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Research Article

Abundance and distribution of species in relation to soil properties in sedge-dominated habitats in Uyo Metropolis, Southern Nigeria

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Abstract

A field research was conducted to assess abundance and distribution of species in relation to soil properties in Sedge-dominated Habitats in Uyo Metropolis, Southern Nigeria Systematic sampling method was used. The result of the study revealed that a total of 12 plant species of which 3 were members of the family Cyperaceae were identified in the habitats studied. The Cyperaceae members found were of the genus: *Cyperus.* Other associated species found were *Sida acuta*, *Scoparia dulcis*, *Chromolaena odorata*, *Eleusine indica*, *Ludwigia decurens* etc. The highest density values obtained in this study is characteristic of *Cyperus iria* in Habitat 4 (9500 st/ha) while the least density value is characteristic of *Plastostoma africanum* in Habitat 2 (200st/ha). Multivariate correlation and regression techniques evidenced that these differences in density of the sedges reflected the functions of various important soil properties such as pH, exchangeable Ca, soil moisture, total nitrogen and available phosphorus. Most specifically, the current result concludes that *Cyperus iria* showed strong affinity for alkaline soils rich in calcium while *Cyperus difformis* and *Cyperus rotundus* showed strong preference for acid soils. *Cyperus difformis, Cyperus rotundus* and *Cyperus haspan* flourished in soils rich in organic manure while *Cyperus iria* colonies were found thrived on soils with limiting levels of phosphorus This result lends knowledge and practical application in environmental management, weed science and habitat ecology.

Introduction

Cyperaceae is one large family amongst the Monocotyledons comprising up to 104 genera and about 5000 species [1]. Though most members of the Cyperaceae are considered serious weeds, they have a wide cosmopolitan distribution, with a dense concentration in the tropics. Despite this, relevant data on these plants are scanty going through literature and herbarium specimens [2]. The wide occurrence of these species enforces the need to intensify research efforts on the economic values and niche preferences of these individual belonging to taxonomically difficult but highly interesting plant family. Pedology is the scientific study of soil properties. Studies have revealed that most often than not, Soil and vegetation is interlocked in a series of intricate relationships which can never be taken for granted. Superficially, it is known that while plants serve as protective coverings for soil and as anchorage against erosion and other physical agents of destruction, it is also major plant nutrient reservoir and home to several beneficial microbes. Hence, from the foregoing it worthy to note that vegetation cover affect the characteristics of soil including pH, nutrient concentrations, texture etc and vice versa. This phenomenon has led to varied impact on vegetation assemblages thus shaping its composition and structure [3,4].

Knowledge of the niche concept theory further applauds this idea that vegetation communities are inevitably mingle in a web of unique connections with incumbent abiotic factors

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in their environment leading to individualistic and communal responses from plants due to these influences [5,6]. In line with the fore going, several erudite scholars have probed this notion supporting the nexus between the vegetation distribution and its soil environment in diverse natural and created ecosystems. Some of these include: [3], in Fresh water swamp forest [7] in vegetable (*Gnetum* sp.) farms [8], in mixed oak forest as well as Ogbemudia and Mbong [9], in some dumpsites.

The roles of these omnipresent soil variations govern the dynamics of plant communities both in terms of numeric abundance and floristic attributes [4,10]. These natural interactions may be especially important from micro to ultra-scales especially in this current era of plant resource conservation and in the wake of climate uncertainties. To this end, this study seeks to reveal knowledge on the influence of pedo-ecological properties on four common Cyperaceae plants found in our immediate environment. This may give birth to management clues useful for their conservation in our clime.

Materials and methods

Study area

This research was carried out in Uyo Local Government Area. It is the Capital city of Akwa Ibom State found within the South-South region of Nigeria. Uyo lies between longitude 37°50'E and 37°51'E and latitudes 55°40'N and 54°59'N. The Local Government Area covers a specific are of about 188.035km² with an estimated population of 3,920,208 and experiences an annual precipitation of approximately 1000mm (AKSG 2019). Uyo is geographically bounded on the East by Uruan Local Government Area, on the west by Abak Local Government Area, Ikono, Ibiono Ibom and Itu Local Government Areas on the North as well as Nsit Ibom, Etinan and Ibesikpo Asutan Local Government Areas on its southern axis. This area is clearly describe in the map below (Figure 1).

