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Diversity Of Epiphytic ferns in the cross river national park, Akamkpa, Nigeria as indicators of forest disturbance

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Abstract

Epiphytic ferns are autotrophic plants that are essential and delicate members of humid forests, such that their diversity can be adversely affected by any form of disturbances in the forests. Generally, their diversity is greater in the primary forest than in disturbed habitats. Thus, the diversity of epiphytic ferns at the core and buffer zone of the Cross River National Park (CRNP), Akamkpa, Nigeria was investigated. In each study site, 10 (20 × 20m) plots were marked out and sampled taking into account (trees with epiphytic ferns, canopy type, bark texture, girth at breast height (GBH), and the presence or absence of grooves on trees). The statistical analysis showed a positive correlation (r = 0.67 and 0.68) in the epiphyte diversity between the core and buffer zone. Six species of epiphytic ferns (*Asplenium nudas*, *Phloebodium aureum*, *Platycerium coronarium*, *Drynaria laurentii*, *Nephrolepsis biserrata* and *Cyathea cooperi*) were recorded in both study sites. Trees with rough bark texture had a higher number of epiphytic ferns than those with smooth bark. The ferns were mostly attached to the trunk (35) followed by the joint between the branch and trunk (15) and the primary branch (6). The low diversity of epiphytic ferns in the core zone of the CRNP is an indicator of forest disturbance.

Keywords: Akamkpa, Cross river national park, diversity, epiphytic ferns, forest disturbance, Nigeria

Introduction

Forest habitats are known to man as a bank of biological diversity and life forms. These different life forms live together and interrelate to form communities (WWF, 2005). Such interrelationships may be an interaction between two different organisms living in close physical association, the interaction between individuals of different species that results in beneficial effects or parasitic and competition amidst species with complementary ecological needs. Several countries have quested to protect and preserve biodiversity by instituting National parks and protected reserves, Nigeria including (Aju and EzeIbekwe, 2010). Cross River National Park (CRNP) in Nigeria is not just one of the 25 biodiversity hotspots in the world but is also looked on as a center of a species being found in a single defined geographic location (Aju and EzeIbekwe, 2010). Gloomily, current reports denote that the park may be undergoing some level of disruptions (Ijeomah *et al.*, 2015).

Forest disruption or disturbance touches on or upon at any activity that does not lead to total riddance of the forest cover but produces an effect upon some or all species disturbed. The level of disruption differs broadly from more than half of the tree cover detached, to the congregation of unobtrusive non-timber species (Bellard *et al*, 2012). For a long time, human reliance on forest resources for timber, fuel wood, construction, and broad purposes have strongly affected forest habitats, leading to more open forests with smaller trees, herbs, and grasses (Barthlott *et al.*, 2001). In addition, grazing and browsing of plants have degraded the forest environments.

Epiphytic ferns (Pteridophytes) are autotrophic plants that grow interdependently on another plant and obtain water and nutrients from the atmosphere and other decomposing plant remains around it (Gotsch *et al.*, 2015). They grow naturally on tree tops fastened to trunks, branches, and leaves of higher plants overhead ground level, where powerful lighting provides recompense for lack of soil (Alpert, 2000; Andama *et al.*, 2003; Hietz *et al.*, 2006). Several epiphytic ferns fasten to trunks and branches of trees, for instance, epiphytic ferns such as *Drynariala urentii* have dense, short, or long-trailing stems. Often the stems are fastened to the host tree species, though in infrequent cases the stems may start on the ground. Epiphytic ferns have exceptional or distinctive fronds that are characteristically modified to capture detritus as the source of nutrients for the ferns (Hietz *et al.*, 2006). Epiphytic ferns are species that rely on their host only for structural support, in so doing, they give back to the ecosystem by, obtaining light and photosynthesizing to manufacture energy, prorating nutriment, and accommodation for several small faunal species living on the tree tops, (e.g. insects, beetles birds, lizards) (Hietz *et al.*, 2006). Epiphytic ferns are mostly found in the tropics. Epiphytic ferns are necessary and fragile members of humid forests, such that their diversity can be seriously affected by any form of disruption in the forests (Hietz *et al.*, 2006). Normally, epiphytic fern diversity is higher in the primary forest than in disrupted habitats (Hickey, 1994). Epiphytic ferns are found beneath the tree canopy where the leaves are sparse, therefore allowing enough streams of sunlight to reach the ferns (Hickey, 1994). Hence, epiphytic ferns can withstand short periods (15-30 minutes) of full sun but favor powerfully sieved or reflected sunlight all-round the day. Epiphytes have exceptional adaptation such as stick-to or other modes of fastening to host tree trunks or branches, impeding wind and other natural elements from striking them down. This ensures their existence at the canopy level (Kromer *et al.*, 2007).

According to Oldekop *et al.*, (2012) "epiphytic ferns can act as likely indicators of forest disruptions, and keeping traces of the changes in the epiphyte community through ecological monitoring is an essential aspect in tropical rain forest management and could offer indications on ecological changes that are occurring within the forest ecosystem." It is evident or apparent that epiphytes give back to the ecosystem by contributing to worldwide species diversity. As observed by Oldekop *et al.*, (2012) epiphyte diversity grows with forest maturity and drop or lessen with habitat segmentation and is contemplated as a robust indicator of forest climax since their existence relies on forest structure, composition, and level of disruption or disturbance.

The enlarged population in Nigeria and the high level of poverty have resulted in an equivalent increase in the level of dependability on forest resources like timber and general farming activities. Accordingly, disruptions such as deforestation, bush burning, oil spillage, and increased anthropogenic activities have led to a drop in forest species composition, general productivity and wildlife, desert encroachment, erosion, and global warming (Callaway *et al.*, 2002). Also, Cross River National Park while it holds diverse flora and fauna species lacks an adequate monitoring scheme. Entrenched within this park are vital species like vascular epiphytes that can be used extensively in monitoring the level of disturbances (Callaway *et al.*, 2002; Cardelus *et al.*, 2006). Sadly though, no such scheme currently exists in the CRNP indelibly posing a threat to incumbent native and endemic species found therein. In view of the foregoing, this study assessed the diversity and distribution of epiphytic ferns in the Cross River National Park (Buffer and Core Zones) as indicators of forest disturbances.

