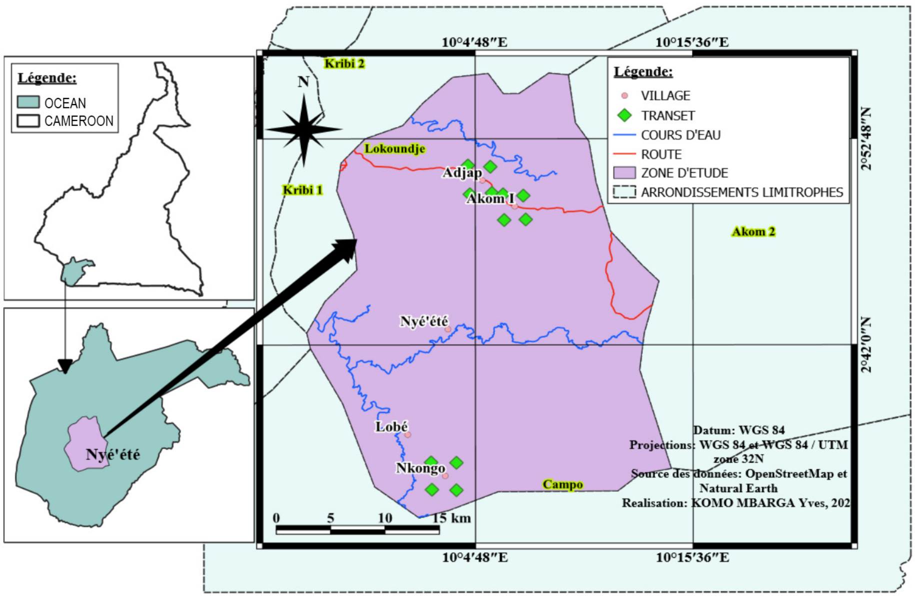

Figure 1 Site location

oil palm, banana, plantain and cocoa cultivation. However, intensive land exploitations are carried out by the plantation company which cultivates rubber and oil palm too on large scales.

Data collection

Four transects (20 m × 1000 m each) were established in each of the collection units (villages). The transects (totalling 2 ha area) were representative of each collection unit for floristic collection (Hall & Bawa 1993, Peters 1997). In total, 12 transects were established and 24 ha were prospected. All plant species (diameter at breast height (DBH) > 10 cm) were systematically inventoried in the transects and their DBH were also measured.

Juvenile plants (saplings and seedlings) collection was done within the 40 plots (four 20 m × 20 m plots per transect) established within the transects. Within each plot, all juvenile plants were systematically counted in the 16 ha as indicated by Todou et al. (2018). Scientific names of species were given according to Cronquist (1981). Identification of the most common species was done directly in the field whenever possible. Some specimens were collected in order to authenticate scientific names at the National Herbarium of Cameroon, the Laboratory of Agriculture and Development Research Institute in Maroua and by botanists from University of Maroua (Cameroon) following Lebrun and Stork (1991, 1992, 1995, 1997) and Arbonnier (2000).

Data analysis

Floristic composition

With the collected data, we calculated the numbers of plant individuals, species, genera and families. The density (D, individuals ha^{-1}) of each species were calculated.

Diversity

The stand specific diversity was described using Simpson's, Shannon–Weaver and equitability indices (Magurran 2004).

Natural regeneration

The number of juvenile plants was compared with that of adult plants. According to Dhaulkhandi et al. (2008), Tiwari et al. (2010) and Nelson and Noweg (2021), regeneration is considered good if the number of juvenile plants > the number of adult plants. There is fair regeneration if the number of juvenile plants ≤ the number of adults plants. If a species is present only in adult stage, it is considered as not regenerating. A species is considered as new in the stand if the species has no adult plants but only juvenile plants. The regeneration rate (SRR) of stand was calculated according to the Poupon (1980) formula:

$$SRR = \frac{JUV}{ADT + JUV} \times 100$$

where, JUV = number of juvenile plants in the stand and ADT = the number of adult plants in the stand. The specific index of regeneration (SIR) was calculated according to Akpo and Grouzis (1996):

$$SIR_i = \frac{JUV_i}{JUV} \times 100$$

where, SIR_i = specific index of regeneration of species i and JUV_i = number of juvenile plants belonging to species i. The Statistical Package for Social Sciences software version 20.0 and Excel (Microsoft Office 2013) were used for data processing and presentation of results.

