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Abundance, distribution and biotic indices of aquatic macrophyte community of a riparian stream in Odot, Niger Delta, Nigeria

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ABSTRACT
The abundance and distribution composition of aquatic macrophyte species in a riparian stream in Odot, rainforest environment of south-south Nigeria were assessed twice a month at three stations between June and December 2014. The modified method of flora collection was used with a random sampling technique. The correlation analysis indicated that the distribution and abundance of aquatic macrophyte composition were significantly ($P<0.05$) different. Overall community structure was made up of 15 families, 18 genera and 19 species. The dominant family was Poaceae (84; 27.81%) with three species while the dominant specie was *Acroceras zizanioides* (66; 21.85%); weed floral contributions were 22 individuals (21.79%) in station 1, 15 individuals (16.67%) in station 2 and 29 individuals (26.14%) in station 3. The family Polygonaceae having only one specie *Polygonum salicifolium* was the least dominant (4; 1.33%). Shannon-Weiner diversity index showed that the highest diversity was recorded in June (2.64) and the least in August (2.29). Monthly macrophyte occurrence peaked in August (46; 15.23 %) and reduced to a minimum in September, November and December (41; 13.58 %). Spatial distribution revealed that of the 302 individual species encountered, station 3 had the highest number (111; 36.75%) while the lowest was observed in station 2 (90; 29.80%); station 1 had 101 individuals contributing 33.33%. The macrophyte community may be described as being polydiverse.

Keywords: Biodiversity, aquatic macrophyte species, monthly, seasonal, riparian stream, Odot

INTRODUCTION
The interest in aquatic macrophytes generally began in the tropics in the beginning of second half of the 20th century. This interest arose from possible advantages and threat the macrophytes may pose to man and water body utilization (Adigun, 2005). Petr (2000) defined aquatic macrophytes as vegetations of angiosperms (flowering plants), ferns, mosses (pteridophytes) and macroscopic algae (stoneworts) that inhabit the inland ecosystems. They are considered photosynthetic organisms of freshwater habitats, comprising vascular plants, aquatic bryophytes and macro-algae growing permanently or temporally in aquatic environments (Jones *et al.*, 2010; Birnin-Yauri, 2010; Aloo *et al.*, 2013).

Naseer *et al.*, (2014) and Dienye (2015) noted that aquatic macrophytes constitute a significant component of the aquatic ecosystem and they are of considerable ecological and economic importance: the manifold role of aquatic macrophytes in freshwater habitats is closely linked to their distribution, which in turn depends on a myriad of factors: light, water temperature, water quality, nutrient enrichment, sediment composition and fluctuations in water levels. A number of characteristics of aquatic plants which make them important to fish include: water purification, nutrient recycling, physical link between water and air for many invertebrates, habitat for zooplankton which feed on phytoplankton, cover for huge range of invertebrates, and for fish, spawning areas and sites of oviposition, food source (living and dead). These affect flow patterns and create discrete habitat which is as functional as physical structure (FAO, 1979; Cowx and Welcomme,

1998; Hrivnak *et al*., 2006). However, submerged macrophytes compete with phytoplankton for nutrients, decreasing the productivity of the water and causing hindrance to the movement of fish, irrigation and navigation (Ita, 1993; Janauer and Dokulil, 2006).

Biotic index is a scale of showing the quality of an environment by indicating the types of organisms present in it and some aquatic plants have been used as indicator species for pollutants including nutrient enrichment (Lowe-McConnell, 1987; Philips and Rainbow, 1993; King and Jonathan, 2003). The measure of the richness or number of distinct taxa (e.g. orders, family and species) at a site and the evenness, relative abundance of different taxonomic groups are determined by counts of all organisms collected. The species composition, abundance and density of aquatic organisms are influenced not only by geographical locations but also by the water quality of their habitats which can, in turn, be adversely affected by human activities (Oben, 2000; Atobatele and Ugumba, 2008).

The effect of environmental parameters on the aquatic macrophyte species of Odot Stream had been studied (Ekpo *et al*., 2015_a). There is paucity of information on the abundance, distribution and biotic indices of aquatic macrophyte species in this riparian stream. This work, therefore, aims to provide a bench mark data on the biodiversity of aquatic macrophyte community in Odot, rainforest environment of south-south Nigeria.

Materials and methods

Study area

Odot Stream in Nsit Atai Local Government Area of Akwa Ibom State, Nigeria is a riparian inland aquatic ecosystem located on latitudes 4°51′0″N and 8°01′0″E (Fig. 1). It has an area of about 17,000 sq. km. The climate is typically that of tropical rainforest belt: comprising dry (November-March) and wet (April-October) seasons. The dry season is characterized by prevalence of dry tropical continental winds from the Sahara desert, and very low mean monthly precipitation. The wet season also is typified by moist tropical maritime winds (from the Atlantic Ocean through the Bight of Bonny) and high mean monthly rainfalls. The stream has a mean depth and width of 1.1 m and 8.3 m respectively. The sediment is a mixture of fine quality sand and muddy deposits at various locations. Detailed explanation of this study area is well documented in Ekpo *et al*., (2015a, b).

