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Article

Floristic composition of vascular epiphytes in a disturbed forest of the Douala- Edea National Park (Cameroon)

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Abstract: The Douala-Edea National Park is a coastal protected area that opens to the Atlantic Ocean, and contains an abundant wildlife which finds a privilege habitat there, and certain taxa such as epiphytes, which are of particular interest for conservation. In many tropical forests, vascular epiphytes are one of the richest taxa, with major impacts on the nutrient and hydrological cycles. The aim of this research was to study the effect of the disturbance of habitat on the floristic composition of vascular epiphytes in the Douala-Edea National Park. This study was carried out between January - April 2021 in three types of disturbed habitats at the northern part of the park. Three plots of 100 m × 100 m dimensions were laid out across three ecosystems along the Sanaga river. The sampling method consisted in the direct observation of five adjacent transects of 100 m x 20 m dimensions inside each plot. Epiphytes species were evaluated on all trees of DBH ≥10 cm. Epiphytes' life-forms and the position on the host trees occupied by the epiphytes were also recorded. A total of 18 species belonging to 16 genera and 13 families were identified. *Culcasia sp.* was the most common species with a relative frequency of 30.27%. Biological indicators were represented by Ferns, with four species, and Orchidaceae, with one species. The epiphytes species richness was highest in the low disturbed habitat (13 species), and lowest in the highly disturbed habitat (8 species). Strict epiphytes were highly recorded in the low disturbed habitat (6 species), and were absent in the highly disturbed habitat. Hemi-epiphytes were the commonest life-form (12 species) in the highly disturbed habitat, and have been defined as indicators of the perturbation of the habitat. Canopy was mostly sollicitated by epiphytes in the low disturbed habitat (66.25%) than the moderate disturbed habitat (49.85%), and highly disturbed habitat (30.66%). It has been found that the different forest sites have an influence on the typology of epiphytic species, and therefore, epiphytic flora should be managed for the conservation of the biodiversity in tropical forests.

Keywords: Biodiversity; Coastal Region; Epiphytism; Host Trees; Protected Area

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1. Introduction

Forests are among the most productive terrestrial ecosystems, and are of great interest from the point of view of agriculture and for mitigating the effects of climate change [1]. Central African forests cover an area of about 241 million ha, including the Congo Basin, and are considered the second largest tropical forest after the Amazon which contain 21.5% of the existing carbon stock in the form of forest biomass across the globe [2,3]. The Atlantic Coast of Cameroon offers many types of ecosystems, among which are the mangroves, floodplain forests, swamp forests or even the vegetation of the old coastal strips [4].

Like other tropical forests, the forests of Central Africa represent a pool of biodiversity, notably, genetic resources whose usefulness is partially known. Among the thirty million plants on earth, epiphytes have been estimated to be around 24,000 species [5]. These organisms are well-known features in tropical forest, as they contribute to the local and regional floristic diversity [6]. Their growth depends on the understory abiotic factors, such as low light intensity, high humidity, and water disponibility. Some of them, belonging to Orchidaceae, have been characterize as an indicators of forest sustainability.

In recent days, forests have been subject to an increase in anthropogenic disturbances [7]. The disturbances lead to the creation of forest gaps that cause changes in resource availability of the physical environment, depending on its scale and severity [8]. In the coastal zone, human activities including the creation of agro-industrial and agricultural zones, fishing and mining prospecting have caused the progressive degradation of the environment. In addition to the presence of a few small plots of plantations or old plantations, the entire coastal line is made up of former fallows and a place of permanent human presence causing enormous consequences on the biodiversity [9].

In Cameroon, the Douala-Edea National Park (DENP) opens to the Atlantic Ocean, and contains an abundant wildlife which finds a privilege habitat there, and certain taxa which are of particular interest for conservation. Unfortunately, in recent years, threats have been identified in DENP ecosystems, such as human activities which are very frequent on the coastal line of the park [4]. The nature of disturbance can directly affect the ecological conditions of the forest understory [10], and may have effect on the epiphytes richness. We hypothesized that in the DENP, the epiphytic richness varies depending on the level of disturbance of the ecosystem. The objective of this research was to study the effect of the forest disturbance on floristic composition of vascular epiphytes in the Douala-Edea National Park.

2. Materials and methods

2.1. Study site

The Douala-Edea National Park (DENP) is located in the Littoral region and belongs to the Kribi-Douala Basin on the Atlantic Coast and covers a large part of the coastal plains of the Cameroonian coastline. It is geographically located between 3°14′–3°35′ N and 9°31′–10°05′ E and is limited to the north by the southern suburbs of Douala, to the south by Kribi, to the west by the Atlantic Ocean and to the east by the national road linking Edea to Kribi making the park located near an industrialized and densely populated area.