RESULTS

Floristic composition of mature and juvenile plants

In total, 127 species belonging to 99 genera and 37 families were identified. Euphorbiaceae (14 species) and Meliaceae (13 species) were the richest families in terms of species number (Figure 2). The richness of 19 families are shown in Figure 2. About 20 families were represented each by only one species and these were grouped as 'Autres'. A total of 130 species belonging to 102 genera and 39 families were related to the natural generation flora (number of juvenile plants species).

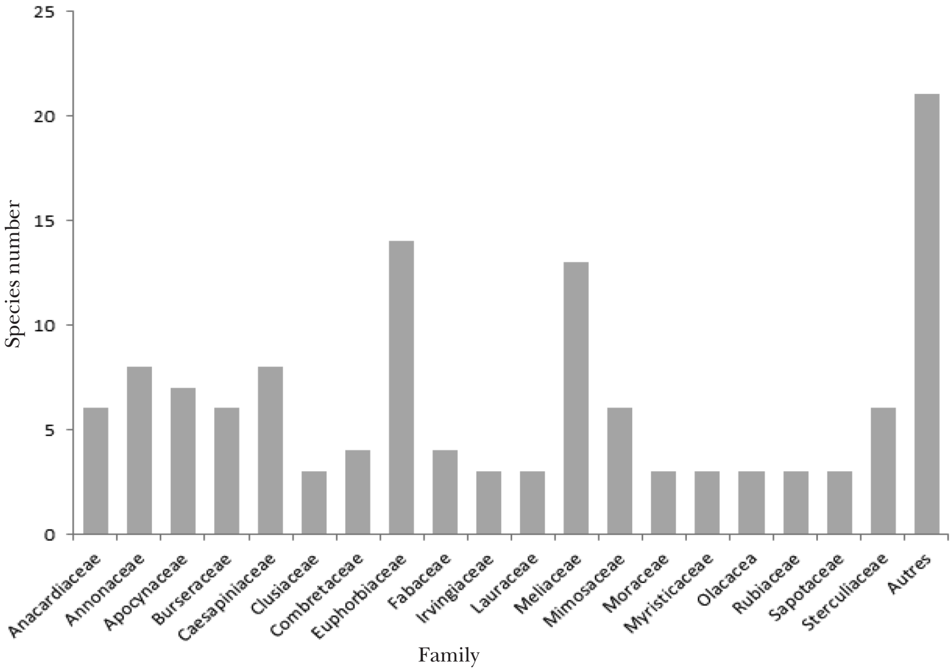

Figure 2 Richness of the most representative families

Specific diversity of mature and juvenile plants

According to Shannon–Weaver (4.65), Simpson (0.99) and Pielou (0.64) indices, there was high diversity of mature plants in Nyé'été rainforest with about the same numbers of individuals. The specific richness and the Shannon index showed high diversified flora (S = 127 species and H = 4.65 > 4). In the forest stand of Akom I, 101 species were recorded, whereas 97 and 87 species were found in Adjap and in Nkongo forest stands respectively. Even at the local level (alpha diversity), specific diversity was high with indices above average and Shannon index > 4. Juvenile stand diversity indices (Shannon index = 4.69, Simpson index = 0.99 and Pielou = 0.59) were comparable to those of adult plants (Table 1).