Materials and methods

Study Area

The study was carried out in the Oban West Division of the Cross River National Park (CRNP), Nigeria between the months of March to Aril, 2016. The Cross River National Park covers a total area of 3000 km^2

centred between latitudes 4.54 and 5.45 and longitudes 8.18 and 8.50 (Margaret, 2015). The Oban division of the CRNP shares a long border with Korup National Park in the Republic of Cameroon, forming a single protected ecological zone (Aigbe and Omokhua, 2015). The division has a rugged terrain, rising from 100 m in the river valleys to over 1,000 m in the mountains. The rainy season starts in March and ends in November, with an annual rainfall of over 3,500mm (Adeyemi *et al.,* 2015). The northern part is drained by the Cross River and its tributaries. The southern parts are drained by the Calabar, Kwa and Korup rivers (Aju and EzeIbekwe, 2010) (Figure 1). Two (2) sites were chosen to compare the diversity and abundance of epiphytic ferns; the Core zone and the Buffer zone. The delineated study area covers about 18 km^2 in area, centred between latitudes 5.3587106' and 5.4591936 and longitudes 8.2899157 and 8.3525793. The core zone of the CRNP is the undisturbed primary forest delineated for the conservation of wildlife and near threatened flora species. This area is usually closed to tourist, and the locals. Human activities are prohibited in such areas by the Nigerian conservation laws. The buffer zone section of the CRNP is considered highly disturbed as it is open to the locals for logging, and other small scale agricultural activities. Tourists, researchers and students have free access to this part of the park. The periphery is open to illegal extraction of woods.

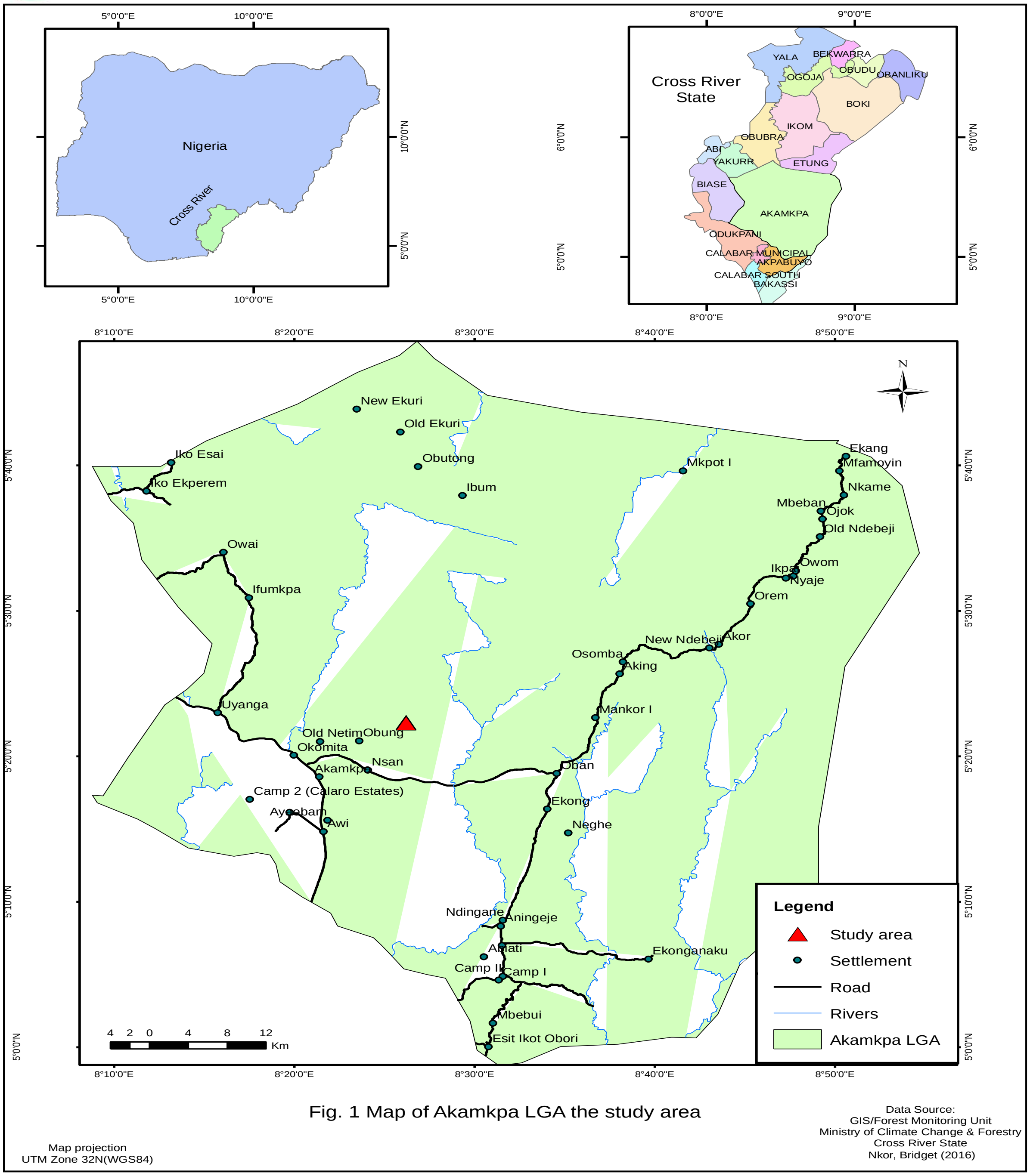

Figure1. Map of Akamkpa LGA showing the study area

Source: GIS/Forest Monitoring Unit Ministry of Climate Change and Forestry, Cross River State, Nigeria

Study design

Two (2) study sites, with 10 plots each laid out in a randomized complete block design were used. Ten plots (20m x 20m) were sampled systematically along a line transect at 10m intervals in each site (Figure 2).

