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Diversity and Taxonomic Classification of Epiphytes in the Federal Capital Territory, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Epiphytes exist in the Federal Capital Territory communities but there is little or no information on their diversity and taxonomy. However, Federal Capital Territory is a treasure house of ethnic communities and some valuable plant species. One major gap across the Federal Capital Territory, is lack of formal record on the diversity and taxonomic classification of the epiphytes. The objective of this study is to collect and identify epiphytes present in the Federal capital Territory, determine species composition and abundance, and further identify the various plants used as hosts by the epiphytes. The greatness of epiphytes has enabled them to exploit a wide range of habitats including tropical and temperate woodlands, plantations and mangroves. In tropical canopies, epiphytes are remarkably diverse and show asynchronous phonological patterns at the community level. A reconnaissance survey of the study on diversity and taxonomic classification of epiphytes

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was carried out from November to December, 2021 in Abaji, Abuja Municipal, Bwari, Gwagwalada, Kuje and Kwali area councils of the Federal Capital Territory (FCT), Nigeria. Eighteen study points were randomly selected from the administrative town and two settlements from each of the area council. The study sites were selected considering the dry riparian nature of the region, altitudinal ranges, notable presence of epiphytes diversity and recommendation from respondents. Data was collected by administering semi-structured questionnaires to 90 respondents for a single face-face interview. Epiphytic plants collected from the field were identified. Those that could not be identified were taken to the Biological Sciences Department, University of Abuja, for identification and documentation. The epiphytes were classified into eight (8) taxonomic groups namely; Polypodiophyta, Tracheophyta, Basidiomycota, Magnoliophyta, Ascomycota, Bryophyta, Marchantiophyta and Anthophyta while four (4) evolutionary taxonomic groups were identified. Based on their mode of life, some epiphytes were classified as Typical Epiphytes while others were Semi Epiphytes and Occasional Epiphytes. The study shows that different epiphytic plants occur in the Federal Capital Territory (FCT), Nigeria, and they belong to various taxonomic groups. Epiphytes in the Federal Capital Territory, and their Taxonomic Groups, indicated that *Nephrolepis bisserata* (Sw.) Schott, *Platycerium stemaria* (P.Beauv.) Desv., *Ficus benghalensis* L., *Ficus vogelii* Miq., *Elaeis guinensis* Jacq., *Ageratum conyzoides* (L.) L., *Ficus leprieurii* (Miquel), *Ficus lutea* Vahl, *Ficus thonningi* Blume, *Ficus exasperate* Vahl., *Ficus platyphylla* Delile, *Polyhandra longiflora* L., *Digitaria ciliaris* (Retz.) Koeler, *Lycoperdon spadiceus* Pers., *Auricularia polytricha* (Mont.) Sacc., *Viburnum tinus* L., *Plagiothecium undulatum* (Hedw. Schimp., *Frullania dilatata* (L.) Dumort., and *Ficus aurea* Nutt. occured in all the area councils of the FCT while *Fomitopsis sp* P.Karst., *Entodon sp* MÜll. Hal. and *Funaria sp* Hedw. were seen in Abaji, Bwari, Gwagwalada, Kuje and Kwali area councils. *Nephrolepis undulata* (Afzel. Ex Sw.) J.Sm. occurred in Bwari, Kuje and Municipal area councils. *Coprinus lagopus* P.Karst., *Daldinia concentrica* (Bolton) Cesati and de Notaris, *Entodontopsis nitens* (Mitt.) W.R.Buck and Ireland, *Syntrichia laevipila* (Brid.) K.F.Schultz. occurred in Bwari, Gwagwalada, Kuje, and Municipal area councils. Having studied the diversity and classification of epiphytes of the Federal Capital Territory, it is recommended that further research analysis be carried on the phytochemical constituents of some of these epiphytes to determine their major classes of compounds.

Keywords: Distribution; abundance; diversity; ecology; phenology.

1. INTRODUCTION

Epiphytes refers to as living organism that grows upon other plant for support. They are usually independent of the host plant for nutrition, although they may sometimes damage the host plant, often by shading [1]. Epiphytes are not restricted to grow on a host plant, for instance, the holo-epiphytes such as orchids can be found growing on wires [2]. They complete their life cycle without contact with the ground. A lot of orchids also constitute the nest epiphytes [3]. They are characterized by appropriate and efficient devices for the collection of large quantities of humus and water (Petruzzelo, 2020).