The park is entirely located in a very low sedimentary plain, from 0 to 50 m altitude. This plain is crossed by streams or swamps which give the only relief to this very flat topography [11]. The climate is equatorial, characterized by abundant rainfall (3000–4000 mm) and generally high temperatures, with a monthly average of 24–29°C. There is also a short dry season, but this is not marked, with an averaged temperature of 26.1°C, and annual precipitation of 2952 mm. December is the driest month (41 mm) and September is the month with the highest rainfall, while February is the hottest month with an average temperature of 27.2°C [12]. This locality belongs to the domain of the coastal Atlantic forest dominated by *Lophira alata* Banks ex CF Gaertn and *Saccoglottis gabonensis* (Bail.) Urb. The vegetation exhibits species diversification with full stratification from tall trees to herbaceous stratum [13]. Four sites have been identified [5]: coastal facies, disturbed forest, the undisturbed environment, and the marshy environment (Figure 1).

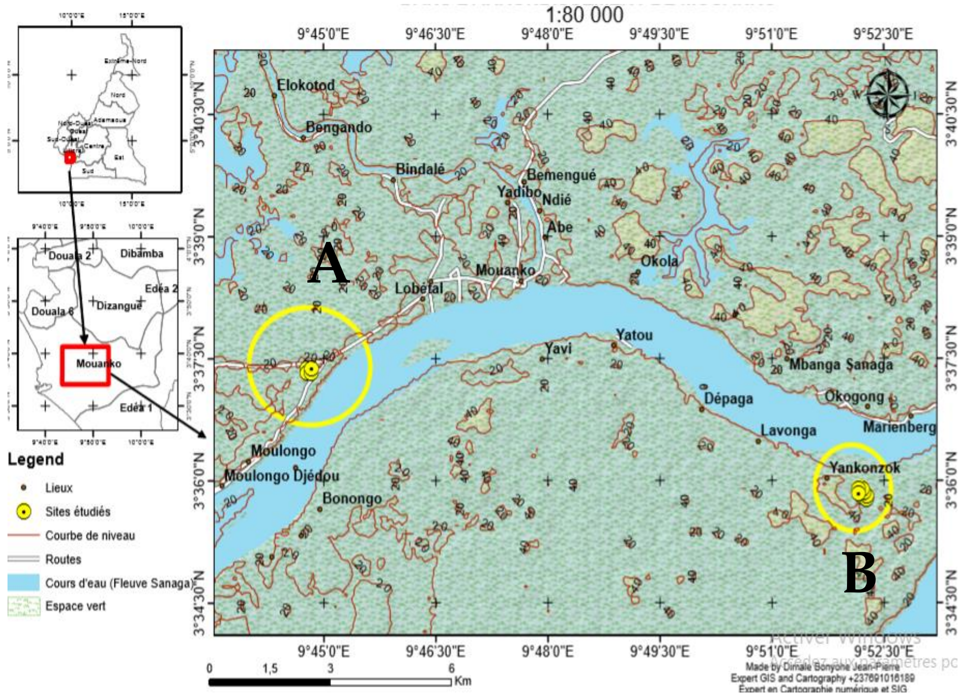

Figure 1. Map of the study area

2.2. Demarcation and enumeration

The study was carried out in two sites located in the two surrounding villages of Malimba and Yankonzok (Figure 1). Field survey was carried out from January-April 2021 in which 3 plots of 1ha each of 100 m x 100 m were established. These plots were categorized in three different sites: low disturbed, moderately disturbed and highly disturbed sites. The highly disturbed habitat was located on flat ground and at an average altitude of 12m. It is a marshy environment, located near the habitations, and characterized by human activities such as felling and banana plantations. The moderately disturbed habitat is far from habitat dwellings, on sloppy ground, with the bottom of the slope been inundated by water. And finally, the low disturbed habitat was close to the moderately disturbed environment with a relatively flat relief.

Each 1ha plot was further divided into five adjacent transects of 100 m x 20 m. In each transect, epiphytes were surveyed on trees with DBH ≥ 10 cm and the species were identified in the field using an identification key of reference manuals such as *Flore du Cameroun* [14], and *Manuel de botanique forestière*: *Afrique tropicale* [15]. Unidentified specimens were taken to the Laboratory of Plant Biology of the University of Douala, and further identified at the National Herbarium of Cameroon, for detailed analysis and taxonomic identification. The epiphytes life-forms were determined according to the methodology of Bogh [16]:

- True or strict epiphytes are species that normally spend their entire lifespan as epiphytes;
- Hemi-epiphytes are species without contact with the ground at the beginning of their life but which they establish later (primary hemi-epiphyte) or which break contact with the ground at the end of their life (secondary hemi-epiphyte);
- Casual epiphytes are species which are normally terrestrial plants, but which can grow on trees.

For the determination of the distribution of epiphytes on the host plant, each host plant was divided into four zones according to the Johansson's method [17] (Fig. 2) which include the: the Trunk Zone (TZ), Inner Crown Zone (ICZ), Middle Crown Zone (MCZ), and Outer Crown Zone (OCZ). The TZ refers to the host trunk areas below the first branch; the ICZ covers the area from the first branch to the second branch; the MCZ covers the area from the second branch to the third branch; and the OCZ refers to the remaining areas above the third branch.