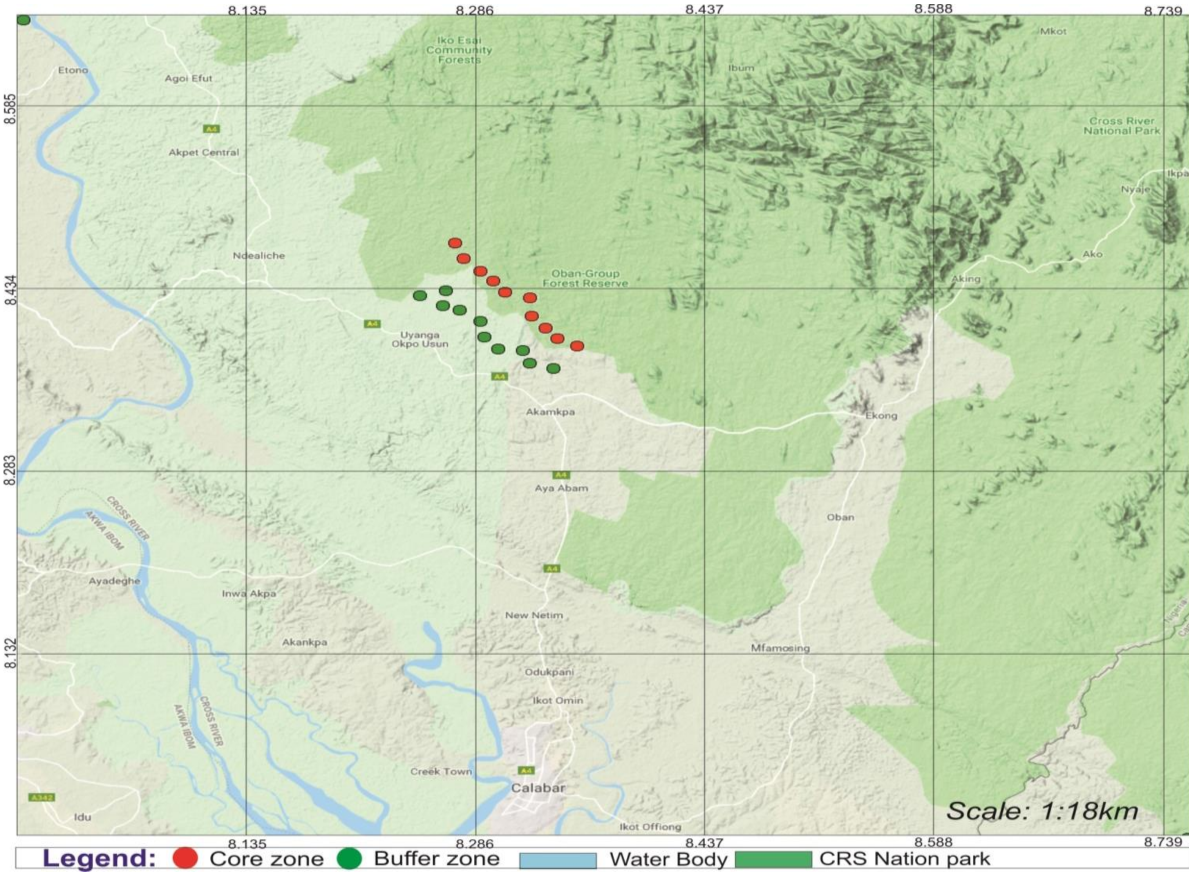

Figure 2.

Map of study area showing location of sampled plots

Source: Google Satellite Map

Sampling technique

The belt transect method was employed for the field survey as adopted by Fewson *et al.* (2005). A 200m^2 area was mapped out for each study site representing disturbed and natural vegetation. At each study site, 10 (20m x 20m) plots with relatively closed trees were delineated with a line transect and used for the study. Sampling was done between March and April 2016 just before the rain to enable accessibility and visibility.

Tree distribution

The field survey was carried out to estimate the number of trees with epiphytic ferns. The trees were surveyed for the presence or absence of grooves, the canopy type, plant height, girth at breast height (GBH), and presence and number of tree stumps. In each plot, all tree species with girth at breast height (GBH) above 30 cm were sampled for the study. The total number of trees in each plot was assessed and each species' frequency of occurrence and abundance were determined. The trees were observed for: their bark texture, presence or absence of epiphytic ferns; presence or absence of grooves and man-made cuts. Total plant height was measured using a Haga altimeter (West, 2009) while tree girth was measured using a measuring tape. Canopy type was categorized for each tree based on tree height; as sub-canopy level (less than 21m), high canopy level (21-40m) and emergent level (more than 40m).

Distribution of epiphytic ferns

Epiphytic ferns on trees were collected noting their points of attachment to the trees (on branches, main trunk, grooves and man-made cuts). All the species within reach were collected while the ones around the canopy were photographed as voucher specimens and taken to the Herbarium section of the Department of Plant and Ecological Studies, the University of Calabar for identification.

Data analysis

All data in this study were analyzed statistically using the Paleontological Statistical Software (PAST) and Statistical Package for Social Sciences (SPSS) at 5% probability ($p<0.05$) level. Tree species with epiphytic ferns in both study sites were computed and abundance were estimated using Shannon Weiner and equitability indices to compare the diversity of tree species between the core and buffer zone. Trees with epiphytic ferns were grouped according to gbh class sizes of tens from 31 cm to 100 cm and compared between the core and buffer zones using a one-way analysis of variance (ANOVA). This was employed in defining the class with higher epiphyte attachment. Canopy type was evaluated as the closed, high, and emergent canopy and analyzed with one-way ANOVA. The total number of epiphytic ferns individuals was estimated in the two sites. Shannon Weiner and equitability indices were used to compare the diversity of epiphytic fern species between core and buffer zone. Sites of attachment of ferns were categorized and compared between the two study sites using a one-way ANOVA. The presence or absence of grooves/cuts on trees with ferns was also contrasted for the two study sites with a one way ANOVA. The relationship between occurrence of epiphytic ferns and tree size (gbh); grooves or cuts and canopy type were determined using Pearson moment correlation.