Natural regeneration

Density of juvenile individuals was 6820 individuals ha^{-1} whereas density of adults, 259.58 individuals ha^{-1}. There were 124 species with good regeneration rate. Three species with fair regeneration rate were recorded (*E. guineensis*, *Dacryodes edulis* and *Diospyros crassiflora*). Three other species were represented by juvenile plants only. These were *Anisophyllea polyneura* (Anisophylleaceae), *Mareyopsis longifolia* (Euphobiaceae) and *Fagara macrophylla* (Rutaceae) (Table 2). Five taxa could not be identified to the species level (*Diospyros* sp., *Driypetes* sp., *Macaranga* sp., *Mareopsis* sp. and *Uapaca* sp.). The specimens were kept by botanists from the University of Maroua for further investigation.

DISCUSSION

Floristic composition of mature woody plant in Nyé'été rainforest

Genetically, diverse species adapt better to environmental conditions than the less diverse ones (Todou 2015). At the ecosystem level, specific diversity ensures the sustainability of ecosystems. In this study, 127 species belonging to 99 genera and 37 families were identified. Euphorbiaceae and Meliaceae were the richest families with regard to their numbers of species. Guedje (2002) and Gonmadje et al. (2012) recorded more species and family number respectively in Bipindi-Akom II and Ngovayang rainforest stand located in the same forest zone in south Cameroon. We observed that Caesalpinaceae, Euphorbiaceae, Annonaceae and Meliaceae had high species numbers. In

Table 1 Diversity characteristics of woody plant species in Nyé'été forest

Diversity parameter	Mature plant	Juvenile plant
No. individuals*	5740	10,912
No. species	127	130
No. genera	99	102
No. families	37	39
Density (individuals ha^{-1})	259.58	2113.42
Basal area (m^2)	621.49	-
Shannon index	4.65	4.69
Simpson index	0.99	0.99
Pielou index	0.64	0.59

*Mature and juvenile plants were prospected in 24 and 16 ha respectively

Table 2 List of species, their abundance and regeneration status

Family	Species	Mature plants (in 24 ha)		Juvenile plants (in 16 ha)			Status
		Ni*	D	Ni*	D	SIR	
Anacardiaceae	*Annickia chlorantha*	116	4.83	236	147.5	2.17	G
	Annickia polycarpa	20	0.83	48	30	0.44	G
	Antrocaryon klaineanum	80	3.33	128	80	1.17	G
	Mangifera indica	44	1.83	84	52.5	0.77	G
	Trichoscypha abut	48	2.00	84	52.5	0.77	G
	Trichoscypha acuminate	56	2.33	120	75	1.1	G
Anisophylleaceae	*Anisophyllea polyneura*	0	0.00	44	27.5	0.40	N
Annonaceae	*Annodium mannii*	52	2.17	100	62.5	0.92	G
	Annona muricata	36	1.50	44	27.5	0.4	G
	Meiocarpidium lepidotum	32	1.33	76	47.5	0.69	G
	Monodora myristica	44	1.83	96	60	0.88	G
	Polyalthia suaveolens	64	2.67	112	70	1.03	G
	Xylopia aethiopica	28	1.17	60	37.5	0.55	G
	Xylopia parviflora	56	2.33	120	75	1.1	G
	Xylopia staudtii	12	0.50	24	15	0.22	G
Apocynaceae	*Alstonia boonei*	80	3.33	120	75	1.1	G
	Landolphia hirsuta	8	0.33	32	20	0.69	G
	Landolphia owariensis	32	1.33	76	47.5	0.55	G
	Picralima nitida	100	4.17	208	130	1.91	G
	Rauwolfia vomitoria	48	2.00	108	67.5	0.99	G
	Tabernaemontana crassa	20	0.83	48	30	0.44	G
	Voacanga africana	88	3.67	156	97.5	1.43	G
Arecaceae	*Elaeis guineensis*	32	1.33	12	7.5	0.11	F
Bignoniaceae	*Markhamia lutea*	40	1.67	92	57.5	0.84	G
	Spathodea campanulata	20	0.83	48	30	0.44	G