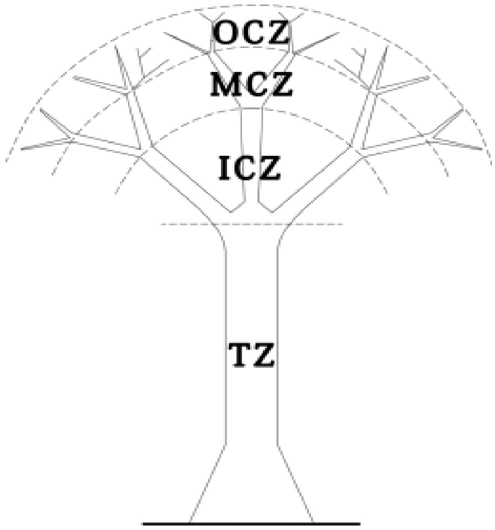

Figure 2. Diagram of the vertical zones of host tree where epiphytes are distribution. TZ: Trunk Zone; ICZ: Inner Canopy Zone; MCZ: Medium Canopy Zone; OCZ: Over Canopy Zone.

2.3. Statistical analyses

Non- parametric tests of Kruskal-Wallis were used to compare the average of specific richness of habitats across sites. Chi-square test was used to compare the relationship between epiphyte species richness and tree diameters were found for each of two sites and across the two sites. Host tree size was approximated using DBH, which also captures elements of the trees. ontogeny. Patterns of epiphyte species richness often change with the host tree's ontogenic stages [18, 19]; a regression equation using linear model was used to study the relationship of vascular epiphyte species richness and host DBH. All analyses were done at a 95% confidence level.

3. Results

3.1. Epiphytic species richness of the Douala-Edea National Park

An inventory of the epiphytic flora indicated 18 species belonging to 16 genera grouped into 13 families (Figure 3). The highest species occurrence did not exceed 50% in the study area. The most common species were *Culcasia* sp. P. Beauv. with 30.27% followed by *Cercestis* sp. Schott (16.5%), *Haumania danckelmaniana* (J. Braun and K. Schum) Milne-Redh (15.74%), and *Raphidophora africana* NE Br.(10.49%). Species with an occurrence under 1% were considered as rare species. There were five rare species, and the most rares were *Funtumia elastica* (Bent.) Stapf. (0.11%), *Campylospermum laxiflora* (De Wild and T. Durand) Tiegh. (0.22%) and Passiflora sp. L. (0.22%). Araceae recorded the highest number of species (4 species). Ferns were represented with four species and two families, and orchids were represented with one species.

Epiphytes species richness varied depending on habitats types. The low disturbed habitat showed the highest species richness with 13 species, followed by the moderately disturbed habitat with 11 species, and the highly disturbed habitat, with eight species. The highest abundance of epiphytes' individuals species was found in the low disturbed habitat which recorded 488 individuals (54.97%). It was followed by the moderately disturbed habitat with 184 individuals (20.65%), and the highly disturbed habitat with 219 individuals (24.58%). The number of species of Strict epiphytes were highest in the low disturbed habitat (6 species), followed by the moderately disturbed habitat (4 species), and the highly disturbed habitat, where no species were encountered. The number of species of hemi-epiphytes were highest in the highly disturbed habitat (8 species), followed by low disturbed habitat (7 species), and the moderately disturbed habitat, with six species. Only one species of casual epiphyte was recorded in the moderately disturbed habitat (Table 1).

(a) **(b)** **(c)**

Figure 3. Some epiphytes species of the study area. a: Bulbophyllum calamarium Lindl.; b: Culcasia sp P. Beauv.; c. Microgramma sp C. Presl.

Table 1. Epiphytic species richness of the Douala-Edea National Park.

Species	Families	Life-forms	LD	MD	HD	Occurrence (%)
Asplenium nidus L.	Aspleniaceae	S	+	+	-	6.89
Asplenium L.	Aspleniaceae	S	+	+	-	5.57
Bulbophyllum calamarium Lindl.	Orchidaceae	S	+	+	-	0.87
Campylospermum laxiflora (De Wild & T. Durand) Tiegh.	Ochnaceae	H	-	-	+	0.22
Cercestis dinklagei Eng.	Araceae	H	+	+	-	3.5
Cercestis Schott	Araceae	H	+	+	+	16.5
Culcasia P. Beauv.	Araceae	H	+	+	+	30.27
Ficus Tourn. ex L.	Moraceae	H	+	+	+	1.09
Funtumia africana (Bent.) Stapf.	Apocynaceae	C	-	+	-	0.11
Haumania danckelmaniana (J. Braun and K. Schum) Milne-Redh.	Marantaceae	H	-	+	+	15.74
Lomariopsis guineensis (Underw.) Alston	Lomariopsidaceae	H	+	-	-	3.28
Microgramma C. Presl	Polypodiaceae	S	+	+	-	0.55
Nephrolepis bisserata (Sw.) Schott	Dryopteridaceae	S	+	-	-	1.2
Passiflora L.	Passifloraceae	H	-	-	+	0.22
Piper L.	Piperaceae	H	+	-	-	1.97
Platycerium stemaria (P. Beauv .) Desv .	Polypodiaceae	S	+	-	-	0.33
Rhaphidophora africana N.E.Br.	Araceae	H	+	+	+	10.49
Stephania Kuntze.	Menispermaceae	H	-	-	+	1.2

C: Casual epiphyte; H: Hemi-epiphyte; S: Strict epiphyte; LD: low disturbed; MD: Moderately disturbed; HD: highly disturbed. + presence; - absence.