Certain ferns belong to the group of proto-epiphytes [4]. They acquire nourishment from the surface of the supporting host and from atmosphere [5]. *Scindapsus officinalis*, a member of the Bromeliaceae family which belongs to the group of epiphytic bromeliads exhibits xerophytism with absorbing peltate scales that act as one-way valves and tank formation by leaf bases [6].

The hemi-epiphytes, at some stage of their development, root in ground soil; and the stranglers Ficus are well known representatives of this group [7]. Vascular and non-vascular epiphytes biomass production in many rain forest canopies is significant, especially in cloud forests [8]. Among vascular plants, epiphytes comprise about 10%, distributed among 84 families with over 25,000 species and they are particularly abundant in the wet tropic [9].

Epiphytes may occur from the basis of tree trunks, limbs, up to the tree crowns on trees as high as 50m or even taller and rarely on the upper leaf surface of the woody plants-epiphylls (Petruzello, 2020). Because epiphytes are mostly found in the tree crowns, these plants are part of the canopy community where the full diversity of organisms remains to be mapped [10]. In some tropical areas, the organic matter released by epiphytes is the most important flux of nutrients

reaching the forest floor [11]. These plants increase the structural complexity of forests because of the frequently dependent fauna associated to these plants [12].

Epiphytes depend totally on host plants and this entire dependency makes them to be more vulnerable to complete deforestation and fragmentation than other flora; when a tree is cut down, all the epiphytes residing on that tree die [13]. They play fundamental importance to forest biodiversity and ecosystem function.

Many epiphytes have habitat preferences especially towards large trees which influence their distributions. This is due to the ability of large trees to accommodate dispersing seeds and because crowns of large trees may be cooler and more ventilated than those of smaller trees due to generally higher wind speed in the upper parts of the canopy [14]. Epiphytes are important contributor to the global plant diversity [15].

It has been estimated that 10% of all global plants are epiphytes and that in tropical countries epiphytes account for 25% of all vascular plant species [16]. Their great diversity and their different adaptations to life in the canopy have enabled them to exploit a wide range of habitats including tropical and temperate woodlands, plantations and mangroves [17]. Epiphytism is not evenly distributed between plant families and epiphytic groups [18]. The global distribution, abundance and diversity of non-vascular groups such as bryophytes and lichens are yet to be assessed, and estimated the global total occurrence of lichens to 20000 species, while Peh et al. [19] calculated the total number of bryophytes to nearly 11000 species. Vascular as well as non-vascular epiphytes are two very diverse [20]. The studies on pharmaceutical ethnobotany in the region of pallars [18] argued that in any given sample plot, non-vascular epiphytes would contribute substantially to the epiphytic diversity, and in some instances exceeded the vascular epiphyte diversity and aboundance [18]. Baldwin and Bradfield [21] reported that “rare” bryophytes species on forest story leaves are actually very abundant in the outer branches of canopy trees. The shift in habitat could be explained by high tree mortality, the opening up of the canopy and the resulting increase in solar radiation [22].

The numerous types of epiphytic adaptations and the variation in growing locations highlighted the importance epiphytes play in forest dynamic processes such as nutrient cycling [23]. Epiphytes are important contributor to the global plant diversity [15] and they provide a wide variety of habitats and food sources for other organisms [24].

The ecology of epiphytes is highly complex and in order to achieve a more comprehensive knowledge, other ecological disciplines must be incorporated [18]. For example, Parrot [25] argued that most ecophysiological studies focused mainly on abiotic factors, whereas biotic interactions such as herbovory, pathogens and competition received only little attention.

Plants in temperate forests [26] and seasonally dry tropical forests [27] tend to have a single, synchronous reproductive cycle each year due to seasonal constraints of temperature and moisture [28]. In wet tropical environments, where annual temperature shows little fluctuation and dry periods are less pronounced, plant phenology may respond to subtle environmental cues, such as small shifts in light, nutrients or precipitation [29].