The study area was chosen due to its nearness to the Ibom International Airport and scarce documentation on the stream. Three sampling stations viz Station 1 (upstream) 04°50′29.3″N and 8° 03′19.9″E; Station 2 (midstream) 04° 50′01.8″N and 08°02′57.8″E and Station 3 (downstream) 04° 49′49.3″N and 08°02′56.1″E (Fig. 1) were established.

Aquatic macrophyte collection and identification

The modified method of macrophyte collection by Wood (1975) was used to take samples twice a month from the three stations between June and December 2014. Sampling of the macrophyte species was done by throwing 1m by 1m quadrat on the land-water interface i.e. the littoral zone. Collections of plant species with their flowers, seeds and roots by hand were made around the stream. These samples were rinsed and taken to the laboratory. Sampled specimens collected were identified in the Laboratory using identification keys such as: Akobundu and Agyakwa (1987); Hussey *et al*., 2007 and Grettys *et al*., 2009).

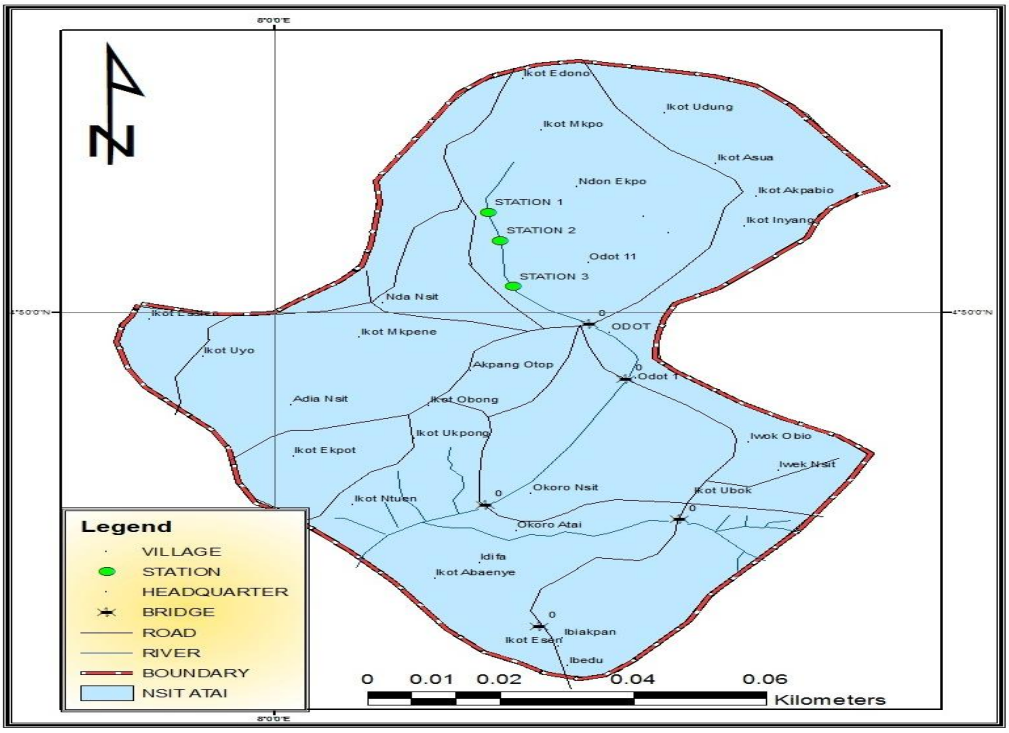

Fig. 1: Map of Nsit Atai L. G. A. in Akwa Ibom State showing the sampling stations in a riparian stream, Odot, Nigeria.

Statistical data analyses

The Statistical Package for Social Sciences (SPSS, version 16) and Microsoft Office Excel software were employed in this study. Analysis of variance (ANOVA) was used to test for month, seasonal and station differences at 5 % probability level.

Frequency of occurrence

This is the number of times an individual specie occurred. Hence, it was calculated according to the formula of Lare-Tier II (2010):

s/N x 100 ---------- (1)

where

s = the number of points where the specie is present.

N = the total number of points surveyed.

Simpson's Diversity Index (SDI)

This quantifies biodiversity, measuring the probability that two individuals randomly selected from a sample belong to the same species or some other species i.e. diversity of the plant community expressed as:

$$D = \frac{1-\Sigma n(n-1)}{N(N-1)} \quad \text{---------- (2)}$$

where

D = Simpson's Diversity

n = the total number of organisms of a particular species

N = the total number of organisms of all species (Williamson and Kelsey, 2009).