Results

Tree species with epiphytic ferns in the study sites

The tree species with epiphytic ferns based on the sampled plots in each study site are presented in Tables 1 and 2. Twenty-two tree species hosted ferns in the core zone (Table 1) while thirteen species hosted ferns in the buffer zone (Table 2).

Table 1. Tree species with epiphytic ferns in the core zone

S/N	Scientific name	Family
1.	*Albizia ferruginea* (Guill & Perr.) Benth.	Fabaceae
2.	*Baphia nitida* Lodd.	Fabaceae
3.	*Calpocalyx cauliflorus* Hoyle.	Fabaceae
4.	*Parkia bicolor* A.Chev.	Fabaceae
5.	*Piptadeniastrum africana* (Hook.f.) Brenan	Fabaceae
6.	*Pterocarpus osun* Craib.	Fabaceae
7.	*Alstonia boonei* De wild.	Apocynaceae
8.	*Cleistopholis patens* (Benth.) Engl. &Diels.	Annonacea
9.	*Irvingia gabonensis* (Aubry-lecomte ex O'Rorke) Baill.	Irvingiaceae
10.	*Klainedoxa gabonensis* Pierre	Irvingiaceae
11.	*Cola acuminata* Schott & Endl.	Sterculiaceae
12.	*Combretodendron macrocarpum* (P.Beauv.)	Lecythidaceae
13.	*Coula edulis* Baill.	Olacaceae
14.	*Diospyros ferrea* (Willd) Bakh.	Ebenaceae
15.	*Entandrophragma utile* Sipo (Dawe & Sprague) Sprague	Meliaceae
16.	*Guarea cedrata* (A.Chev.) Pellegrin	Meliaceae
17.	*Musanga cecropioides* R.Br & Tedlie	Moraceae
18.	*Pycnanthus angolensis*(Welw.) Warb	Myristicaceae
19.	*Stuadtia stipitata* (Warb.) Warb.	Myristicaceae
20.	*Strombosia pustulata* Oliv.	Olacaceae
21.	*Treculia obovoides* N.E. Br.	Moraceae
22.	*Uapaca guineensis* Mull. Arg.	Euphorbiaceae

S/N = Serial number

Table 2. Tree species with epiphytic ferns in the buffer zone

S/N	Scientific name	Family
1.	*Albizia ferruginea* (Guill & Perr.) Benth.	Fabaceae
2.	*Parkia bicolor*A.Chev.	Fabaceae
3.	*Anthocleista vogelii* Planch.	Gentianaceae
4.	*Cleistopholis patens* (Benth.) Engl. &Diels.	Annonacaea
5.	*Xylopia aethiopica* (Dunal) A. Rich.	Annonacaea
6.	*Entandrophragma utile* Sipo (Dawe & Sprague) Sprague	Meliaceae

7.	*Irvingia gabonensis* (Aubry-lecomte ex O'Rorke) Baill	Irvingiaceae
8.	*Lophira alata* Banks ex Gaertn.	Ochnaceae
9.	*Afzelia africana* Sm.	Fabaceae
10.	*Newbouldia laevis* Seem.	Bignoniaceae
11.	*Alstonia congensis* Engl.	Apocynaceae
12.	*Pycnanthus angolensis* (Welw.) Warb	Myristicaceae
13.	*Coula edulis* Baill.	Olacaceae

S/N = Serial Number

Diversity indices of tree species with epiphytic ferns between the core and buffer zone

The Shannon Weiner (H) and equitability (E) index was used to compare the diversity of tree species with epiphytic ferns between the core and buffer zone. The result of the analysis shows that the core zone had a higher H index of 4.02 compared to the buffer zone with H=2.52 while the buffer zone had a higher equitability index of 0.9834 compared to the core zone with E=0.9609 (Table 3). The low H index and higher equitability index of the buffer zone is an indication of less number of trees as compared to the core zone which had more trees.

Table 3. Diversity of tree species and epiphytic ferns between core and buffer zone

Tree species diversity between core and buffer zone		
Diversity indices	**Core zone**	**Buffer zone**
Shannon Weiner index (H)	4.021	2.522
Equitability index (E)	0.9609	0.9834
Epiphytic ferns diversity between core zone and buffer zone		
Diversity indices	**Core Zone**	**Buffer zone**
Shannon Weiner index (H)	1.75	1.67
Equitability index (E)	0.9630	0.8851

Canopy type

Canopy types of tree species with epiphytic ferns are presented in (Table 4). Three canopy types; high canopy, sub-canopy and emergent canopy tree species with epiphytic ferns were observed in the core zone with seventeen (17), three (3) and two (2) tree species respectively while two canopy types; high canopy and sub-canopy were observed in the buffer zone with one (1) and twelve (12) tree species respectively.

Table 4. Canopy types of tree species with epiphytic ferns in the study sites

S/N	**Canopy type**	**Core zone**	**Buffer zone**
		Number of species	**Number of species**
1	High canopy level	17	1
2	Sub-canopy level	3	12
3	Emergent level	2	0
Total		22	13

S/N=Serial number

Girth at breast height (GBH) of trees with epiphytic ferns

The results of GBH of tree species with epiphytic ferns in the core and buffer zone are presented in Figure 3. For the core zone, the GBH class size of 41-50cm had the highest distribution, this was closely followed by 31-40 cm, 51-60 cm, 61-70 cm, 71-80 cm, and >100 cm respectively. The buffer zone, however, had most of the species distributed within 31-40 cm and 41 –50 cm class sizes respectively. At 31-40 cm gbh class size, the core and buffer zone recorded 6 tree species each, while at 41-50 cm, the core zone had the highest number (10) of tree species as compared to six (6) recorded in the buffer zone. Only the core zone recorded tree species with GBH above 100 cm. There was a significant difference (p≤0.01) in GBH class distribution between the core zone and buffer zone (Table 5).