Vegetation and soil sampling

Species were sampled in 10m x 10m quadrats, spaced at regular intervals of 20m according to the methods of Ubom (1996) and Greig-Smith [11]. In each quadrat, plants were enumerated and species were properly identified to the species level. Voucher specimens of unknown species were collected for proper identification at the Botany and Ecological Studies Departmental Herbarium, University of Uyo, Akwa Ibom State. Frequency of occurrence and density of the species encountered were estimated according to the methods of Ubom, et al. [3].

Also within each quadrat, two soil samples were obtained at the depths of 0- 15 cm respectively which was later bulked to form a composite sample according to Mbong and Ogbemudia [12]. The soil samples were air- dried and preserved for laboratory analysis. Soil pH was determined using Hanna hand held pH meter. Available phosphorus, Exchangeable Ca and Organic matter were determined using standard methods [13].

Statistical analysis

Mean and standard error were computed from triplicate values obtained from the determination of soil physico-

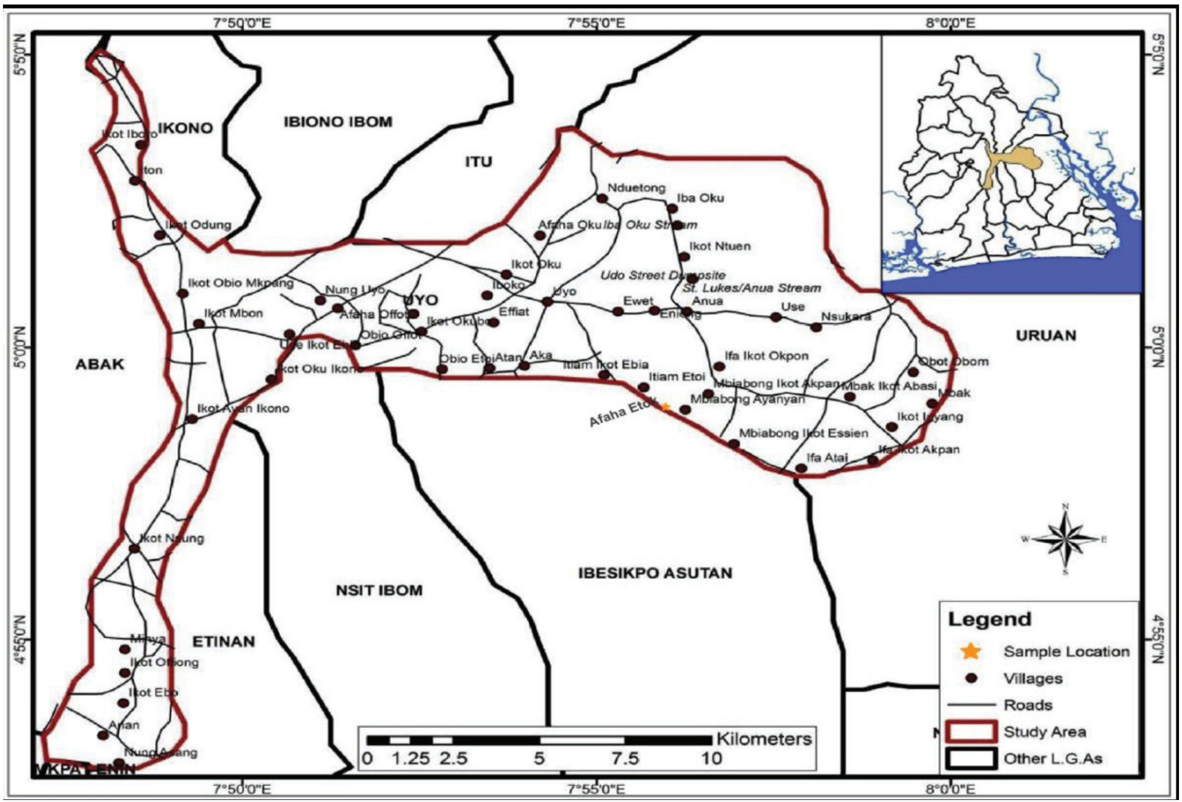

Figure 1: Map of Uyo Local Government Area Showing Sampling Location.