3.2. Diversity of Epiphytic host trees in the Douala-Edea National Park

The inventory of epiphytic host trees showed a total of 70 species belonging to 53 genera and 30 families. The Fabaceae and Mimosaceae represented 43.75% of the host trees species, followed by the Annonaceae and Olacaceae families which recorded four species each. Vascular epiphytes were not recorded on nine species belonging to the same number of families. A total of 538 individual host trees were recorded, for a total of 855 individuals in the different habitats, giving an epiphytic rate of 62.92%. *Staudtia kamerunensis* Warb. was the most abundant epiphytic host tree with 34 individuals. It was followed by *Strombosia grandifolia* Hook.f. Ex Benth. (31 individuals) and *Anthonotha macrophylla* P. Beauv. (30 individuals). Low disturbed habitat recorded the greatest number of host trees (254 individuals) than the moderately disturbed habitat (147 individuals) and the highly disturbed habitat (127 individuals).

The chi square test revealed a significant difference between the rate of epiphytism of low disturbed habitat (80.49%) and moderately disturbed habitat and highly disturbed habitat (k = 70.39; p< 0.0001). The most common epiphytic host trees in the low disturbed habitat were *S. grandifolia* (31 individuals), *Dasylepis thomasii* L. (29 individuals) and *Afrolicania elaeosperma* Mildbr. (27 individuals). In the highly disturbed habitat, the most common epiphytic host trees were *Anthonotha lamprophylla* (Harms) J. Leonard (23 individuals) and *S. kamerunensis* (22 individuals). And in the moderately perturbed habitat, the most common epiphytic host trees were *Diospyros crassifolia* L., GE Schatz and Lowri (21 individuals), *A. macrophylla* (18individuals) and *Macaranga spinosa* Mull. Arg. (14 individuals) (Table 2).

Figure 4 shows epiphytic species richness and abundance of host trees. The highst epiphytic richness was obtained in *Lophira alata* Banks ex C.F. Gaertn. (S= 10, n= 35) and *S. kamerunensis* (S= 10, n= 60), while the highest epiphytic abundance was obtained on *S. kamerunensis, Afrolicania eleosperma,* and *Strombosia grandifolia.* They were followed by three species, *A. elaeosperma* (S= 9, n= 56), *Coula edulis* Baill. (S= 9, n= 29), and *Klainedoxa gabonensis* Pierre ex Engl. (S= 9, n= 30). Species with the most epiphytic abundance was *S. grandifolia* (n= 61), hosting seven epiphytes species.

Table 2. Host trees and their epiphytic abundance in the Douala-Edea National Park

Species	Families	No. of individuals sampled				No. of individuals hosting epiphytes			
		LD	MD	HD	overall	LD	MD	HD	overall
Afrolicania elaeosperma Mildbr.	Chrysobalanaceae	30	0	0	30	27	0	0	27
Afrostyrax kamerunensis Perkins & Gilg	Huaceae	4	0	0	4	3	0	0	3
Afzelia Africana Sm. ex Pers.	Fabaceae	2	0	0	2	0	0	0	0
Albizia glaberrima (Schumach. & Thonn.) Benth.	Mimosaceae	19	0	0	19	13	0	0	13
Alsodeiopsis weissenborniana J. Braun & K. Schum	Icacinaceae	3	1	3	7	3	1	3	7
Annickia chlorantha (Oliv.) Setten & Maas	Annonaceae	0	8	2	10	0	5	1	6
Annonidium manii Oliver.	Annonaceae	0	0	2	2	0	0	0	0
Anthocleista sp Afzel. Ex R.Br.	Loganiaceae	0	0	3	3	0	0	2	2
Anthonotha lamprophylla (Harms) J. Leonard	Fabaceae	0	8	38	46	0	6	23	29
Anthonotha macrophylla (P. Beauv.	Fabaceae	0	36	28	64	0	18	12	30
Antiaris toxicaria (J.F. Gmel.) Lesch.	Moraceae	4	14	0	18	4	7	0	11
Baillonella toxisperma Pierre	Sapotaceae	0	0	6	6	0	0	2	2
Baphia Afzel. ex G. Lodd.	Fabaceae	0	2	12	14	0	0	8	8