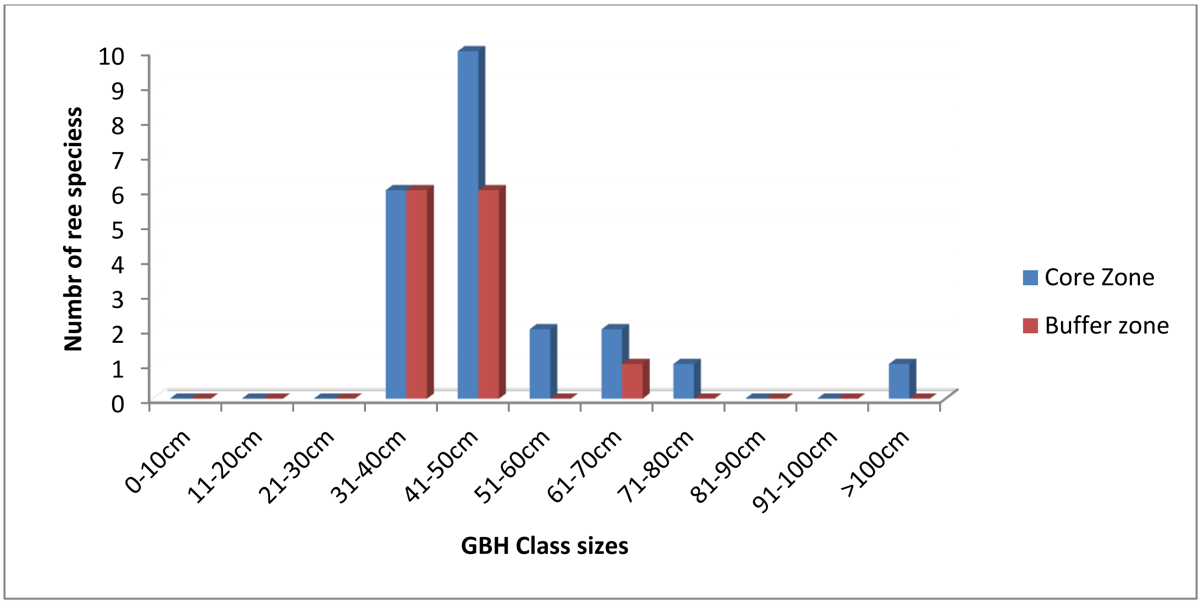

Figure 3. Mean gbh class size distribution of tree species with epiphytes in the study area

Table 5. One-way ANOVA of mean GBH of tree species between core zone and buffer zone

Source of Variation	SS	Df	MS	F	P-value	F critical
Between sites	4667.521	1	4667.521	8.643903	0.006512*	4.195972
Within sites	15119.4	28	539.9785			
Total	19786.92	29				

* = Statistically significant at 99% confident interval (p≤0.01)

Bark texture of tree species that hosted epiphytic ferns

The results of bark texture of tree species that hosted epiphytic ferns in this study are presented in (Table 6). Of the six species of epiphytic ferns recorded in both study sites; five occurred interchangeably on both rough and smooth barks while *Nephrolepis biserrata* occurred specifically on host tree species with rough bark in both sites.

Table 6. Bark texture of tree species that hosted epiphytic ferns in core and buffer zone

No	Epiphytic ferns	Bark texture of host tree species	
		Smooth	Rough
1	*Nephrolepis biserrata* (Sw) Schott	-	+
2	*Asplenium nidus* L.	+	+
3	*Platycerium coronarium* (O.F.Mull) Desv	+	+
4	*Phlebodium aureum* (L.) J.Sm	+	+
5	*Cyathea cooperi* (W.J.HookerexF.vonMueller) Domin	+	+
6	*Drynaria laurentii* Christ) Hieron	+	+

* presence = +; absence = -

Sites of attachment of ferns to host tree species

The results of the sites of ferns attachment to host tree species in the study sites are presented in Table 7. Three points of attachment of ferns to host tree species (on the tree trunk, branch attachment point to the tree trunk and main branches) were recorded in the core zone while the buffer zone had two (tree trunk and the branch attachment point to tree trunk). There was no significant difference (P≤0.05) in the attachment of epiphytic ferns to the tree trunk between the core and buffer zone (Table 8). However, the number of epiphytic ferns found on the point of attachment of tree branch to the tree trunk was significantly different (p≤0.01) between the core and buffer zones (Table 9).

Table 7. Sites of attachment of ferns on the host tree

Point of attachment of ferns	Core zone	Buffer zone
	Number of tree species	
Tree trunk	10	12
Branch attachment point to tree trunk	6	1
Main branch	6	-

Table 8. Comparison of attachment of epiphytic ferns on tree trunk using ANOVA test between core zone and buffer zone

Source of Variation	SS	df	MS	F	P-value	F crit
Between Sites	0.002778	1	0.002778	0.004379	0.947837	4.300949
Within Sites	13.95556	22	0.634343			

Total	13.95833	23

Table 9. Comparison of epiphytic ferns on point of attachment of branch to the tree trunk using ANOVA test between core zone and buffer zone

Source of Variation	SS	Df	MS	F	P-value	F crit
Between sites	2.7	1	2.7	6.593023	0.015866*	4.195972
Within sites	11.46667	28	0.409524			
Total	14.16667	29				

* = Statistically significant at 99% confident interval (p≤0.01)

Presence or absence of grooves and manmade cuts on trees with epiphytic ferns

The results of the presence or absence of grooves and manmade cuts on trees with epiphytic ferns for the study sites are presented in Tables 10 and 11. Field observation showed that nine of the fifteen tree species sampled with epiphytic ferns in the core zone had grooves, while six had man-made cuts (Table 10). For the buffer zone, five of the thirteen tree species sampled had grooves while three had man-made cuts (Table 11). There was no significant difference (P≤0.05) for the presence of grooves and manmade cuts between the core and buffer zone.