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chemical properties. Analysis of variance (ANOVA) and Fisher least significant different (LSD) test were employed to ascertain significant differences between the means of the physicochemical properties of the studied soils. Pearson's correlation computed through SPSS was employed to ascertain the nature and strength of association existing between soil properties and density values of sedges in the study area according to the methods of Mbong, et al. [10]. In order to probe the influence of soil properties on the distribution of sedges, bivariate regression (logarithmic) was employed. Only sedges with moderate to high significant Carl Pearson association coefficient were adopted for this protocol Ubom [14].

Result

The distribution of sedges and associated species found in the study area is shown in Table 1. The table records a total of 12 plants unevenly distributed in four habitats. Habitat 1 recorded up to 5 species of which 1 is a sedge, Habitat 2 records two sedges and two associated species, Habitat 3 has three species of which only includes one sedge and then Habitat 4 which has 8 species (out of which 3 sedges were present). The highest plant density obtained in this study was characteristic of Habitat 4 (9500 stands ha^{-1} obtained for *Cyperus iria*) while the least density was the characteristic of Habitat 2 (200 stands ha^{-1} recorded for *Plastostoma africanum*) Table 2.

Table 3 shows the mean physicochemical properties of the soils of sedge dominated habitats in Uyo. The soil pH was highest in Habitat 1 (6.62±0.095) but least in habitat 4 (4.95±0.14). Conversely, soil organic matter was highest in habitat 4 (2.95 ±0.15) but least in habitat 3 (2.52±0.20). Also, available phosphorus was highest in habitat 3 (33.92±3.28) but was least in habitat 1 (19.94±0.13). Also, a higher value of 19.01±0.11 recorded for soil exchangeable Ca in habitat 1 whereas a lower value of 8.85±0.05 was recorded in habitat 3. Soil moisture content was highest in habitat 1 (46.71±2.51) but least in habitat 2 (38.96±6.42).

The correlation matrix (Table 4) revealed high significant correlation coefficients between soil properties and density of sedges in the studied location. The matrix shows that Available phosphorus correlated negatively and significantly with soil exchangeable Ca (-0.979*) wheareas on the contrary, soil moisture content correlated positively and significantly with exchangeable Ca (0.971*). Also, *Cyperus iria* correlated positively and significantly with the soil pH (0.985*) while *Cyperus difformis* orrelated positively and significantly with *Cyperus rotundus* (0.999**). The regression of soil properties on the individual sedges yielded predictive equations with statistically high levels of accuracy. *Cyperus iria* was sensitive to soil pH, Available phosphorus and Exchangeable Calcium. On the other hand *Cyperus difformis* and rotundus were sensitive to soil pH and organic matter while *Cyperus haspan* exclusively sensitive to soil organic matter (Table 5).

Discussion

The vegetation physiognomy of the study area shows a total of four sedges with other associated species. This occurrence agrees with the principles of Mbong et. al. [12], that plant do not grow in isolation and that different species growing together in the same habitat under similar environmental conditions will differ in their tolerance or response to environmental gradient. This justifies the variability recorded in the patchy occurence and density of the species encountered. This was noted by earlier researchers [15].The numeric gaps as judged from the density values of the Cyperaceae species and other plants underscores the variability in species response to the soil

Table 1: The geographical coordinates for sedge habitats.

Habitat	Longitude	Latitude
1	7° 56' 31.40"	4° 59' 25.84"
2	7° 56' 32.06"	4° 59' 25.89"
3	7° 56' 31.34"	4° 59' 26.42"
4	7° 56' 31.38"	4° 59' 28.47"

Table 2: Plant distribution in the study area.