Phenological studies in tropical regions have typically examined flowering and fruiting in trees or understory shrubs [30]. Far less is known about patterns of epiphyte phenology in the canopy [31], Epiphytes in tropical canopies are remarkably diverse and likely show asynchronous phonological patterns at the community level. Because epiphytes are key players in primary productivity, carbon sequestration, water and nutrient cycling, and mutualistic interactions with pollinating and seed-dispersing animals [32], studies on epiphytes are important addition to our understanding of tropical processes. Production of flowers and fruits when appropriate pollinators and seed dispersers are present can increase reproductive success and plant fitness [33].

2. MATERIALS AND METHODS

The Federal Capital Territory (FCT) falls within the Guinean forest – savanna mosaic zone of the West African sub – region [34]. It is bounded by Kaduna state (to the North), Kogi state (to the South), Niger state (to the West) and to the East is Nasarawa state.

The Federal Capital Territory lies between the latitude of 8^{o} 25^{o} and 9^{o} $25^{'}$N and longitude 6^{o} 45^{o} and $45^{'}$E of the Greenwich Meridian; an area covering about 8000km^{2} [35]. The FCT has six area councils namely: Abaji, Abuja Municipal, Bwari, Gwagwalada, Kuje and Kwali area councils (Fig. 1).

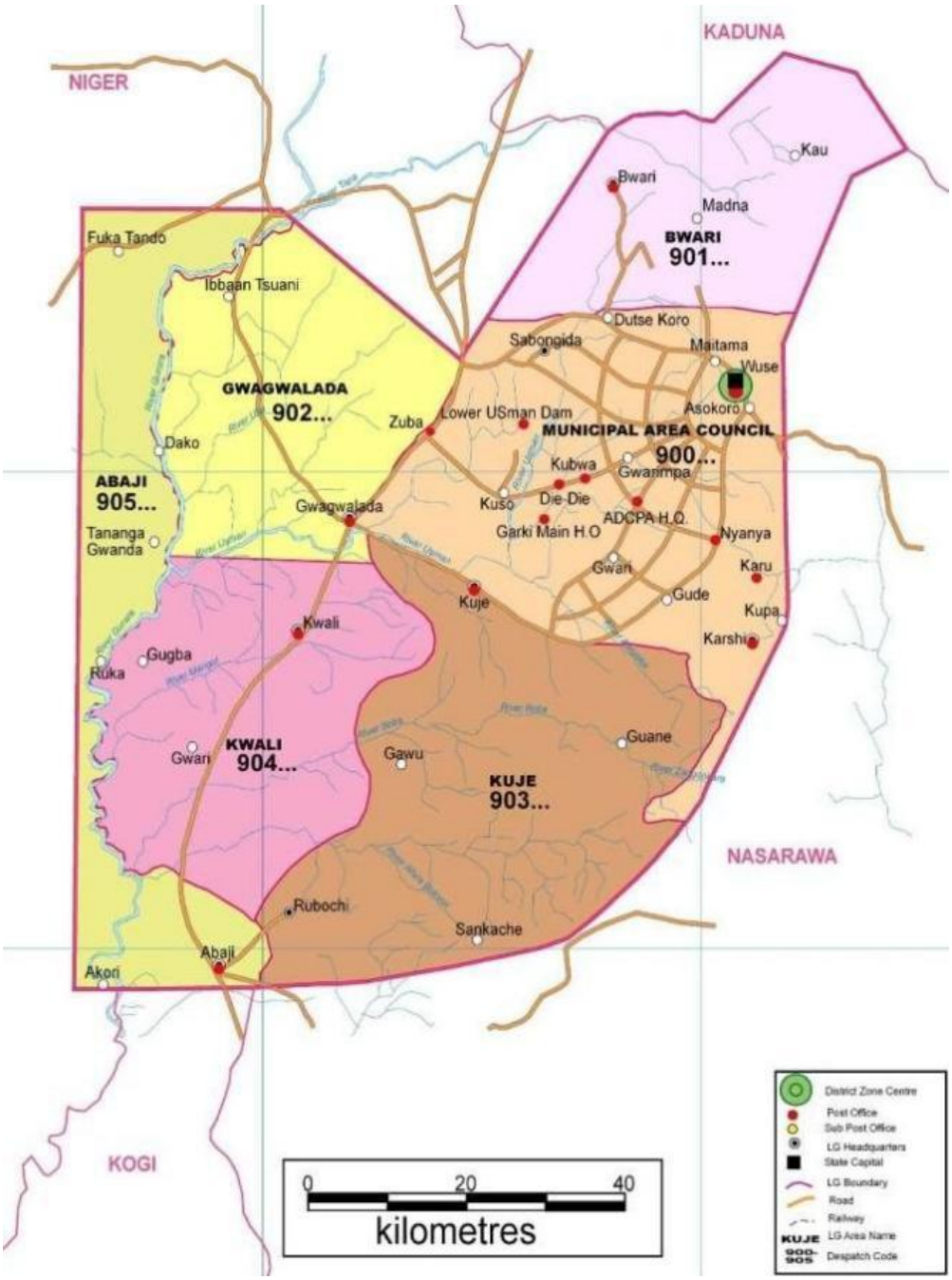


Fig. 1. Map of the Federal Capital Territory Showing the Six Area Councils
Source: Department of Planning and Survey, F.C.D.A, Abuja, 2017 [36]

A reconnaissance survey of the study area was carried out from November to December, 2021 in the six area councils of the FCT namely; Abaji, Abuja Municipal, Bwari, Gwagwalada, Kuje and Kwali [36].

The study was survey research in which a total of 90 respondents were randomly drawn from the six area councils that make up FCT. Species recommendation during preparatory field observations were done. All epiphytes were collated and analyzed using information on diversity and taxonomic classification. Data was collected using field surveys on diversity of epiphytes as described by Igbarese and Ogbole [37]. Field survey was carried out in the company of a Field Assistant who identified the plant in local languages. The plants that could not be

