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Diversity and Phorophyte Preference of Vascular Epiphytic Flora on Avenues within the University of Port Harcourt, Nigeria

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Abstract

This study evaluated the species composition, diversity and phorophyte preference of epiphytes at the University of Port Harcourt located in southern part of Nigeria. Purposive sampling technique was used to select sites representing major avenues in the three campuses (Abuja, Choba and Delta) of the University. Data were collected on species name of phorophytes, number of individuals, diameter at breast height (dbh) and height, and species/number of epiphytes present on them. The points/sections of attachment of epiphytes on phorophytes were also recorded. A total of eight species of epiphyte belonging to six families were recorded in the study. Species diversity was higher in Abuja campus (Simpson 1-D=0.81; Shannon H=1.79), followed by Choba campus (Simpson 1-D=0.73; Shannon H=1.09) and Delta campus (Simpson 1-D=0.56; Shannon H=0.93). Species richness was highest in Abuja campus (n=8) followed by Delta campus (n=4) and Choba campus (n=3). Similarity in epiphyte species composition was highest between Choba and Delta campuses (85.71%), followed by Delta and Abuja campuses (66.67%) and lowest between Choba and Abuja campuses (54.55%). The family-Polypodiaceae, had the highest number of species (n=3). Microgramma owariensis had the highest relative abundance (27%) followed by Platycerium bifurcatum (26%) while Tillandsia utriculata and Peperomia pellucida had the least relative abundance (3%). Epiphyte abundance was weakly correlated with both the dbh and height of phorophytes. However, epiphytes were more abundant on phorophytes with rough/scaly/corky/flaky barks than on those with smooth barks. The planting of avenue tree species with rough barks is recommended to enhance the diversity of epiphytes in the study area.

Key Words: abundance, avenue trees, diversity, epiphytes, phorophyte features

Introduction

Tropical rain forest ecosystems are known to be very diverse in terms of the number of life forms that are found in them. The presence of epiphytes on phorophytes to a large extent depends on the ability of the phorophytes to possess architectural and morphological features that are favourable for their establishment and survival (De Sousa and Colpo 2017). The abundance and survival of most epiphyte species are therefore dependent on the characteristics of the phorophyte, and a positive correlation has been found between their diversity and the structural and anatomic characteristics of phorophytes (Adhikari et al. 2017).

According to Benzing (1990), the existence of epiphytes, which is very important to diversity of most tropical forest ecosystems, starts from the forest understory to the periphery of tree crowns. The importance of epiphytes cannot be overemphsized as they do not only provide substrate and

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food substance for many species of fauna inhabiting forest canopies, but also increases the complexity (spatial and structural) of the canopy; thus, creating habitats for the diversification of canopy-based fauna including birds and insects (Ellwood et al. 2002; Ellwood and Foster 2004). They also influence carbon uptake, the production of biomass and the cycling of nutrients as well as provision of shelter and nesting materials for other organisms like birds (Ellwood et al. 2002; Bartels and Chen 2012)

Studies on abundance and diversity of epiphytes point to their suitability as a group of species that represents a good indicator group of biodiversity that can be monitored to assess the effects of forest disturbance (Yulia et al. 2011; Woods 2013). The size and abundance of phorophytes and stand characteristics such as stand age, tree species composition and dispersal limitation have been identified to be among the many factors that influence the diversity and distribution of epiphytes in the tropical forest ecosystems (Zhao et al. 2015).

Epiphytes which are almost exclusively found in tropical countries constitute about 9-10% of all vascular plant species globally and represent up to 25% of all vascular plants in tropical countries (Watson et al. 1987; Nieder et al. 2001; Zotz 2013). However, Burns (2007) noted that the diversity of epiphytes has been altered, due to constant deforestation and other human activities including urbanization.