Berlinia Sol. ex Hook.f. & Benth.	Fabaceae	0	0	1	1	0	0	1	1
Blighia K.D. Koening	Sapindaceae	1	0	0	1	1	0	0	1
*Brachystegia milbraedii*Harms	Fabaceae	5	0	5	10	4	0	2	6
Carapa Aubl.	Meliaceae	0	5	0	5	0	2	0	2
Cleistopholis Pierre ex Engl	Annonaceae	1	0	0	1	1	0	0	1
Cola acuminata (P. Beauv.) Schott &Endl.	Sterculiaceae	23	0	0	23	19	0	0	19
Cola mahoundensis Pellegr.	Sterculiaceae	0	0	1	1	0	0	0	0
Coula edulis Baill.	Olacaceae	19	0	0	19	16	0	0	16
Dasylepsis Thomasii Obama & Breteler	Achariaceae	35	0	0	35	28	0	0	28
Dialium L.	Fabaceae	0	8	16	24	0	4	8	12
Dichostemma glaucescens Pierre	Apocynaceae	0	2	5	7	0	1	2	3
Didelotia africana Baill.	Mimosaceae	0	10	4	14	0	8	1	9
Diospyros crassifolia Linan, GE Schatz and lowry	Ebenaceae	0	37	0	37	0	21	0	21
Diospyros hoyleana F. White	Ebenaceae	1	21	3	25	1	8	3	12
Distemonanthus benthamianus Baill.	Fabaceae	1	0	0	1	1	0	0	1
Entandrophragma angolensis (Welw.) C. DC.	Meliaceae	4	0	0	4	1	0	0	1
Entandrophragma utile (Dawe & Sprague) Sprague	Meliaceae	1	0	0	1	1	0	0	1
Erythroxylum manii Oliver.	Erythroxylaceae	0	2	0	2	0	0	0	0
Funtumia africana (Benth.) Stapf	Apocynaceae	0	17	18	35	0	9	4	13
Funtumia elastica (Preuss) Stapf	Apocynaceae	12	0	0	12	7	0	0	7
Gilletiodendron pierreanum (Harms) J. Leonard	Caesalpiniaceae	11	0	0	11	10	0	0	10
Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill.	Irvingiaceae	10	0	0	10	9	0	0	9
Irvingia grandifolia (Engl.) Engl.	Irvingiaceae	0	1	0	1	0	1	0	1
Klainedoxa gabonensis Pierre ex Engl.	Irvingiaceae	6	0	0	6	6	0	0	6
Lophira alata Banks ex C.F. Gaertn.	Ochnaceae	1	5	7	13	1	4	6	11
Macaranga spinosa Mull. Arg	Euphorbiaceae	0	34	0	34	0	14	0	14
Magnistipula glaberrima Engl.	Chrysobalanacea e	0	0	1	1	0	0	0	0
Mamma africana Sabine	Clusiaceae	0	1	0	1	0	1	0	1
*Manilkara fouilloyana*Aubrév. & Pellegr.	Sapotaceae	15	0	0	15	12	0	0	12
Memecylon arcuatomarginatum Gilg ex Engl.	Melastmataceae	0	0	1	1	0	0	1	1
Musanga cecropioides R. Br. ex Tedlie	Urticaceae	0	3	0	3	0	2	0	2
Mitragyna stipulosa (DC.) Kuntze	Rubiaceae	3	0	1	4	0	0	1	1
Nauclea diderrichii (De Wild.) Merr.	Rubiaceae	0	0	4	4	0	0	3	3
Nauclea pobeguinii (Hua ex Pobég.) Merr.	Rubiaceae	1	0	0	1	1	0	0	1
Ochna L.	Ochnaceae	0	18	13	31	0	9	6	15
Pancovia laurentii (De wild.) Gilg ex De Wild	Sapindaceae	1	0	0	1	0	0	0	0
Panda Oleosa Pierre	Pandaceae	6	0	0	6	6	0	0	6
Pentaclethra macrophylla Benth.	Fabaceae	0	13	0	13	0	7	0	7
Piptadeniastrum africanum (Hook.f.) Brenan	Mimosaceae	2	0	0	2	2	0	0	2
Polygala parviflora Poir.	Olacaceae	1	0	0	1	0	0	0	0
Pycnanthus angolensis (Welw.) Warb.	Myristicaceae	0	2	3	5	0	1	1	2

Ricinodendron heudelotti (Baill.) Pierre ex Heckel	Euphorbiaceae	2	0	0	2	2	0	0	2
Rinorea oblongifolia (C.H. Wright) C. Marquant ex Chipp.	Violaceae	0	0	3	3	0	0	0	0
Staudtia kamerunensis Warb.	Myristicaceae	16	3	34	53	12	0	22	34
Stemonocoleus micranthus Harms	Fabaceae	12	0	0	12	6	0	0	6
Strombosia grandifolia Hook.f. ex Benth.	Olacaceae	33	0	0	33	31	0	0	31
Strombosia scheffleri Eng.	Olacaceae	7	0	0	7	7	0	0	7
Strombosia zenkeri Engl.	Olacaceae	18	0	0	18	17	0	0	17
Symphony globulifera L. f.	Clusiaceae	2	0	0	2	1	0	0	1
Tabernaemontana Plum. ex L.	Apocynaceae	0	4	15	19	0	2	7	9
Terminalia superba Eng. & Diels	Combretaceae	0	1	0	1	0	1	0	1
Treculia africana Decaisne ex Trecul.	Moraceae	6	0	0	6	4	0	0	4
Uvariodendron (Engl. & Diels).R.E.FR.	Annonaceae	0	0	14	14	0	0	6	6
Vepris hiernii Gernii	Rutaceae	0	0	1	1	0	0	0	0
Vitex ferruginea Schumach. & Thonn.	Verbenaceae	0	11	0	11	0	8	0	8
Vitex L.	Verbenaceae	0	14	2	16	0	7	2	9
Xylopia acutiflora (Dunal) A. Rich.	Annonaceae	10	0	0	10	7	0	0	7
Total		328	281	246	855	264	147	127	538