identified in the field were taken to the Biological sciences Department, University of Abuja, for proper identification of their vernacular names, scientific equivalent, and documentation. Lichens samples were identified by applying direct microscopic observation and thin layer chromatography (TCL).

Identification of plants was done with the aid of a Handbook of African Medicinal Plants [38]. The inventory of available epiphytes were recorded, and literature on epiphytes searched to back up the claims by the respondents. Data was collected by administering semi-structured questionnaires to 90 respondents for a single purpose face-to-face interview.

Data was analyzed using standard diversity analytical tools such as determination of respondent's consensus factor, sincerity level, ranking and scoring.

Prior written informed consent as advised by Bradai et al. [39] was taken from the respondents. All the epiphytes were collated and analyzed using diversity and taxonomic information. Pearson correlation analysis was used to determine the relationship between diversity and scientific classification in order to assess variable pronounced with the most impact. Species diversity was calculated according to Shannon – Wiener diversity index [40] in each station. The Shannon – Wiener's index (H') of species diversity was given as:

H' = - ∑PiLnPi…….. [41]; where Pi was the proportion of the total number of individuals occurring in species i.

Species richness was determined using the Margalef's Index (D) for species richness: D = (S – 1) / LnN……. [42].

Where S = number of species and N = number of individuals.

The structure and composition of epiphyte communities (biological parameters) were analyzed through descriptive statistical tools on SPSS. This permitted the determination of the percentage composition, relative abundance of the species and species identified for each sample.

After identification, identified species were deposited at the University of Abuja herbarium.

3. RESULTS

A total number of thirty (30) epiphytic species which cut across various taxonomic groups were collected from three points selected randomly from each of the area councils: administrative town and two settlements. The scientific classification of the epiphytes based on their taxonomic groups and area councils where they were present in the Federal Capital Territory is represented in Table 1 and plates from 1 – 29 below.