continued

Table 2 Continued

Family	Species	Mature plants (in 24 ha)		Juvenile plants (in 16 ha)			Status
		Ni*	D	Ni*	D	SIR	
Bombacaceae	*Ceiba pentandra*	60	2.50	108	67.5	0.99	G
Boraginaceae	*Cordia platythyrsa*	16	0.67	36	22.5	0.33	G
Burseraceae	*Aucoumea klaineana*	148	6.17	208	130	1.91	G
	Canarium schweinfurthii	48	2.00	100	62.5	0.92	G
	Dacryodes edulis	76	3.17	64	40	0.59	F
	Dacryodes macrophylla	48	2.00	108	67.5	0.99	G
	Dacryodes igaganga	28	1.17	68	42.5	0.62	G
	Santiria trimera	32	1.33	68	42.5	0.62	G
Caesalpiniaceae	*Afzelia bipindensis*	40	1.67	92	57.5	0.84	G
	Berlinia bracteosa	12	0.50	24	15	0.22	G
	Cynometra sp.	24	1.00	52	32.5	0.48	G
	Dialium dinklagei	12	0.50	24	15	0.22	G
	Distemonanthus benthamianus	20	0.83	36	22.5	0.33	G
	Microberlinia brazzavillensis	16	0.67	36	22.5	0.33	G
	Monopetalanthus microphyllus	12	0.50	36	22.5	0.33	G
	Scorodophloesus zenkeri	112	4.67	180	112.5	1.65	G
Cecropiaceae	*Myrianthus arboreus*	76	3.17	132	82.5	1.21	G
Clusiaceae	*Garcinia kola*	48	2.00	84	52.5	0.77	G
	Garcinia lucida	32	1.33	60	37.5	0.55	G
	Allanblackia floribunda	56	2.33	104	65	0.95	G
Combretaceae	*Combretum micranthum*	56	2.33	108	67.5	0.99	G
	Terminalia ivorensis	24	1.00	52	32.5	0.48	G
	Terminalia macroptera	36	1.50	44	27.5	0.4	G
	Terminalia superba	60	2.50	112	70	1.03	G
Ebenaceae	*Diospyros crassiflora*	32	1.33	60	37.5	0.55	F
	Diospyros sp.	28	1.17	40	25	0.37	G
Euphobiaceae	*Alchornea cordifolia*	28	1.17	52	32.5	0.48	G
	Drypetes gossweileri	16	0.67	40	25	0.37	G
	Drypetes sp.	32	1.33	56	35	0.51	G
	Hevea brasiliensis	64	2.67	84	52.5	0.77	G
	Macaranga burifolia	20	0.83	32	20	0.29	G
	Macaranga sp.	20	0.83	44	27.5	0.4	G
	Maesobotrya sp.	24	1.00	40	25	0.37	G
	Mareyopsis longifolia	0	0.00	32	20	0.29	N
	Margaritaria discoidea	20	0.83	48	30	0.44	G
	Plagiostyles africana	44	1.83	92	57.5	0.84	G
	Ricinodendron heudelotii	44	1.83	88	55	0.81	G
	Uapaca esculenta	44	1.83	92	57.5	0.84	G
	Uapaca guineensis	80	3.33	136	85	1.25	G
	Uapaca sp.	40	1.67	84	52.5	0.77	G
Fabaceae	*Baphia leptobotrys*	32	1.33	60	37.5	0.55	G
	Erythrophleum suaveolens	76	3.17	124	77.5	1.14	G
	Guibourtia demeusei	32	1.33	76	47.5	0.69	G
	Pterocarpus soyauxii	48	2.00	88	55	0.81	G