Habitat/Species	Family	Density(stha^{-1})
Habitat 1		
Mitrocarpus villosus	Rubiaceae	600
Chromolaena odorata	Asteraceae	400
Sida acuta	Malvaceae	400
Centrosema pubescens	Leguminosae	300
Cyperus haspan	Cyperaceae	2500
Habitat 2		
Cyperus haspan	Cyperaceae	4000
Scoparia dulcis	Scoparaceae	800
Cyperus iria	Cyperaceae	3000
Plastostoma sp.	Rubiaceae	200
Habitat 3		
Cyperus iria	Cyperaceae	2100
Bidens pilosa	Asteraceae	400
Sida acuta	Malvaceae	400
Habitat 4		
Cyperus iria	Cyperaceae	9500
Cyperus difformis	Cyperaceae	3000
Scoparia dulcis	Scoparaceae	1500
Cyperus rotundus	Cyperaceae	4000
Mitrocarpus villosus	Rubiaceae	1700
Ludwigia decurens	Onagraceae	3000
Sida acuta	Malvaceae	900
Eleusine indica	Gramineae	400

Table 3: Soil Physical and Chemical Properties of Sedge Habitats.

	Habitat 1	Habitat 2	Habitat 3	Habitat 4
pH	6.62±0.095	6.51±0.10	5.25±0.01	4.95±0.14
Organic Matter (%)	2.54±0.06	2.87±0.01	2.52±0.20	2.95±0.15
Av. P. (mg/kg)	19.94±0.13	31.2±1.40	33.92±3.28	30.50±1.37
Ex. Ca (cmol/kg)	19.01±0.11	9.05±0.15	8.85±0.05	11.75±0.15
Soil Moisture (%)	46.71±2.51	38.96±6.42	40.13±9.81	42.77±6.23

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Table 4: Soil-vegetation correlation matrix of Sedge-dominated Habitats in Uyo.

	pH	Org. Matt.	Av. P	Ex. Ca.	Moisture	*C.Iria*	*C.haspan*	*C.difformis*	*C.rotundus*
pH	1								
Org. matt.	-.222	1							
Av. P	-.623	.323	1						
Ex. Ca	.457	-.358	-.979*	1					
Moisture	.233	-.329	-.905	.971*	1				
C.Iria	.985*	-.053	-.592	.418	.195	1			
C.haspan	-.352	.664	-.212	.291	.415	-.235	1		
C.difformis	-.687	.691	.175	-.058	.122	-.577	.913	1	
C. rotundus	-.687	.691	.175	-.058	.122	-.577	.913	.999**	1

Note: * = significant at 0.05; **= significant at 0.01; Av. P = available phosphorus; Ex. Ca = exchangeable calcium; Org. matt = organic matter

Table 5: Influence of soil properties on the abundance of Sedges in the Habitats.

Species	Equation	Prediction Accuracy(R^2)
C. iria	- 50.21+30.90 ln(pH)	98.3
C. difformis	35.28-18.96 ln(pH)	70.1
C. rotundus	36.54-19.64 ln(pH)	70.1
C. difformis	-31.49+33.55 ln(Org. matt.)	68.4
C. rotundus	-32.62+34.76 ln(Org matt.)	68.4
C. haspan	3.09+5.20 ln(Org matt.)	65.8
C. iria	42.15-11.40 ln(Av. P)	58.4
C. iria	-7.95+4.89 ln(Ex. Ca)	37.3

properties such as pH, calcium, organic matter soil moisture regimes and available phosphorus in the four habitats.

It is believed that the dominance rate of members of Cyperaceae weeds particularly those *Cyperus iria*, *Cyperus haspan*, *Cyperus difformis* and *Cyperus rotundus* is related with the fact that these soils have substantial and reasonable moisture content in them. This aligns with the soil moisture values recorded in these results and tangles with Akobundu and Agyakwa [16] opinion that sedges flourish in soils with moderate to high moisture regimes because they have ability to adapt to such situations. This trend may be practically explained in that their seeds are produced in large quantities and are being spread almost evenly by wind, rain splashes or slow water current across the nutrient-rich muddy substrate.

On the other hand, the low density noted for *Plastostoma africanum*, *Sida acuta*, *Centrosema pubesens* etc may be linked with their poor adaptability to the existing environmental conditions inherent in the habitat or ineffective reproductive strategies. This idea aligns with the views of [7,17] opined that efficient reproductive strategies and good dispersal capabilities are the two factors that could explain dominance and rarity in natural ecosystems.