Table 10. Presence or absence of grooves and manmade cuts on trees with epiphytic ferns in the core zone

S/N	Tree species	With Groove	With manmade cuts
1	*Piptadeniastrum Africana* (Hook. f.) Brenan	1	0
2	*Parkia bicolor* A. Chev.	1	1
3	*Baphia nitida*. Lodd.	1	0
4	*Diospyros ferrea* (Willd) Bakh.	0	1
5	*Irvingia gabonensis* (Aubry-lecomte ex O'Rorke) Baill	0	0
6	*Coula edulis* Baill.	0	1
7	*Calpocalyx cauliflorus*. Hoyle	1	0
8	*Stuadtia stipitata* Warb.) Warb.	1	1
9	*Guarea cedrata* (A.Chev.) Pellegrin	1	1
10	*Treculia obovoides* N.E. Br.	0	0
11	*Strombosia pustulata* Oliv.	0	0
12	*Pterocarpus osun* Craib	1	0
13	*Klainedoxa gabonensis* Pierre.	1	1
14	*Entandrophragma utile* Sipo (Dawe & Sprague) Sprague	1	0
15	*Pycnanthus angolensis* (Welw.) Warb	0	0
Total		9	6

Table 11. Presence or absence of grooves and manmade cuts on trees with epiphytic ferns in the buffer zone

S/N	Tree species	With Groove	With manmade cuts
1	*Lophira alata* Banks ex Gaertn.	0	0
2	*Anthocleista vogeili* Planch.	1	0
3	*Afzelia Africana* Sm.	0	1
4	*Irvingia gabonensis* (Aubry-lecomte ex O'Rorke) Baill	1	0
5	*Entadrophragma utile* Sipo (Dawe & Sprague) Sprague	1	1
6	*Cleistopholis patens* (Benth.) Engl. &Diels.	0	0
7	*Xylopia aethiopica* (Dunal) A. Rich.	0	0
8	*Albizia ferruginea*.(Guill & Perr.) Benth.	1	1
9	*Alstonia congensis* Engl.	1	0
Total		5	3

Recorded Epiphytic ferns species and their distribution on tree species in the study sites

A total of six species of epiphytic ferns belonging to four families were recorded in both study sites (Plate 1). The summary of epiphytic fern species/number of individuals of each species censored in both the buffer and core zone are presented in Table 12. A total of sixty six epiphytic individuals belonging to the six species were recorded in the study area. Of this number, forty five (45) individuals were recorded in core zone while twenty one individuals were recorded in the buffer zone.

The results of the distribution of epiphytic ferns on tree species between the core and buffer zone are presented in Tables 13 and 14. In the core zone, *Parkia bicolor*, *Guarea cedrata* and *Klainedoxa gabonensis* hosted 4 species of epiphytic ferns each, *Piptadeniastrum africana*, *Baphia nitida*, *Diospyros ferrea*, *Irvingia gabonensis*, *Calpocalyx caudiflorus*, *Staudtia stipitata* and *Etandrophagna utile* hosted 3 species each while the other tree species hosted 2 each (Table 13). In the buffer zone, *Albizia ferruginea* hosted 4 species of ferns, *E. utile* and *X. aethiopica* hosted 3 species each, the other tree species hosted 2 each while *Lophira alata* had 1 species (Table 14). The statistical analysis showed a significant difference ($p \leq 0.05$) in the distribution of epiphytic individuals between the core and buffer zone (Table 15). The Pearson's rank correlation analysis showed a weak positive ($r=0.27$) and negative ($r= -0.29$) correlation between canopy type and epiphytic distribution in the core and buffer zone respectively and a positive correlation ($r=0.67$ and $r=0.68$) between gbh and epiphyte distribution in both sites respectively (Table 16).



Asplenium nidus L. *Phloebodium aureum* (L.) J.Sm. *Platycerium coronarium* (O.F.Mull) Desv.



Drynaria laurentii (Christ) Hieron *Nephrolepis biserrata* (Sw) Schott *Cyathea cooperi* (W.J.Hooker ex F.vonMueller) Domin

Plate 1. Epiphytic ferns censored in the study sites

Table 12. Summary of Epiphytic ferns censored in core and buffer zones

Epiphytic ferns	**Family**	**Core zone (abundance)**	**Buffer zone (abundance)**
Nephrolepis biserrata (Sw.) Schott	Nephrolepidaceae	8	4
Asplenium nidus L.	Aspleniaceae	4	7
Platycerium coronarium (O.F. Mull) Desv	Polypodiaceae	9	2
Phlebodium aureum (L.) J.Sm	Polypodiaceae	10	2
Cyathea cooperi (W. J. Hooker ex F. vonMueller) Domin	Cyatheaceae	8	2
Drynaria laurentii (Christ) Hieron	Polypodiaceae	6	4
Total		45	21