The need for the establishment of urban forests in the face of deforestation orchestrated by urbanization has been recognized globally. Green spaces in urban areas including avenue trees contribute immensely in enhancing the quality of life through the provision of macro and micro-habitats for a wide range of species (Bullock 2008). The enhancement of epiphyte community diversity in urban forest ecosystems, will to a large extent, contribute to the realization of ecologically complex and more resilient plant communities in our urban environments.

Despite the fact that studies have been conducted on epiphytes in urban areas in different parts of the world (Adhikari 2012, 2017; Fudali 2012; Bhatt et al. 2015), there is paucity of information on the diversity, distribution and phorophyte preference of epiphytes in urban environments in Nigeria, as the available studies dealt with the tropical rainforest or partially disturbed ecosystems in tropical rainforests (e.g. Akinsoji 1990; Adubasim et al. 2018 respectively). Such knowledge is needed for the enhancement of the structural and ecological complexity of urban forest communities using epiphytes. This study therefore evaluated the diversity and phorophyte preference of epiphytes in avenues within the three campuses of the University of Port Harcourt, in order to bridge this gap in knowledge. It is hoped that the findings will encourage management decisions that will enhance the ecological complexity and roles of the avenue plant communities in the University of Port Harcourt and other urban forests in Nigerian cities.

Materials and Methods

Study area

This study was conducted at the three campuses of University of Port Harcourt (Abuja, Delta and Choba campuses). The University of Port Harcourt is located on latitude 4°53' 14''N through 4°54' 42''N and longitude 6°54' 00''E through 6°55'50''E (Chima and Ofodile 2015), in the southern part of the Niger Delta area of Nigeria. The area has a tropical climate characterized by rainy season between April and October and a dry season between January and March. Efe and Weli (2015) reported an average annual temperature of 27.2°C for Port Harcourt. The annual rainfall in Port Harcourt ranges from 2000 to 2500 mm with the heaviest rainfall occurring in the month of September (Chinazor 2016). The City lies at an average altitude of about 12 m above mean sea level (Akukwe and Ogbodo 2015).

Experimental design and data collection

Data were collected from trees growing along purposively chosen avenues covering a distance of 1 km in each of the three campuses of University of Port Harcourt. Tree species within 10 m radius on both sides of the chosen avenues were identified to species level and the number of individuals counted and recorded. In addition, the diameter at breast height (dbh) and total height of each of the trees with epiphyte presence were measured using a diameter tape and a clinometer, respectively. All species of epiphytes occurring in each phorophyte were also identified to species level and the number of individuals counted and recorded for each species. Species of epiphytes with clumping and climbing nature were counted as one individual in any part of the phorophyte where they were growing or for the entire phorophyte where they were found to extend from its base to the canopy. The individual trees belonging to different species without the presence of epiphytes on them were also counted and recorded. The points of attachment and extent of epiphyte presence on each of the phorophytes were also observed and recorded. Identification of epiphytes was done by an experienced taxonomist with the aid of Aigbokhan (2014).

Data analysis

The relative abundance of epiphytes in each of the campuses with respect to the total abundance of epiphytes in the three campuses was computed using Equation (1).

$$RA = \frac{a}{TA} \times \frac{100}{1} \text{ --------------------------------------(1)}$$

Where: RA = Relative Abundance (%)
a = abundance of epiphytes in a campus
TA = Total Abundance of epiphytes in the three campuses

- Species richness of epiphytes in a campus was determined by counting the number of species of epiphytes observed in each campus.
- Alpha (within-campus) diversity of epiphytes was measured using Shannon-Wiener index (Kent and Coker 1992) and Simpson index (Simpson 1949). Both indices have also been used by other workers (e.g. Chima et al. 2013; Leishangthem and Singh 2018; Rahman et al. 2019) to measure alpha diversity.

Shannon-Wiener Index (H) is expressed as:

$$H = -\sum_{i=1}^{s} pi \text{ In } pi \text{--------------------------------------(2)}$$

Where:
pi = the proportion of individuals of the ith species of epiphyte in a campus.
s = the total number of species of epiphytes enumerated in a campus.