The density values noted for *Ludwigia decurrens* compares with those of the Cyperaceae species in this study [17]. This is justified in that it can be interpreted to mean that these species may share similar environmental and nutrient requirements and this phenomenon is suggestive of a considerable level of competition in these habitats. Agreeing with this, Verma and Agrawal [18] noted that density estimates give information on the degree of competition in within a particular habitat. This is evident in this study in that, there is a visible but short-ranged variation in the numerical strength of species such as *Centrosema pubesens*, *Bidens pilosa*, *Sida acuta*, *Plastotoma sp.*, *Chromolaena odorata* and *Eleusine indica* which is an indication of a fierce and continuous competition for scarce environmental resources.

The suitability of correlation analysis in ascertaining the nature and strength of relationships existing between pairs of variables and the role of regression analyses in predicting the influence of associated variables on each other as found in this research is well documented by previous researchers [3,14,19,20]. Currently the high significant correlation coefficient obtained between *C. difformis* and *C rotundus* in the matrix cannot be ignored because it hints that both sedges share similar soil nutrient preferences. Also, the matrix indicated that *Cyperus iria* showed strong affinity for alkaline soils while *Cyperus difformis* and *Cyperus rotundus* showed high preference for acidic soils with increased organic matter content. This pattern of relationship exhibited by *Cyperus difformis* and *Cyperus rotundus* reflects that habitats dominated by them witnessed continuous decomposition of dead plant materials (litter) giving rise to soil organic matter which on deposition is constantly associated with the addition of reasonable amounts of organic acids to the soil which keeps reducing the amount of calcium in the habitats. This is in tandem with Stevenson [21].

Specifically, *Cyperus iria* showed negative moderate association with the amounts of available phosphorus in the soil which explains that high density of this plant were observed in sites with low available phosphorus. In line with this trend, the regression model bears a negative slope. This is not unmatched. Here the relationship is understood in that this fast growing sedge persistently keeps drawing reasonable amounts of phosphorus from the soil stock, leaving room for deficits with little or slow compensative replacement since this much needed macro nutrient is necessary to maintain its existing colonies and facilitate the establishment of new ones. On a general note, phosphorus is required by plants for the synthesis of ATP, constitution of plant nucleic structure and in the maintenance of plant health and vigor from seedling stage to maturity [18].

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Positive correlates and slope values obtained in the matrix and in the models respectively between sedges (*Cyperus difformis*, *Cyperus rotundus* and *Cyperus haspan*) and soil organic matter reflect that these plants flourished in sites with high organic matter content. The role of organic matter as an essential source of nitrogen in soils can never be undermined (Mbong, 2013). The continuous presence of moisture in the soil facilitates microbial activities enhancing the decay and decomposition of dead plant materials giving rise to a regular supply of nitrogen to the plants in the study area. Nitrogen is not only necessary for plant growth but is also necessary for the synthesis of chlorophyll [22].

Notable are the negative slopes obtained in the regression equation explaining the distribution of *C. difformis* and *C. rotundus* in relation to soil pH. This trend summarize that these two sedges thrive on acidic soils. In simple terms, *high density of C. difformis* and *C. rotundus* were recrded on sites with low pH. On the contrary, the regression model relating *C. iria* with soil pH and exchangeable Ca both carry positive slopes which bear evidence that *C. iria* bloom is favored with an increasing pH. This not novel but in this account it authenticates the fact that increased calcium concentration in these sites foster enhanced values of soil pH and this observation tallies with Gould and Harper [23-26], view that these enhance pH increases the availability of nutrients to plants giving rise to a high dense cover of *C. Iria* in almost all the sites. Again, the increased pH facilitates microbial decomposition of plant debris giving rise to rapid nitrogen release into the soil.

Conclusion

This research concluded that, the study area is endowed with a total of 13 plant species of which 4 were members of the family Cyperaceae. The Cyperaceae members mostly found were mostly of the genera: *Cyperus.* Other associated species found were *Sida acuta*, *Scoparia dulcis*, *Chromolaena odorata*, *Eleusine indica*, *Ludwigia decurens* etc. These species are unevenly distributed in the four habitats. The differences in their distribution have been explained as a function of variations in soil properties such as pH, moisture content, organic matter, exchangeable Ca and available phosphorus. The interactions existing between plant species with soil properties thus indicate their importance in this ecosystem. The information obtained from this study could be useful in the management and conservation of lawns and (or) other sedge-dominated habitats.

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