Table 13. Epiphytic Fern distribution in the core zone

S/N	Tree species	Family	Total no. of epiphytic ferns hosted by tree species	Epiphytic ferns					
				Nephrolepsis bisereta (SW)	*Asplenium nidus* L.	*Platycerium coronarium* (O.F.	*Phlebodium aureum* (L.) J. Sm	*Cyathea cooperi* (W. J. Hooker ex f.	*Drynaria laurentii* (Christ) Hieron
1.	*Piptadenistrum Africana* Hook f. Brenan	Fabaceae	3	0	0	1	2	0	0
2.	*Parkia bicolor* A. Chev.	Fabaceae	4	2	0	1	0	0	1
3	*Baphia nitida* Lodd.	Fabaceae	3	1	0	2	0	0	0
4.	*Diospyros ferrea* (Willd) Bakh.	Ebenaceae	3	0	2	0	1	0	0
5.	*Irvingia gabonensis* Aubry-lecomte) ex O'Rorke) Baill.	Irvingiaceae	3	0	0	0	0	2	1
6.	*Coula edulis* Baill.	Burseraceae	2	1	0	0	0	1	0
7.	*Carlpocalyx cauliflorus* Hoyle	Fabaceae	3	0	0	1	1	0	1
8.	*Staudtia stipitata* (Warb.) Warb.	Myristicaceae	3	2	0	0	0	1	0
9.	*Guarea cedrata* (A. Chev.) Pellegrin	Malvaceae	4	0	1	1	2	0	0
10.	*Treculia obovodes* N.E. Br.	Moraceae	2	0	0	0	1	1	0
11.	*Strombosia pustulata* Oliv.	Olacaceae	2	0	0	0	0	2	0
12.	*Pterocarpus osun* Craib.	Fabaceae	2	1	0	0	1	0	0
13.	*Klanedoxa gabonensis* Pierre	Irvingiaceae	4	1	0	0	0	1	2
14.	*Etandrophagma utile* Sipo (Dawe & Sprague) Sprague	Meliaceae	3	0	0	0	2	1	0
15.	*Pycnanthus angolensis* (Welw.) Warb.	Myristicaceae	2	0	1	1	0	0	0
Total			45	8	4	7	10	9	5

Table 14. Epiphytic fern distribution in the buffer zone

S/N	Tree species	Family	Total no. of epiphytic ferns hosted by tree species	Epiphytic ferns					
				Nephrolepsis bissereta (S. W.) Schott	*Asplenium nidus* L.	*Platycerium coronarium* (O.F. Mull.) Desv.	*Phlebodium aureum* (L.) J. Sm	*Cyathea cooperi* (W.J. Hooker ex f. von Mueller) Domin	*Dyrnaria laurentii* (Christ) Hieron
1.	*Lophira alata* Banks ex Gaertn.	Ochnaceae	1	0	1	0	0	0	0
2.	*Anthocleista vogelli* Planch	Gentianaceae	2	0	1	0	1	0	0
3	*Afzelia africana* Sm.	Fabaceae	2	0	2	0	0	0	0
4.	*Irvingia gabonensis* (Aubry-lecomte ex O'Rorke) Baill.	Irvingiaceae	2	1	0	0	0	1	0
5.	*Entandrophagma utile* (Dawe & Sprague) Sprague	Meliaceae	3	0	2	0	0	0	1
6.	*Cleistopholis patens* (Benth) Engl. & Diels	Anonaceae	2	2	0	0	0	0	0
7.	*Xylopia aethiopica* (Dunal.) A. Rich	Anonaceae	3	0	0	2	0	0	1
8.	*Albizia ferruginea* (Guill & Perr.) Benth	Febaceae	4	0	1	0	1	0	2
9.	*Alstonia cogenesis* Engl.	Apocynaceae	2	1	0	0	0	1	0
Total			**21**	**4**	**7**	**2**	**2**	**2**	**4**

Table 15. One-way ANOVA Comparing epiphytic fern distribution between core zone and buffer zone

Source of Variation	SS	Df	MS	F	P-value	F crit
Between sites	60.75	1	60.75	14.63855	0.00334*	4.964603
Within sites	41.5	10	4.15			
Total	102.25	11				

* = Statistically significant at 99% confident interval (p≤0.01)

Table 16. Correlation showing relationship between % occurrence of epiphytic ferns and tree size (gbh), grooves, manmade cuts and canopy type

Comparison	Core zone		Buffer zone	
	Pearson Correlation (r)	Strength of Correlation	Pearson Correlation (r)	Strength of Correlation
% Occurrence of epiphytes vs Tree size (gbh)	0.670848498	Strong Positive	0.685243553	Strong Positive
% Occurrence of epiphytes vs Canopy type	0.272002433	Weak positive	-0.288977994	Weak negative
% Occurrence of epiphytes vs Tree with grooves	0.101889891	Weak positive	0.612586514	Strong Positive
% Occurrence of epiphytes vs Tree with manmade cuts	0.104545504	Weak positive	-0.28837217	Weak negative

Discussion

In this study, the result of tree distribution in the study sites showed that epiphytic fern species were recorded on trees with a girth at breast height (GBH) >30 cm in each study site. This may be due to the fact that epiphytic ferns tend to favor older trees (Alpert, 2000). The study revealed a relatively higher species diversity of trees in the core zone compared to the buffer zone. The difference in tree species composition and abundance (Tables 1 and 2) between the core and the buffer zone is an indication of a disturbed ecosystem as a result of human interference such as logging and agricultural activities in the buffer zone. This finding is in conformity with the works of Margaret (2015) and Mucunguzi (2017) who reported a low diversity of tree species and distribution in the buffer zone of CRNP and Kibale National Park, Western Uganda, respectively. Also, Erhenhi and Obadoni (2016) reported greater human influence to be the causal factor for the difference observed in tree species composition between the strictly restricted forest area and forest buffer zone (forest re-growth area) in any protected area. The result of the canopy type revealed three canopy types based on tree height. High canopy (77.3 %), sub-canopy (13.6 %), and emergent canopy (9.1

%) were observed in the core zone while two canopy types; were high canopy (11.1 %) and sub-canopy (88.9%) were observed in the buffer zone (Table 4). Generally, differing canopy sizes offer varied micro-climatic settings (Munoz et al., 2003), which determines the space occupied by epiphytes; their mode of dispersal, and their formation on tree host (Nieder et al., 2000). Results from this research showed that epiphytic fern distribution was not determined by the canopy area of the sampled host tree species, this finding disagrees with that of Yeaton and Gladstone (1982) and Hylander and Nemomissa (2008) who stated that the availability of epiphytic species and their abundance on calabash and coffee tress depended largely on the canopy area.