continued

Table 2 Continued

Family	Species	Mature plants (in 24 ha)		Juvenile plants (in 16 ha)			Status
		Ni*	D	Ni*	D	SIR	
Hippocrataceae	*Salacia nitida*	20	0.83	32	20	0.29	G
Humiriaceae	*Sacoglottis gabonensis*	144	6.00	248	155	2.28	G
Hymenocardiaceae	*Hymenocardia heudelotii*	40	1.67	92	57.5	0.84	G
Icacinaceae	*Leptaulus daphnoides*	16	0.67	60	37.5	0.55	G
Irvingiaceae	*Irvingia gabonensis*	80	3.33	152	95	1.39	G
	Irvingia robur	12	0.50	36	22.5	0.33	G
	Klainedoxa gabonensis	64	2.67	88	55	0.81	G
Lauraceae	*Beilschmiedia mannii*	16	0.67	28	17.5	0.26	G
	Beilschmiedia obscura	24	1.00	36	22.5	0.33	G
	Persea americana	40	1.67	56	35	0.51	G
Lecythiadaceae	*Petersianthus macrocarpus*	68	2.83	144	90	1.32	G
Malvaceae	*Theobroma cacao*	24	1.00	36	22.5	0.33	G
	Triplochiton scleroxylon	20	0.83	28	17.5	0.26	G
Meliaceae	*Carapa procera*	68	2.83	120	75	1.1	G
	Chlorophora excelsa	48	2.00	96	60	0.88	G
	Entandrophragma angolense	16	0.67	32	20	0.29	G
	Entandrophragma candollei	20	0.83	40	25	0.37	G
	Entandrophragma utile	60	2.50	104	65	0.66	G
	Entandrophragma cylindricum	56	2.33	96	60	0.88	G
	Guarea cedrata	20	0.83	40	25	0.37	G
	Guarea thompsonii	44	1.83	132	82.5	1.21	G
	Khaya anthotheca	44	1.83	84	52.5	0.77	G
	Khaya ivorensis	8	0.33	32	20	0.29	G
	Lovoa trichilioides	40	1.67	72	45	0.66	G
	Trichilia rubescens	32	1.33	56	35	0.51	G
	Trichilia welwitschii	16	0.67	32	20	0.29	G
Mimosaceae	*Albizia ferruginea*	36	1.50	100	62.5	0.92	G
	Parkia biglobosa	12	0.50	24	15	0.22	G
	Pentaclethra eetveldeana	24	1.00	44	27.5	0.4	G
	Pentaclethra macrophylla	88	3.67	172	107.5	1.58	G
	Piptadeniastrum africanum	84	3.50	164	102.5	1.51	G
	Tetrapleura tetraptera	76	3.17	144	90	1.32	G
Moraceae	*Musanga cecropioides*	44	1.83	76	47.5	0.69	G
	Treculia africana	12	0.50	32	20	0.29	G
	Treculia obovoidea	76	3.17	152	95	1.39	G
Myristicaceae	*Coelocaryon preusi*	80	3.33	144	90	1.28	G
	Pycnanthus angolensis	72	3.00	140	87.5	1.28	G
	Staudtia kamerunensis	32	1.33	64	40	0.59	G
Myrtaceae	*Syzygium aromaticum*	60	2.50	116	72.5	1.06	G
Ochnaceae	*Lophira alata*	188	7.83	328	205	3.01	G
Olacaceae	*Coula edulis*	76	3.17	132	82.5	1.21	G
	Strombosia grandifolia	44	1.83	96	60	0.88	G
	Strombosia pustulata	36	1.50	84	52.5	0.77	G