Table 1. Epiphytes in the Federal Capital Territory, and their Taxonomic Groups

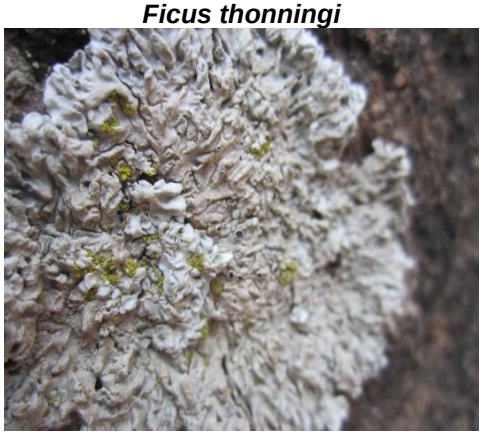
Divison	Order	Family	Genus	Species	Area Council
Polypodiophyta	Polypodiales	Nephrolepidaceae	*Nephrolepis*	*biserrata*	ABJ, BWR, GWA, MUN, KUJ, KWL
Polypodiophyta	Polypodiales	Polypodiaceae	*Platycerium*	*stemaria*	BWR, ABJ, GWA, MUN, KUJ, KWL
Tracheophyta	Rosales	Moraceae	*Ficus*	*benghalensis*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Rosales	Moraceae	*Ficus*	*vogelii*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Arecales	Arecaceae	*Elaeis*	*guineensis*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Asterales	Asteraceae	*Ageratum*	*conyzoides*	ABJ, BWR, GWA, MUN, KUJ , KWL
Tracheophyta	Rosales	Moraceae	*Ficus*	*leprieurii*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Rosales	Moraceae	*Ficus*	*lutea*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Rosales	Moraceae	*Ficus*	*thonningii*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Rosales	Moraceae	*Ficus*	*exasperata*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Rosales	Moraceae	*Ficus*	*platyphylla*	ABJ, BWR, GWA, MUN, KUJ, KWL
Tracheophyta	Polypodiales	Lomariopsidaceae	*Nephrolepis*	*undulata*	BWR, KUJE, MUN
Tracheophyta	Fabales	Fabaceae	*Polyhandra*	*longiflora*	ABJ, BWR, GWA, MUN,

Divison	Order	Family	Genus	Species	Area Council
					KUJ, KWL
Tracheophyta	Poales	Poaceae	*Digitaria*	*ciliaris*	ABJ, BWR, GWA, MUN, KUJ, KWL
Basidiomycota	Polyporales	Fomitopsidaceae	*Fomitopsis*	*sp*	ABJ, BWR, GWA, KUJ, KWL
Basidiomycota	Agaicales	Agaricaceae	*Lycoperdon*	*spadiceus*	ABJ, BWR, GWA, MUN, KUJ, KWL
Basidiomycota	Agaicales	Psathyrellaceae	*Coprinus*	*lagopus*	GWA, KUJ
Basidiomycota	Auriculariales	Auriculariaceae	*Auricularia*	*polytricha*	ABJ, BWR, GWA, MUN, KUJ, KWL
Magnoliophyta	Dipsacales	Adoxaceae	*Viburnum*	*tinus*	ABJ, BWR, GWA, MUN, KUJ , KWL
Ascomycota	Xylariales	Hypoxylaceae	*Daldinia*	*concentrica*	GWA, KUJ
Bryophyta	Hypnales	Stereophyllaceae	*Entodontopsis*	*nitens*	GWA, MUN
Bryophyta	Hypnales	Plagiotheciaceae	*Plagiothecium*	*undulatum*	ABJ, BWR, GWA, MUN, KUJ, KWL
Bryophyta	Hypnales	Entodontaceae	*Entodon*	*sp*	ABJ, BWR, GWA, KUJ, KWL
Bryophyta	Pottiales	Pottiaceae	*Syntrichia*	*laevipila*	BWR, GWA
Bryophyta	Funariales	Funariaceae	*Funaria*	*sp*	ABJ, BWR, GWA, KUJ, KWL
Marchantiophyta	Porellales	Frullaniaceae	*Frullania*	*dilatata*	ABJ, BWR, GWA, MUN, KUJ, KWL
Anthophyta	Urticales	Moraceae	*Ficus*	*aurea*	ABJ, BWR, GWA, MUN, KUJ, KWL

KEY
GWA - Gwagwalada
ABJ - Abaji
BWR - Bwari
KUJ - Kuje
MUN - Municipal
KWL - Kwali