LD: Low disturbed; MD: Moderately disturbed; HD: Highly disturbed

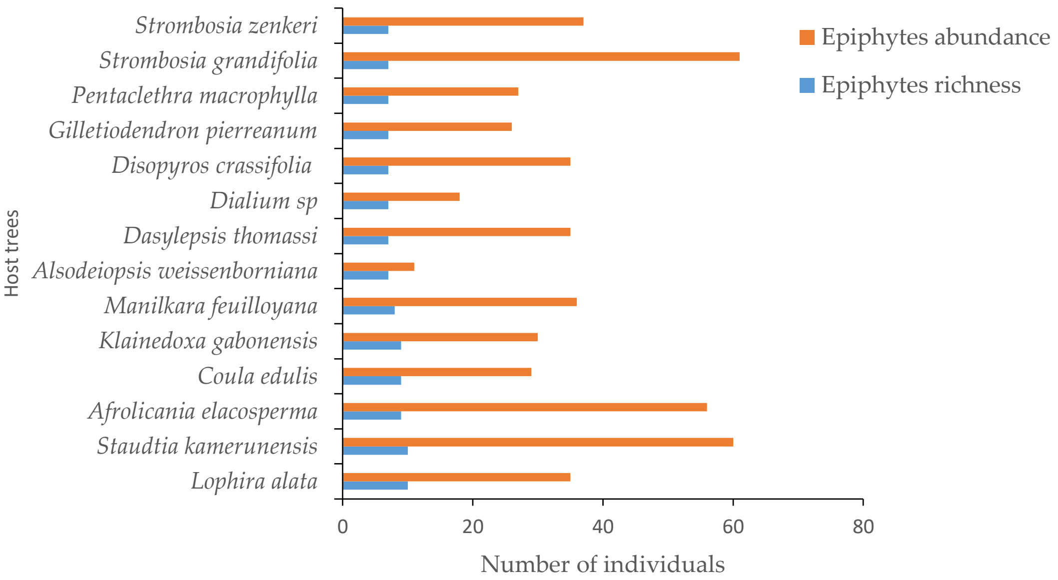

Figure 4. Epiphytic abundance of host trees in the Douala-Edea National Park

3.3. Distribution of epiphytes on host trees in the Douala-Edea National Park

Variation of the host tree species richness of epiphytes across the three types of habitats was significant between the trunk zone (k=30.9, ddl =3, p<0.0001) and inner canopy zone (S=1.29±0.52), medium canopy zone (S=1.24 ±0.4), and over canopy zone (S=1.13±0.36) (Table 3). Variation of the vertical distribution of epiphyte species richness in each habitat was not significantly different.

Figure 5 illustrates the solicitation of fixation zones by the epiphytes in the different habitats. There is an ascending gradient for Trunk zone occupation from the low disturbed habitat (33.75%) to moderately disturbed habitat (50.15%) and highly disturbed habitat (69.34%). The Inner canopy zone was most solicited in the low disturbed habitat (29.37%), and least solicited in the highly disturbed habitat (20.58%). There was also an ascending gradient of the over canopy zone occupation, from the highly disturbed (1.92%), moderately disturbed (4.75%) and low disturbed habitats (13.75%).

Table 3. Epiphytic richness of the fixation zones of hosts trees

Fixation zones	Min.	Max.	Mean±SD	K	ddl	p
TZ	1	5	1.35±0.62	30.910	3	<0.001
ICZ	1	4	1.24±0.52			
MCZ	1	3	1.13±0.4			
OCZ	1	3	1.11±0.36			

TZ : Trunk zone ; ICZ : Inner crown zone ; MCZ : Medium crown zone ; OCZ : Over crown zone

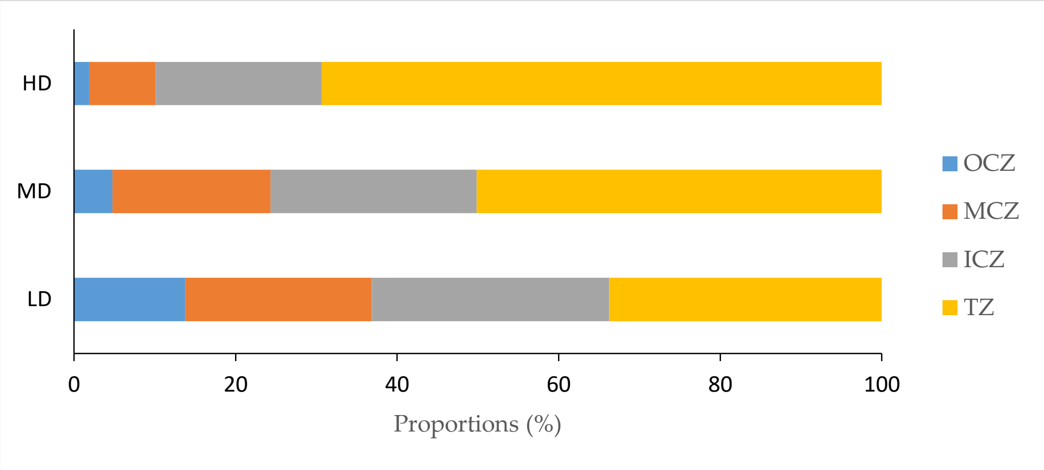

Figure 5. Fixation zones solicitations (%) of host trees by epiphytes species in each habitat type. Low disturbed (Ld), moderately disturbed (MD), and high disturbed (HD).