continued

Table 2 Continued

Family	Species	Mature plants (in 24 ha)		Juvenile plants (in 16 ha)			Status
		Ni*	D	Ni*	D	SIR	
Palmaceae	*Phoenix reclinata*	56	2.33	100	62.5	0.92	G
Rhizophoraceae	*Poga oleosa*	76	3.17	148	92.5	1.36	G
Rubiaceae	*Hallea ciliata*	72	3.00	88	55	0.81	G
	Hallea stipulosa	16	0.67	32	20	0.29	G
	Sarcocephalus diderrichii	44	1.83	96	60	0.88	G
Rutaceae	*Fagara macrophylla*	0	0.00	24	15	0.29	N
Sapindaceae	*Blighia sapida*	16	0.67	36	22.5	0.33	G
	Eriocoelum macrocarpum	32	1.33	80	50	0.73	G
Sapotaceae	*Aningeria robusta*	80	3.33	136	85	1.25	G
	Baillonella toxisperma	56	2.33	108	67.5	0.99	G
	Tieghemella heckelii	16	0.67	40	25	0.37	G
Sterculiaceae	*Cola acuminata*	16	0.67	32	20	0.29	G
	Cola nitida	24	1.00	56	35	0.51	G
	Cola pachycarpa	48	2.00	92	57.5	0.84	G
	Cola ricinifolia	24	1.00	44	27.5	0.4	G
	Eribroma oblongum	60	2.50	108	67.5	0.99	G
	Pterygota macrocarpa	8	0.33	32	20	0.29	G
Verbenaceae	*Vitex grandifolia*	44	1.83	96	60	0.88	G

Ni = number of individuals, D = density, SIR = specific index of regeneration, G = good, F = fair, N = new species

Ivory Coast, precisely in the Anguédédou humid forest where the forest research station of CNRA is located, Rubiaceae, Annonaceae, Euphorbiaceae, Lamiaceae, Mennispermaceae and Sapindaceae are among the richest in species (Kouadio et al. 2016). The African humid tropical forests are among the most complex and richest ecosystems of the planet. Differences in the number of taxa and the richness of families may be due to anthropogenic activities observed in the investigated site. Indeed, the Nyé'été rainforest is highly disturbed by anthropogenic activities by employees from the rubber plantation company. Before the rubber plantation company was built, there were little logging and agricultural activities around and in the forest (personal observation).

The calculation of the diversity indices (Shannon, Simpson and Pielou) as part of this work showed high diversity and fairly good equitability. The Shannon index was above 4 indicating high diversity (Magurran 2004, Yédomonhan 2009). The Bipindi-Akom II rainforest not far from the study site also had high Shannon diversity index of 5.55 (Guedje 2002).

Natural regeneration of woody plant in Nyé'été rainforest

Many tropical forests have disappeared due to the increasing need of new agricultural land. Therefore, the study and the understanding of forest regeneration processes are important to properly manage forest resources. A natural regeneration is the establishment of trees from seeds that fall and germinate in-situ (Harmer 2001). According to Chazdon and Guariguata (2016), in appropriate conditions, natural regeneration of tropical forests occurs from itself, following ecological processes of species colonisation. This is the basis for understanding the dynamics of woody vegetation.

Natural regeneration involves recruitment, juvenile mortality and different stages of development, and survival (Traoré 1997). Natural regeneration can be vegetative or by natural seedling, but in Nyé'été rainforest, natural regeneration was assessed by the number of individuals. Following Dhaulkhandi et al. (2008) and Tiwari et al. (2010), we conclude that the regeneration status observed in this study is generally good, with some exception, since the recorded number of juvenile individuals ha^{-1} is higher than adults. Moreover, the numbers of the juvenile plant species, genera and families were also higher than those of the mature plants. Three species (*A. polyneura*, *M. longifolia* and *F. macrophylla*) were new species in the study site because they were only represented by juvenile individuals. Similar observation was reported by Todou et al. (2018) in the Sena Oura forest (located in Sudanian phytogeographical domain) where several new plant species were recorded and about 30 species did not show any regeneration state. Although tropical humid forests have higher diversity and more fertile soil, recovery of species composition may take longer than in dry tropical forest (Rozendaal et al. 2019). Indeed, the number of species is so high that it will be all the more complicated for the rarest species to recover. Occurrences of domesticated plants such as *Mangifera indica* (density of mature plants 1.83 individuals ha^{-1} and juvenile plants, 52.5 individuals ha^{-1}), *Persea americana* (mature plants 1.67 individuals ha^{-1} and juvenile plants 35 individuals ha^{-1}) and *Theobroma cacao* (mature plants 1.00 individuals ha^{-1} and juvenile plants 22.5 individuals ha^{-1}) can be explained by the establishment of the rubber plantation company in 1975 after which the number of villages around Nyé'été rainforest drastically increased. Anthropogenic activities increased in the Nyé'été rainforest favouring the establishment of these domesticated plants and their dissemination in the forest. In this forest, the regeneration status of the domesticated species was good although the mortality rate was high due to physiological stress in the wild and non-cultivated environment.