Ficus thonningi

***Elaeis guinensis* persistent old frond**



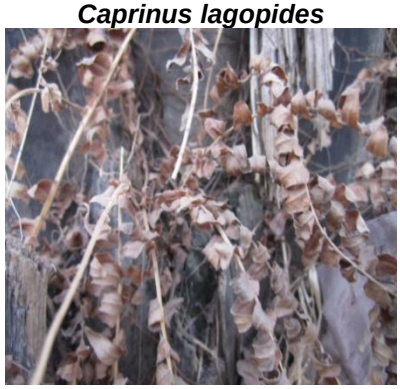
Daldina concentrica

Auricularia polytricha

Ficus lepriori

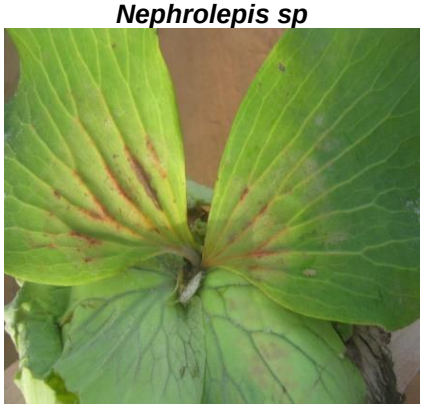
Caprinus lagopides

Funeria sp



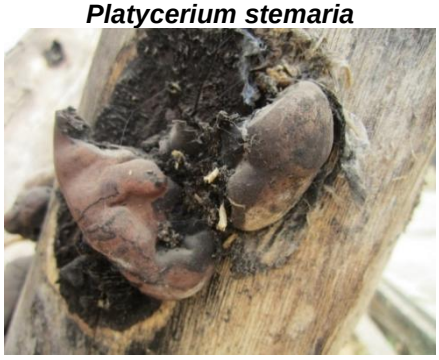
Nephrolepis sp

Platycerium stemaria



Sporophyte phenological phase of *Platycerium stemaria*

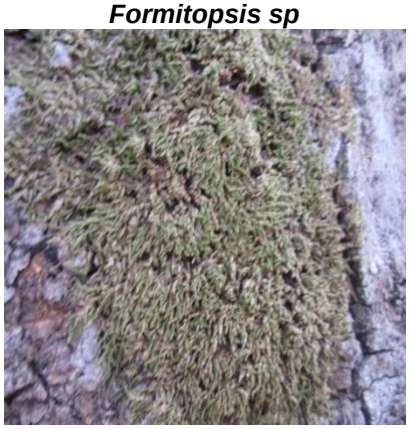
Syntrichia laevipila



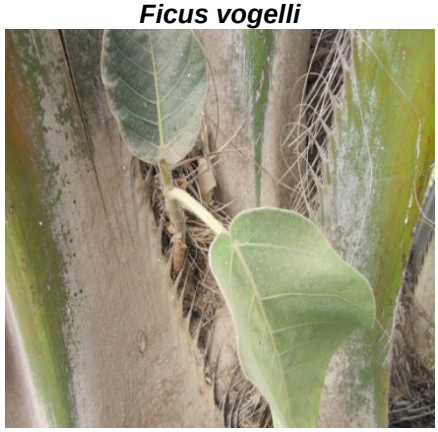
Frullania dilatata

Formitopsis sp

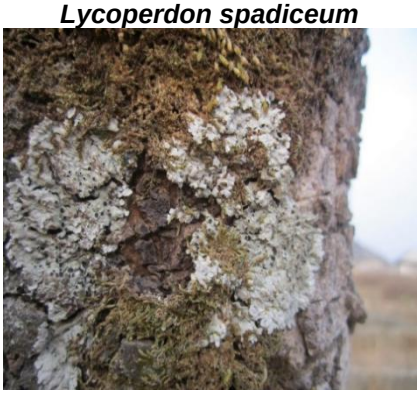
Ficus vogelli



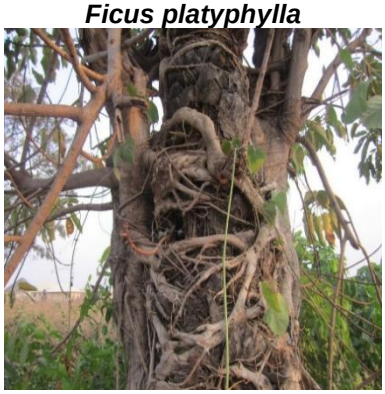
Lycoperdon spadiceum



Ficus platyphylla



Lycoperdon spadiceus* and *Daldina cocentrica



Ficus sp

Plagiothecium undulatum

Digitaria sp

Nephrolepis undulata* and *Ageratum conyzoides

Ficus sp., Calyptrochium emarginatum* and *Cyrtorchis sedeni

Entodon sp

***Ageratum conyzoides*, *Nephrolepis exaspirata, Ficus* sp**

Viburnum tinus

Ficus aurea

Ficus platyphylla

Peperomia pelucida

Epiphytes roots

Plates 1 – 29. Photos of Identified Host and Epiphytes Plants in the Federal Capital Territory

Table 2. Epiphytic Classification Based on Mode of Life

Epiphytes	Family	Taxonomic Group	Epiphytic Classification
Nephrolepis biserrata	Dennstaediaceae	Pteridophyte	Typical Epiphyte
Platycerium stemara	Polypodiaceae	Pterydophyte	Typical Epiphyte
Ficus benghalensis	Moraceae	Angiosperm	Semi Epiphyte
Ficus vogelii	Moraceae	Angiosperm	Semi Epiphyte
Ficus platyphylla	Moraceae	Angiosperm	Semi Epiphyte