Simpson Index as expressed below was used to allow for a direct relationship between the index and diversity:

$$\text{Simspon } (1-D) = 1 - \frac{\sum ni(ni-1)}{N(N-1)} \text{ ---------------(3)}$$

Where:
ni = number of individuals of the ith species of epiphyte in a campus
N = total number of epiphytes in a campus

Beta diversity was measured using Sorensen Similarity Index (SI) after Magurran (1996).

$$SI = \frac{2a}{2a+b+c} \text{ ---------------------------------- (4)}$$

Where: SI = Sorensen Index
a = the number of species of epiphyte present in both campuses
b = the number of species of epiphyte present in Campus 1 but absent in Campus 2
c = the number of species of epiphyte present in Campus 2 but absent in Campus 1

- Coefficient of Correlation analysis was done to test for the effects of diameter at breast height and height of phorophytes on the abundance of epiphytes.

Results

Abundance of epiphytes in the campuses

The species of epiphytes, their families, common names and abundance in the three campuses are shown in Table 1. A total of eight (8) species of epiphytes belonging to six families were found in all the campuses with all the species and families present in Abuja campus. Only four species belonging to three families occurred in Delta Campus while three species belonging to two families were found in Choba Campus. *Microgramma owariensis* (Snake fern), and *Platycerium bifurcatum* (Staghorn), were the most abundant epiphytes in Abuja Campus and Delta Campus, respectively while the population (abundance) of both species were the same in Choba Campus and higher than *Nephrolepis biserrata* (Giant Sword Fern), which was the other species found there. In terms of the overall abundance of epiphytes, Abuja Campus was highest (86.74%), followed by Delta Campus (10.79%) and Choba Campus (2.47%).

Abundance of epiphytes on phorophytes

Fig. 1 shows the abundance of epiphytes on different species of phorophyte. Abundance of epiphytes was highest on *Azadirachta indica*, followed by *Elaeis guineensis* while *Albizia lebbeck*, *Citrus sinensis* and *Hura crepitans* had very low abundance of epiphytes on them. Phorophytes with rough, scaly, corky and flaky bark texture mostly had a higher abundance of epiphytes than those with smooth barks.

Frequency of epiphytes on phorophytes in the study area

The frequency of epiphyte occurrence on the host tree species in the three campuses is shown in Table 2. Out of a total of 413 trees enumerated in the three campuses, epiphytes were present on 245 (59%) of them and absent on 168 (41%). In Abuja Campus with the highest number of enumerated trees (306), epiphytes were found on 201 trees (66%) and absent on 105 trees (34%). In Delta Campus with 81 enumerated trees, epiphytes were present on 44 (54%) and absent on 37 (46%) while Choba Campus with a total of 26 enumerated trees had epiphytes present on 7 (27%) and absent on 19 (73%). Tree species with rough barks had more epiphytes growing on them.

Parts of phorophytes with epiphytes and their frequencies

The parts of the phorophytes where epiphytes were observed in the three campuses are shown in Table 3. The canopies of the phorophytes were found to be richer with epiphytes, followed by canopy/trunk, trunk, tree base and whole tree, respectively. Epiphytes were present in tree canopies in the three campuses with greater percentage in canopies of phorophytes in Abuja campus, followed by Delta campus, with the lowest percentage recorded for Choba campus. Epiphytes covering all parts of phorophyte and the base alone were observed only in Abuja Campus, while those on the trunk and both canopy/trunk of phorophytes were found in Abuja and Choba campuses.