CONCLUSION

This investigation yielded useful information on the ecological importance and the natural regeneration status in the tropical rainforest of Cameroon. A total of 127 woody plant species were recorded in the investigated areas of Nyé'été tropical rainforest with high diversified flora (Shannon value > 4). The regeneration status of the forest was good. Only three species (*A. polyneura*, *M. longifolia* and *F. macrophylla*) were recorded as new in this forest. All mature individuals were represented by juvenile individuals. Thus, this study pointed out the increasing need for extensive investigation for the largely unstudied forest areas in Cameroon even in savannah area. The presence of domesticated species was justified by establishment of villages near the forest by rubber plantation company employees. The results contribute to the knowledge of potential floristic of woody plants for the sustainable management of Cameroonian forests.

REFERENCES

Akpo LE & Grouzis M. 1996. Influence du couvert sur la régénération de quelques espèces ligneuses sahéliennes (Nord-Sénégal, Afrique occidentale). *Webbia* 50: 247–263.

Arbonnier M. 2000. *Arbres, Arbustes et Lianes des Zones Sèches d'Afrique de l'Ouest.* CIRAD, MNHN & UICN, Montpellier.

CARPE (Central African Regional Program for the Environment). 2005. *The Forest of the Congo Basin: A Preliminary Assessment.* CARPE Management Team, Kinshasa.

Chazdon RL & Guariguata MR. 2016. Natural regeneration as a tool for large-scale forest restoration in the tropics: prospects and challenges. *Biotropica* 48: 716–730. https://doi.org/10.1111/btp.12381

Cronquist A. 1981. *An Integrated System of Classification of Flowering Plants.* Columbia University Press, New York.

Dhaulkhandi M, Dobhal A, Bhatt S & Kumar M. 2008. Community structure and regeneration potential of natural forest site in Gangotri, India. *Journal of Basic and Applied Sciences* 4: 49–52.

Essama-Nssah B & Gockowski JJ. 2000. *Forest Sector Development in a Difficult Political Economy: An Evaluation of Cameroon's Forest Development and World Bank Assistance. Evaluation Country Case Study Series.* The World Bank, Washington DC

Gemerden Bs & Hazeu GW. 1999. *Landscape Ecological Survey (1:100,000) of the Bipindi Akom II LolodorfRegion. Southwest Cameroon.* Tropenbos-Cameroon Documents 1. Tropenbos Cameroon Programme, Kribi.

Gonmadje C, Doumange C. Sunderland Terence CH, Balinga Michael & Sonké B. 2012. Analyse phytogéographique des forêts d'Afrique Centrale: le cas du massif de Ngovayang (Cameroun). *Plant Ecology and Evolution* 145: 152–164. http://dx.doi.org/10.5091/plecevo.2012.573

Guedje MN. 2002. La gestion des populations d'arbres comme outil pour une exploitation durable des produits forestiers non ligneux: l'exemple de *Garcinia lucida* (sud Cameroun). PhD thesis, Free University of Brussels, Bruxelles.

Hall P & Bawa K. 1993. Methods to assess the impact of extraction of non-timber tropical forest products on plant populations. *Economic Botany.* 47: 234–247. http://dx.doi.org/10.1007/BF02862289.