3.4. Relationships between vascular epiphyte species richness and host tree diameter

The epiphytic species richness was not significantly related to host tree DBH when species were analysed separately. However, the epiphytic species richness increased significantly with host tree DBH when species were grouped (F=7.33, ddl =1, p=0.01) (Figure 6).

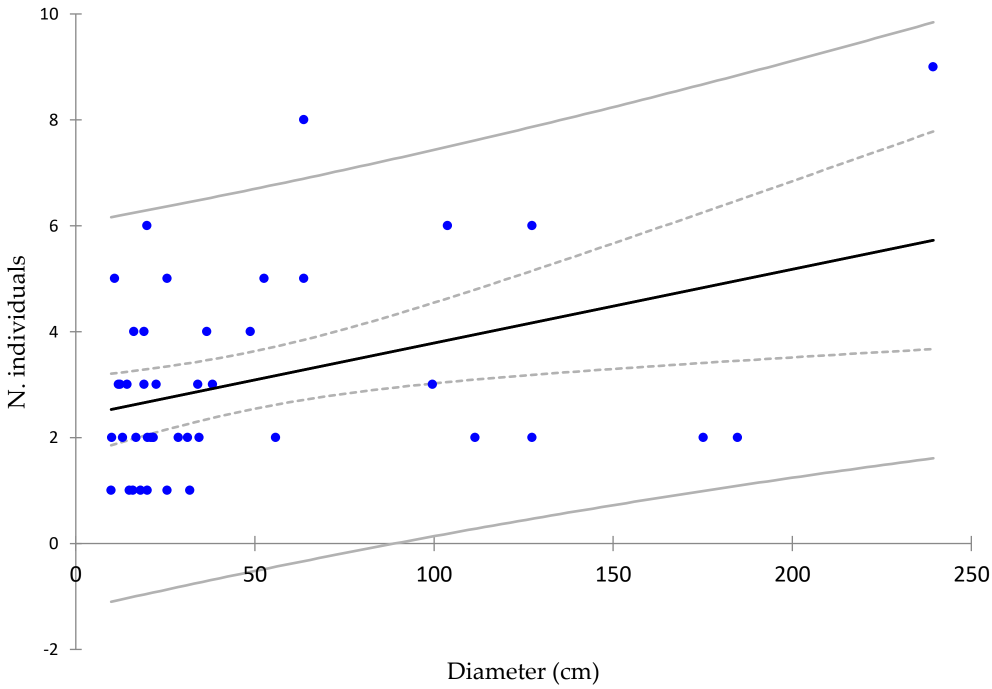

Figure 6. Linear regression between abundance of epiphytes and host trees diameter in the Douala-Edea National Park.

3.5. Correlations between epiphytes species, number of host tree species, and habitat

The host trees (F= 2.09; ddl = 87; p< 0.0001), habitat type (F= 2.11; ddl = 67; p< 0.0001) and their interaction (F= 14.18; ddl = 3; p< 0.0001) had significant effects on the composition of the vascular epiphytes in the forest of the Douala-Edea National Park. Variation in the composition of epiphytes was explained more by the interaction between plant species and habitat (28.7%) than the host species (23.1%). Habitat recorded less contribution (5%) in the variation of vascular epiphytes.

4. Discussion

The inventory of vascular epiphytes revealed 18 species in the study area. They were divided into three groups which comprise of: strict epiphytes, hemi-epiphytes, and casual epiphytes. *Culcasia* sp., which is in the Araceae family, had the highest frequency of occurrence. *Bulbophyllum calamarium* Lindl. was the only Orchidaceae species found in the study site. In the montane forests of the Korup National Park, there were 154 epiphytes species, where the Orchidaceae family was the most common family with 66% of frequency of occurrence [4]. A total of 35 species was found in the southern China, with orchids and pteridophytes dominating [17]. In Democratic Republic of Congo, there were 61 species belonging to 34 families. Epiphytes have a large distribution around the world, reaching a proportion of 30% in the Neotropical forests. However, these sites have a relatively high number of epiphytic species especially the Korup National Park which is undisturbed thus indicating that the level of disturbance has an influence on the occurrence of epiphytes especially in the Orchidaceae family. African forests contain half of epiphytes diversity, dominated by the Ferns. More than 80 Angiosperms families belong to epiphytes species, like Cactacaeae, Ericaceae, Gesneriaceae, Melastomataceae, Piperaceae, Rubiaceae, Bromeliaceae and Orchidaceae [20]. From an environmental point of view, orchids can be useful in the identification of areas of endemism, and their pattern showed that they can be used as indicators of areas with high diversity [21]. The low

Orchidaceae richness observed in the DENP therefore suggests that this ecosystem has low diversity, which is abnormal, because tropical forests are characterized by high biodiversity. Although tropical forests are characterized by high diversity, a low diversity in this study indicates the effects of disturbance in tropical forests. In Cameroon, the Rubiaceae and Orchidaceae family together represent 10 to 15% of the flora of this country. Some of them have a restricted distribution or are known only from a small number of collections, or even only from the type specimen [22].