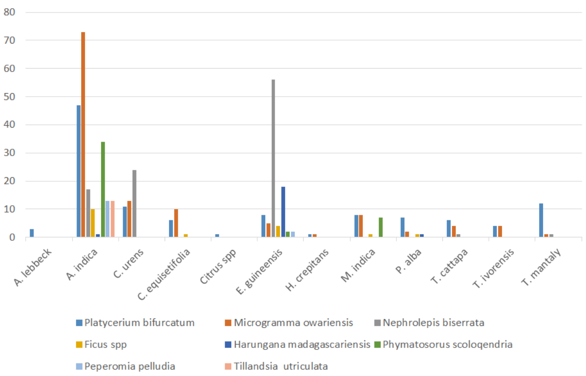

Fig. 1. Abundance of epiphytes on phorophytes. Source: Field survey, 2019.

Table 1. Checklist and abundance of epiphytes in the three campuses

S/N	Species	Family	Common name	Choba	Delta	Abuja	Entire
1	*Platycerium bifurcatum*	Polypodiaceae	Staghorn	4	28	83	115
2	*Microgramma owariensis*	Polypodiaceae	Snake fern	4	16	103	123
3	*Nephrolepis biserrata*	Davalliaceae	Gaint sword fern	3	1	95	99
4	*Phymatosorus scoloqendria*	Polypodiaceae	Monarch fern	-	-	43	43
5	*Ficus sp.*	Moraceae	Ficus	-	3	14	17
6	*Harungana madagascariensis*	Hypericaceae	Haronga tree	-	-	20	20
7	*Peperomia pellucida*	Piperaceae	Pepperomia	-	-	15	15
8	*Tillandsia utriculata*	Bromeliaceae	Tillandsia	-	-	13	13
	Total abundance			11	48	386	445
	Relative abundance (%)			2.47	10.79	86.74	100

Source: Field survey, 2019.

Table 2. Frequency of epiphyte occurrence on phorophyte species in the three campuses

Species	Origin	Bark texture	Campuses						Total	
			Choba		Delta		Abuja			
			Present	Absent	Present	Absent	Present	Absent	Present	Absent
Albizia lebbeck	Exotic	Smooth to fissured	-	-	3	2	-	-	3	2
Azadirachta indica	Exotic	Rough with wide fissures/scaly	-	-	1	-	92	5	93	5
Caryota mitis	Exotic	Rough/flaky	3	-	-	-	23	-	26	-
Casuarina equisetifolia	Exotic	Rough, furrowed and flaky	-	-	10	4	2	1	12	5
Chrysophyllum albidum	Exotic	Rough	-	1	-	-	-	-	-	1
Citrus sinesis	Exotic	Rough	-	-	-	2	-	1	-	3
Cocus nucifera	Exotic	Smooth/scaly	-	-	-	10	-	-	-	10
Delonix regia	Exotic	Smooth and slightly cracked	-	5	-	-	-	7	-	12
Elaeis guineensis	Native	Rough/scaly	-	1	5	3	57	7	62	11
Eucalyptus sp.	Exotic	Smooth	-	1	-	-	-	-	-	1
Gmelina arborea	Exotic	Smooth	-	5	-	-	-	-	-	5
Hura crepitans	Exotic	Spiny	-	-	-	-	1	2	1	2
Irvingia gabonensis	Native	Smooth to scaly	-	-	-	-	-	2	-	2
Mangifera indica	Exotic	Rough/scaly	-	-	2	2	9	6	11	8
Milicia excelsa	Native	Rough and fissured	-	-	-	-	2	1	2	1
Moringa oleifera	Exotic	Smooth to corky	-	-	-	2	1	-	1	2
Pisea americana	Exotic	Rough and fissured	-	-	-	2	1	-	2	1
Plumeria alba	Exotic	Smooth to scaly	-	-	4	3	4	2	8	5
Polyalthia. longifolia	Exotic	Cracked with age but masked by drooping leaves	-	-	-	4	-	7	-	11
Roystonea regia	Exotic	Smooth and stout	-	-	-	-	-	13	-	13
Spondias cytherea.	Exotic	Rough	-	-	-	-	-	8	-	8
Spondias mombin	Exotic	Rough	-	-	-	-	-	1	-	1
Terminalia. catappa	Exotic	Rough	-	2	-	-	7	6	7	8
Terminalia ivorensis	Native	Rough	4	1	-	-	-	-	4	1
Terminalia mantaly	Exotic	Smooth	-	3	12	10	1	37	13	50
		Total	7	19	44	37	201	105	245	168

Source: Field survey, 2019.