Harmer R. 2001. The effect of plant competition and simulated summer browsing by deer on tree regeneration. *Journal of Applied Ecology* 38: 1094–1103. https://doi.org/10.1046/j.1365-2664.2001.00664.x

Kouadio KR, Bakayoko A, N'guessan KA & Konan D. 2016. Diversité et structure floristiques sous des peuplements d'acacias Australiens en zone forestière de la Côte d'Ivoire. *European Scientific Journal.* 35: 229–246. https://doi.org/10.19044/esj.2016.v12n35p229

Lebrun JP & Stork AL. 1991, 1992, 1995, 1997. Enumération des Plantes a Fleurs d'Afrique Tropicale (4 volumes). Conservatoire et Jardin Botaniques de Genève. Genève.

Magurran AE. 2004. *Measuring Biological Diversity.* Blackwell Publishing, Malden.

Martinez Pastur GJ, Vanha-Majamaa I & Franklin JF. 2020. Ecological perspectives on variable retention forestry. *Ecological Processes* 9: 12. https://doi.org/10.1186/s13717-020-0215-3

Moon H & Solomon T. 2018. Forest decline in Africa: trends and impacts of foreign direct investment: a review. *International Journal of Current Advanced Research*: 16356–16361. https://doi.org/10.24327/ijcar.2018.16361.3021

Nelson J & Noweg T. 2021. Assessment of forest regeneration following a series of disturbances in two types of primary forest at Bungo Range, Bau, Sarawak. *Journal of Tropical Forest Science* 33: 126–136. https://doi.org/10.26525/jtfs2021.33.2.126

Peters CM. 1997. *Exploitation Soutenue des Produits Forestiers Autres que le Bois en Forêt Tropicale Humide: Manuel d'initiation Ecologique.* World Resources Institute, Washington.

Poupon H. 1980. *Structure et Dynamique De La Strate Ligneuse D'une Steppe Sahélienne au Nord du Sénégal.* Travaux et Documents de l'ORSTOM. No. 115. ORSTOM, Paris.

Rozendaal DMA, Bongers F & Aide TM et al. 2019. Biodiversity recovery of Neotropical secondary forests. *Science Advances* 5: eaau3114. https://doi.org/10.1126/sciadv.aau3114

Suchel JB. 1987. *Rainfall Patterns and Regimes Rainfall in Cameroon.* Doc. Geographic Tropical No. 5. CEGET-CNRS, Talence.

Tchatchou B, Sonwa DJ, Ifo S & Tiani AM. 2015. *Déforestation et Dégradation des Forêts dans le Bassin du Congo: État des Lieux, Causes Actuelles et Perspectives.* CIFOR Occasional Paper No. 120. Center for International Forestry Research (CIFOR), Bogor. https://doi.org/10.17528/cifor/005457

Tiwari GPK, Tadele K, Aramde F & Tiwari SC. 2010. Community structure and regeneration potential of *Shorea robusta* forest in subtropical submontane zone of Garhwal Himalaya, India. *Nature and Science* 8: 70–74.

Todou G. 2015. Distribution, adaptation environnementale et diversité génétique de *Dacryodes buettneri* (Engl.) HJ Lam et *Dacryodes edulis* (G Don) HJ Lam (Burséracées) en Afrique centrale. PhD thesis, University of Yaoundé I, Cameroon.

Todou G, Dedangsou S & Ibrahima A. 2018. Evaluation of structure and natural regeneration status of woody plant species of eastern part of National Park of Sena Oura, Chad. *International Journal of Environment, Agriculture and Biotechnology* 3: 1571–1581. http://dx.doi.org/10.22161/ijeab/3.5.2

Traoré SA.1997. Analyse de la flore et de la végétation de la zone de Simenti (Parc National du Niokolo Koba), Sénégal oriental. Third cycle thesis, Cheikh Anta Diop University of Dakar, Dakar.

WRI (World Resources Institute). 2012. *Interactive Forest Atlas of Cameroon. Version 3.0. Overview Report.* WRI, Washington.

Yédomonhan H. 2009. Plantes mellifères et potentialités de production de miel en zones guinéenne et soudano-guinéenne au Bénin. PhD thesis, Université d'Abomey-Calavi, Abomey-Calavi.