This can be confirmed by the fact that in the inventories carried out, there was a higher frequency of occurrence of epiphytes in the low disturbed habitat compared to the moderately and highly disturbed habitat. Likewise, there also was significantly more epiphyte species ($P< 0.0001$) in the low disturbed habitat than the moderately and high disturbed habitat. It thus means that habitat have a significant role in determining epiphyte composition of an ecosystem. This is similar to the results obtained by [23] who indicated a significant difference in the composition of vascular epiphytes in secondary forest than in the cultivated forest, reflecting the varying degree of ecosystem disturbance. A study that directly compared epiphyte communities in 40-year old and secondary forests in the Dominican Republic found a diversity of epiphyte life forms, species richness and abundance were higher in old growth forests [24]. Epiphytes, as vulnerable as they are known to be, can serve as a good indicator group of biodiversity that can be monitored to assess the effects of forest disturbance [25]. In the case of this study, the degradation of the environment increases the flow of light in the undergrowth, and thus favors the appearance of non-specialist species such as hemi-epiphytes and casual epiphytes on host trees. Factors such as light, water, and substrate conditioned the presence of epiphytes on trees. For example, the epiphytes encountered in the Azagny National Park were mainly linked to wetlands [26].

The Araceae family was the dominant family with four species inventoried, namely *Cercestis dinklagei* Eng., *Cercestis* sp. Schott, *Culcasia* sp., and *R. africana*. It differs from the results obtained in the montane forests of Korup National Park, where Orchidaceae showed a dominance over epiphytic flora with 66%of species [4]. Lowland forests generally have less epiphytes richness than montane forests which have adequate conditions such as altitude, rainfall and humidity for the installation of epiphytes. The Ferns identified in the study area essentially occupied the lower strata and occurred only in the moderately and highly disturbed habitats which showed signs of anthropization. Ferns have been identified as bio-indicators of changes of forest structure in the mountain ecosystem of the Kahuzi-Biega National Park in eastern DRC [27].

The Trunk zone had more epiphytes species in the highly disturbed habitats, and canopy was more solicited in the low disturbed habitat. The level of degradation as well as the light intensity would be responsible for the poor richness of the canopy in epiphytes. Indeed, low luminosity associated with high humidity are the factors favoring the installation of epiphytes, especially in tropical mountain forests. An increasing gradient of epiphytes from the crown to the trunk was found in a montane forest, while the canopy was richest in epiphyte species [16, 28]. This demonstrates the specificity of each forest ecosystem based on environmental parameters on the vertical distribution of epiphytes. Water dependence is also a common criterion for the distribution of epiphytes on forest strata. The units used by Schnell classification are (i) the hygrophilic epiphytes of the base of the trunks, (ii) the hygro-mesophilic epiphytes of the middle region of the trunks, (iii) the mesophilic epiphytes of the large branches and the top of the trunks of large trees, and (iv) the xerophilic epiphytes of the upper branches [29]. This therefore means that the environmental conditions of DENP allow the development of hygro -mesophilic and mesophilic species.

There was a significant increase of species richness and host tree diameter across the species habitat type, and no significant relation between specific richness and host tree DBH for each species. This might be because ontogenic parameters aren't a condition for the installation of epiphytes species on trees. Their installation depends on ecological parameters, regardless of host species. Wang [16] explained that the increases in epiphyte species richness with DBH by the increase of area for epiphyte colonization and growth, coupled with increased exposure to epiphyte propagule rain over the course of a longer host tree life. This pattern may also result from the diversity in micro environments available on larger tree trunks [30, 31]. The solicitation of canopy by vascular epiphytes was declined with the level of disturbance of the habitat. Exposure to winds will naturally increase with tree height, further adding to the potential for epiphytes growing closer to the tops of trees to experience greater water evaporation. Thus, the lower light intensity and higher humidity in the understory compared to the crown layers are more favourable for the growth of epiphytes [28, 32]. This could explain the higher epiphytic richness of trunk zone than in the outer crown zone of host trees in the different sites. Essentially, the forest could serve as a seed source of epiphytes to other forests.

5. Conclusion

The disturbed habitat of the Douala-Edea National Park's epiphytic flora had more hemi-epiphytes species than Ferns and Orchids. Then, hemi-epiphytes seemed to be characteritic of a disturbed habitat. The level of the disturbance of the habitat affects the epiphytic richness of the park, particularly strict epiphytes. Host trees were diversified, and a gradient of increasing number of epiphytes species with the trunk circumference of host plant was observed. The level of the disturbance had a significant role in the vertical distribution of epiphytes on host trees, the canopy had more epiphytes than trunk in the low disturbed habitat. Further research should be carried out on the biology of strict epiphytes to ensure their conservation.

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