Table 3. Points of attachment of epiphytes on phorophytes in the study areas

Epiphyte position	Counts			
	Total	Choba	Delta	Abuja
Whole tree	4	-	-	4 (100%)
Tree base	15	-	-	15 (100%)
Canopy	121	7 (5.79%)	4 (3.31%)	110 (90.91%)
Trunk	42	-	30 (71.43%)	12 (28.57%)
Canopy and trunk	63	-	3 (4.76%)	60 (95.24%)
Total	245	7	37	201

Source: Field survey, 2019.

Diversity of epiphyte species in the study area

Table 4 shows that epiphyte species diversity was highest in Abuja campus (Simpson 1-D=0.81; H=1.79), followed by Choba campus (1-D=0.73; H=1.09) and lowest in Delta campus (Simpson 1-D=0.56; H=0.93). However species richness was highest in Abuja campus (n=8) followed by Delta campus (n=4) and lowest in Choba (n=3).

Table 5 shows the similarity of epiphyte species among the three campuses of the University of Port Harcourt. Similarity in epiphyte species composition was highest between Choba and Delta campuses (SI=85.71%), followed by Abuja and Delta Campuses (SI=66.67%) and lowest between Choba and Abuja campuses (SI=54.55%).

Relationship between number of epiphytes species and phorophyte size (dbh and height)

Table 6 shows the relationship between the number of epiphytes and diameter at breast height and the height of phorophytes. The coefficient of correlation (r) was less than 0.5 which means that the dbh and height of the phorophytes are not factors for epiphyte attachment. The test for relationship was nonsignificant and weak, implying that neither epiphyte abundance nor species richness was significantly affected by phorophyte height and dbh.

Discussion

The highest relative abundance and diversity of epiphytes in Abuja campus can be attributed to higher phorophyte species richness, abundance and diversity in Abuja campus. Ijeomah et al. (2013) had also reported higher abundance of trees including species like *Azadirachta indica* and *Elaeis guineensis*, which were found to have more epiphytes, in Abuja campus than in the other campuses of the University. Choba campus had the least abundance of epiphytes probably because of the fewer number of trees and anthropogenic activities such as pruning of tree branches and/or felling of whole trees which often take place in the campus. These activities cause alterations and disturbances to the natural environment and the habitat which play a major role in changing the diversity and distribution of vascular epiphytes (Flores-Palacios and García-Franco 2004; Hietz et al. 2006; Krömer et al. 2007). The highest similarity in epiphyte species composition observed between Choba and Delta campuses is attributable to a high similarity in avenue tree species composition between the two campuses. Ijeomah et al. (2013) also observed that avenue tree species composition was most similar between Delta and Choba campuses, followed by Abuja and Delta campuses while the least similarity was observed between Abuja and Choba campuses. Similarity in epiphyte species composition among the three campuses as

Table 4. Diversity indices of epiphytes in the different campuses

Variables	Choba	Delta	Abuja
Species S	3	4	8
Individuals	11	48	386
Simpson 1-D	0.73	0.56	0.81
Shannon H	1.09	0.93	1.79

Source: Field survey, 2019.

Table 5. Sorensen's similarity indices on epiphyte species composition for the three campuses

	Choba	Delta	Abuja
Choba	*	85.71%	54.55%
Delta		*	66.67%
Abuja			*

Source: Field survey, 2019.

Table 6. Relationship between number of epiphyte species and phorophyte size (DBH) and height

Relationship	Coefficient of correlation (r)	Significance	Remark
Number of epiphytes*DBH	0.022	0.735	Very weak (NS)
Number of epiphytes*Height	0.115	0.072	Very weak (NS)

NS, not statistically significant at $p \leq 0.05$.
Source: Field survey, 2019.

observed in this study followed exactly the same trend.