Ficus aurea	Moraceae	Angiosperm	Semi Epiphyte
Ficus thonningi	Moraceae	Tracheophyta	Typical Epiphyte
Ficus exasperata	Moraceae	Tracheophyte	Typical Epiphyte
Ageratum conyzoides	Asteraceae	Angiosperm	Occasional Epiphyte
Elaeis guineensis	Araceae	Angiosperm	Occassional Epiphyte
Lycoperdon spadiceum	Agaricaceae	Fungi/Thallophyte	Typical Epiphyte
Coprinus lagopus	Psalthyrellaceae	Fungi/Thalophyte	Typicaal Epiphyte
Auricularia polytricha	Agaricaceae	Fungi/Thallophyte	Typicalal Epiphyte
Daldinia concentrica	Hypoxylaceae	Fungi/Thallophyte	Typical Epiphyte
Ficus leprieurii	Moraceae	Angiosperm	Semi/ Epiphyte
Frullania dilatata	Frullanaceae	Bryophyte	Typical Epiphyte
Plagiothecium undulatum	Plagiotheciaceae	Bryophyte	Typical Epiphyte
Entodon nitens	Entodontaceae	Bryophyte	Typical Epiphyte
Syntrichia laevipila	Pottiaceae	Bryophyte	Typical Epiphyte
Digiteria ciliaris	Poaceae	Tracheophyta	Typical Epiphyte
Viburnum tinus	Adoxaceae	Tracheophyte	Typical Epiphyte
Ficus lutea	Moraceae	Tracheophyte	Typical Epiphyte
Nephrolepis undulata	Oleandraceae	Pteridophyte	Occasional Epiphyte
Ficus thonningi	Moraceae	Tracheophyte	Typical Epiphyte
Ficus exasperata	Moraceae	Tracheophyte	Typical Epiphyte
Funeria sp.	Funariaceae	Bryophyte	Typical Epiphyte
Fomitopsis sp.	Formitopsidaceae	Polyporales	Occasional Epiphyte

The epiphytes were classified based on their mode of life as shown in Table 2 abpve. Some epiphytes were Typical Epiphytes while others were Semi Epiphytes and Occasional Epiphytes.