The results of GBH of trees with epiphytic ferns (Figure 4) showed that there was a significant difference ($p \leq 0.05$) in GBH class distribution between the core and buffer zone as revealed by the one-way ANOVA (Table 5), which suggests that trees with epiphytic ferns had a varying range of girth measurement and each of them offered specific advantages to fern population. The result also revealed that moderately sized tree girth (31cm-70cm) recorded the highest epiphytes, with the core zone recording trees with higher girth size than the buffer zone (Figure 4). Zots and Volrath (2003), Koster et al. (2011) and Woods et al. (2015) reported similar findings that the girth size of tree species plays a huge role in determining epiphytic fern diversity and distribution. Cook et al. (2002) however, observed that the relationship between ferns and tree girth is not only dependent on habitat diversity but the availability of the particular tree species for colonization by epiphytic ferns and the age of the tree (Janzen and Liesner, (1980). Mehltreter et al. (2005) similarly reported that for timber species, their gbh had a direct relationship with epiphytic fern diversity. This is not surprising because older trees ordinarily have more points of attachment for epiphytic fern than younger trees', since they have been around much longer and have the ability to accommodate higher diversity and create more micro ecosystems (Hietz and Hietz-Seifert, 1995; Nieder et al., 2001; Flores-Palacios and Garcia-Franco, 2004). According to Nieder et al. (Nieder et al., 2001) basal girth increases as the tree species ages, explaining its relevance in epiphytic fern occupation especially in an undisturbed habitat.

Quantitative analysis of bark texture was made based on observation. In this study the tree bark texture was categorized into; rough and smooth types. In the core zone 73.33% of censored species had rough bark while 26.67% had smooth bark. On the other hand the occurrence of both smooth and rough bark texture in the buffer zone was almost uniform with 44.44 % and 55.56 % respectively (Table 6). According to Johansson (1974) the structural characteristics of trees such as bark texture, presence or absence of latex, resins or inclination of branches have influence on epiphyte settlement. Epiphytic ferns are more abundant on host's species with rough bark, with favorable conditions such as increased moisture and appreciable water holding capability. According to Mehltreter, et al. (2005) bark thickness and water retention capacity are strongly correlated. This could be responsible for the higher number of epiphytic ferns found on tree species in the core zone, since these ferns more readily attach to a rough bark texture (Ijeomah et al., 2015). Five species of epiphytes were found to be distributed on both smooth and rough barked host's plants. On the other hand, only one of the total censored epiphytic species Nephrolepis biserrata was restricted to hosts with rough bark in both the core and buffer zones (Table 4). This result indicates that hosts with rough bark held more epiphyte species. This supports Nadkarni (2000) theory that tree species with rough bark provide more area and favorable conditions for the epiphytic attachment than host with smooth bark texture.

The result of sites of attachment of ferns on the host tree showed that tree trunk had the highest number of epiphytic fern for both study sites followed by the branch attachment spot on the tree trunk (Table 7). However, only core zone recorded ferns on the primary branch. This suggests that both trunk and branches provided suitable habitats for fern occupation on the tree hosts. Rough tree trunk texture generally hold more epiphytic species due to the presence of cuts and crevices that accumulate detritus and litter on such host species, on the other hand smoother stems lack the appropriate conditions for the attachment and survival of epiphytic species. These smooth stems are often shaded which means that epiphytic species may have inadequate lighting for growth (Chomba et al., 2011). Inclined trunks and branches more readily amass detritus, absorb atmospheric nitrates and nutrients and maintain humid conditions than upright stems and erect twigs (Nardkani, 1984). Todzia (1986) observed that epiphytes depend more on organic matter traps on inclined stems than atmospheric nutrients since they are more reliable. Sloppiness of branches and tree trunks also increases the ability of the species to intercept light radiations and easily allows accumulation of spores and organic matter, conditions that are vital for epiphytic attachment and improve structural entrapment of seeds and spores (Barkman, 1995; Chomba et al., 2011).Very few studies have paid attention to under branch height. Few reports found that the distribution of epiphytic species was only weakly or not related to under branch height (Woods et al., 2015; Zhao et al., 2015). Gentry and Dobson (1987) observed that epiphytic ferns are found more in the top-story of forest stratum, since they are light loving species.

The results of presence or absence of grooves and manmade cuts on trees with epiphytic ferns revealed that fifteen (15) trees with ferns in Core zone had grooves and 8 trees had man-made cuts (Table 10) while, buffer zone recorded 6 and 3 trees with grooves and man-made cuts respectively (Table 11). Epiphytes generally prefer substrates or host plants with the capacity to retain moisture. Grooves or cuts with more dead organic matter will undoubtedly enhance the chances of epiphytes surviving dry conditions because of its ability to trap and conserve moisture than the smoother trunks (Benzing 1981; Benzing, 1990). Asplenium nidus for instance is more predominant in tree species with grooves and manmade cuts (Benzing 1990). The presence of grooves and cuts on trees therefore provided anchor points as well as organic matter and moisture that enhanced the epiphyte distribution in this study.

The results of Epiphytic ferns distribution (12) and (Table 13) revealed that of the 66 epiphytic ferns individuals distributed in both study sites, core zone (45) had more epiphytic ferns than buffer zone (21); suggesting that core zone probably offered more microhabitats that encouraged higher distribution of epiphytes. According to Flores-Palacios and García-Franco (2001), Krömer and Gradstein (2003), epiphyte diversity increases with the age of the forests habitat and their distribution can be affected by forest disturbance. In this study, epiphyte diversity is the same in both the core and buffer zones, however the number of these species on tree hosts is higher in core zone than buffer zone, indicating that Core zone provided a more enabling micro-sites for epiphyte occupation or probably because of less disturbances than buffer zone. Studies by Buckling et al. (2000), Roxburgh et al. (2004), Barlow et al. (2007), Pardini et al. (2009), and Oldekop et al. (2012) showed that epiphytic ferns have been used successfully in assessing environmental degradation in forest habitats and that higher fern species richness has been recorded in remote sites, which may well be correlated to intermediary intensities of natural degradation in forests. The 66 individuals belonging to six species (Plate 1) of epiphytes (*Nephrolepis biserrata, Asplenium nidus, Platycerium coronarium, Phlebodium aureum, Cyathea cooperi* and *Drynaria laurentii*) as revealed in this study may represent the normal richness of epiphytic flora in the CRNP.

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