Microgramma owariensis recorded the highest occurrence followed by *Platycerium bifurcatum*. This result is consistent with Adubasim et al. (2018) who noted that *Platycerium bifurcatum* and *Microgramma owariensis* were among the highest occurring epiphyte species in the University of Benin, which is also located in the Southern part of Nigeria. Little soil and shady humid environments favour their establishment and these factors could have been responsible for their high abundance in the study area. *Nephrolepis biserrata* which was the third most abundant epiphyte species in the study area was also reported by Oloyede et al. (2014) as one of the most common species in Obafemi Awolowo University Estate also in southwestern Nigeria. However, our result contradicts that of Adubasim et al. (2018) who reported that *Nephrolepis biserrata* was the least abundant epiphyte species in a partially disturbed tropical rainforest ecosystem. This observed difference is probably due to the fact that our study was conducted in an urban environment. The presence of two accidental epiphytes (*Ficus sp.* and *Harungana madagascariensis*) which account for about 25% of the total epiphyte species richness in this study, could be attributed to the disturbed nature of urban environments. Although the accidental epiphytes do not have the morphophysiological adaptations of the ordinary epiphytes, they sometimes attain maturity on phorophytes without rooting in the soil. Other workers (e.g. Furtado and Neto 2015; Santana et al. 2017; Alvim et al. 2020) have reported high richness of accidental epiphyte species in urban green areas of Juiz de Fora, Brazil and suggested that the disturbed nature of the urban environment may have been responsible for that.

Higher abundance of epiphytes in Abuja campus is attributable to higher abundance of phorophytes in the campus especially *Azadiractha indica* and *Elaeis guineensis*. Migenis and Ackerman (1993) reported that some tree species are generally better for epiphyte attachment and growth than others. This is probably due to the ability of some tree species to possess more of the desirable traits or characteristics for epiphyte attachment and growth. For instance, *Azadiractha indica* with a very rough, widely fissured and scaly bark was observed to harbour the highest number and species of epiphytes. Other earlier workers like Akinsoji (1990), Andama et al. (2003), Oloyede et al. (2014) and Zhao et al. (2015) noted that epiphyte species thrive better in trees that have large bark, canopy, and rough bark. The nonsignificant correlation between number of epiphytes and phorophyte height and the diameter at breast height is consistent with the findings of Wang et al. (2016) and Boelter et al. (2011), respectively.

Although there was not much phorophyte specificity of epiphytes in this study, *Nephrolepis biserrata* was found to be associated with *Elaeis guineensis* (Oil palm tree). Ter Steege and Cornelissen (1989) noted that some vascular epiphytes significantly prefer one phorophyte species over another. The dominance of epiphytes in the canopy than in other parts of phorophytes is as a result of its closeness to incident rays of light. This agrees with several other studies like Paudel et al. (2015), Addo-Fordjour et al. (2008), Chomba et al. (2011) and Adubasim et al. (2018) which show that epiphytes are associated with crown height which influences a number of factors that enhance epiphyte abundance and diversity including the surface area available for colonization, availability of substrates, mechanical support, exposure to sunlight, among others. However, the results differ from those of Quaresma and Jardim (2014) and Oloyede et al. (2014) which reported highest abundance and species richness of epiphytes on phorophyte trunks.

Conclusion

Phorophyte height and diameter at breast height showed a weak correlation with epiphyte abundance. However, the abundance and diversity of epiphytes were enhanced by increase in phorophyte species abundance, diversity and roughness of bark. Tree canopies had the highest abundance of epiphytes than other parts of the phorophytes. *Azadirachta indica* had the highest abundance and diversity of epiphytes than any other phorophyte species, followed by *Elaeis guineensis*. The planting of avenue tree species with rough barks is recommended to enhance the abundance and diversity of epiphytes in the study area.

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