4. DISCUSSION

The study shows that different epiphytic plants occur in the Federal Capital Territory (FCT), Nigeria, and they belong to various taxonomic groups. Table 1: Epiphytes in the Federal Capital Territory, and their Taxonomic Groups, indicated that *Nephrolepis bisserata* (Sw.) Schott, *Platycerium stemaria* (P.Beauv.) Desv. *Ficus benghalensis* L., *Ficus vogelii* Miq., *Elaeis guinensis* Jacq., *Ageratum conyzoides* (L.) L., *Ficus leprieurii* (Miquel), *Ficus lutea* Vahl, *Ficus thonningi* Blume, *Ficus exasperate* Vahl. *Ficus platyphylla* Delile, *Polyhandra longiflora* L., *Digitaria ciliaris* (Retz.) Koeler, *Lycoperdon spadiceus* Pers., *Auricularia polytricha* (Mont.) Sacc., *Viburnum tinus* L., *Plagiothecium undulatum* (Hedw. Schimp. *Frullania dilatata* (L.) Dumort. and *Ficus aurea* Nutt. were found to be present in all the area councils of the FCT while *Fomitopsis sp* P.Karst., *Entodon sp* MÜll. Hal. and *Funaria sp* Hedw. were seen in Abaji, Bwari, Gwagwalada, Kuje and Kwali area councils. *Nephrolepis undulata* (Afzel. Ex Sw.) J.Sm. occurred in Bwari, Kuje and Municipal area

councils. Other epiphytes that were present included *Coprinus lagopus* P.Karst., *Daldinia concentrica* (Bolton) Cesati and de Notaris, *Entodontopsis nitens* (Mitt.) W.R.Buck and Ireland, *Syntrichia laevipila* (Brid.) K.F.Schultz. They occurred in Bwari, Gwagwalada, Kuje, and Municipal area councils.

The taxonomic classification of the epiphytes further indicated that *Nephrolepsis bisserata* (Sw.) Schott, *and Platycerium stemaria* (P.Beauv.) Desv., belong to the Division Polypodiophyta [43]. According to Heatwole et al. [44], *Ficus benghalensis* L., *Ficus vogelii* Miq., *Ageratum conyzoides* (L.) L., *Ficus lepriori* (Miquel), *Ficus lutea* Vahl, *Ficus thonningi* Blume, *Ficus exasperate* Vahl., *Ficus platyphylla* Delile, *Polyhandra longiflora* L., *Digitaria ciliaris* (Retz.) Koeler, belong to Tracheophyta while *Fomitopsis sp* P.Karst., *Lycoperdon spadiceus* Pers., *Caprinus lagopides* P.Karst. and *Auricularia polytricha* (Mont.) Sacc., are Basidiomycota [45]. According to Hartley [46], *Viburnum tinus* L., is of the Division Magnoliophyta with *Daldina concentrica* (Bolton) Cesati and de Notaris, belonging to Ascomycota [47]. *Entodontopsis nitens* (Mitt.) W.R.Buck and Ireland, *Syntrichia laevipila* (Brid.) K.F.Schultz., *Plagiothecium undulatum* (Hedw.) Schimp., *and Frullania dilatata* (L.) Dumort., belong to *Marchitophyta* [48] while *Ficus aurea* Nutt. is a member of Anthophyta [49]. *Entodon sp* MÜll. Hal. and *Funaria sp* Hedw. represent the Division Bryophyta [50]. Table 2: Epiphytic Classification Based on Mode of Life indicated that *Nephrolepis bisserata, Platycerium stemaria, Ficus thonningi, Ficus exasperata, Lycoperdon clavatum, Caprinus lagopides, Auricularia polytricha, Daldinia concentrica, Frullania dilatata, Plagiothecium, Entodon nitens, Syntichia laevipila, Digitaria ciliaris, Vibrnum tinus, Ficus lutea, Ficus thonningi, Ficus are* typical epiphytes [51] while *Ficus benghalensis, Ficus vogelii, Ficus lepriori, Ficus plathphylla, Ficus aurea, Ficus exasperata and Funaria sp* are semi epiphytes [52] *Ageratum conyzoides, Elaeis guineensis, Nephrolepis undulata* and *Fomitopsis sp* are occasional epiphytes [53,54].

5. CONCLUSION

The research shows that different types of epiphytes exist in the Federal Capital Territory, and they belong to various taxonomic groups. They live as typical, semi or occasional epiphytes. The outcome of this research will obtain documentary information on the Diversity and Taxonomic Classification of Epiphytes in the Federal Capital Territory (FCT).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

We hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

CONSENT

As per international standards or university standards, respondents' written consent has been collected and preserved by the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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