Simpson's Dominance Index (DI)

This is a heterogeneity index referred to as a measure of dominance and weighted towards the abundance of the commonest species (Ogbeibu, 2005). It varies from 0 – 1 and gives the probability that two individuals drawn at random from a population belong to the same species. It measures combined frequency of occurrence and relative abundance into a dominance value that characterizes the dominance of any specie and calculated thus (Lare-Tier II, 2010; Williamson and Kelsey, 2009):

$$DI = \frac{(\Sigma ra\text{-}z)}{(N \times rmax) \times 100} \quad \text{---------- (3)}$$

where

r = the abundance score for a species at each point, summed from points numbered from a to z

rmax = the theoretical maximum

N = the total number of points surveyed

Species evenness or equitability (E)

This is the degree to which all species are equally represented in the community (King and Jonathan, 2003). The equitability index (E) measures the actual number of species that are equally common and was computed according to the formula described by King and Jonathan (2003):

$$E = e^{H} \quad \text{---------- (4)}$$

where,

H = Shannon–Wiener index; and

e = Base of natural logarithm (2.7182)

Shannon-Wiener Index (H)

This is an independently derived function (Ogbeibu, 2005) and is normally distributed, facilitating the application of routine statistical procedures to test foe differences in means (King and Jonathan, 2003) was calculated as:

$$H = - \Sigma (n_1/N \ln (n_1/N)$$

Where,

N_1 = Number of individuals in a sample from the community

n_1 = Number of individuals in species 1 in a sample from the community

Species richness (S)

Margalef's index (di) was calculated using the formula (Ogbeibu, 2005) below to determine species richness:

$$di = \frac{(S - 1)}{(\log N)} \quad \text{---------- (5)}$$

Where,

S = Species variety or total number of species

N = Total number of individuals in the sample

According to Lawson *et al*., (2013), the occurrence of the macrophyte species was described using a subjective acronym (COR): in which C stands for common; O for occasional or R for rare species. Macrophyte species were considered Common, when a species occurred above 20 individuals; Occasional, when often below 20 individuals and Rare, when not found often usually less than 10 individuals.

RESULTS

The findings on the aquatic macrophyte species in a riparian stream in Odot streams are reported below:

Macrophyte species composition

Data on species composition revealed that there were 15 families, 18 genera and 19 species (Table 1). The family Poaceae had the highest number of species (3; 15.79%). Two families (Alismataceae and Cyperaceae) had two species (10.52%) each while the rest (Amaranthaceae, Asteraceae, Athyriaceae, Cabombaceae, Commelinaceace, Costaceae, Lentibulariaceae, Marantaceae, Nymphaeaceae, Onagraceae, Polygonaceae and Potamogetonaceae) had only one specie (5.26 %) each.

Table 1 depicts macrophyte species occurrences in the three categories. Those considered as Common were only four species (21.05%), viz: *Sagittifolia sagittifolia, Alternanthera philoxeroides, Nymphaea odorata* and *Acroceras zizanioides.* Occasional macrophyte species were nine (47.37%) and they included *Alisma subcordatum, Eclipta prostata, Diplazium sammati, Brasenia schreberi, Costus afer, Cyperus esculentus, Marantochloa cuspidata, Ludwigia longifolia* and *Brachiaria lata* while those occurring as Rare species were six (31.58 %), namely *Commelina benghalensis,*

Cyperus dives, Utricularia stellaris, Echinocloa spp, Polygonum salicifolium and *Potamogeton natans.*

The aquatic macrophyte species exist in three life forms emergent (e.g. *S. sagittaria, A. subcordatum,* etc), submerged (*A. philoxeroides, P. natans,* etc) and floating (*B. schreberi, U. stellaris, N. odorata*, etc).

Table 1: Aquatic macrophyte species composition, family, scientific and common names and their rating in a riparian stream in Odot, Nigeria

S/N	Plant Family	Botanical name	Rating	Common Name
1.	Alismataceae	*Sagittaria sagittifolia*	C	Arrowhead
2.	″	*Alisma subcordatum*	O	Water plantain
3.	Amaranthaceae	*Alternanthera philoxeroides*	C	Alligator weed
4.	Asteraceae	*Eclipta prostata*	O	False daisy
5.	Athyriaceae	*Diplazium sammati*	O	Water shield
6.	Cabombaceae	*Brasenia schreberi*	O	Water shield
7.	Commelinaceae	*Commelina benghalensis*	R	Tropical spiderwort
8.	Costaceae	*Costus afer*	O	Bush cane
9.	Cyperaceae	*Cyperus dives*	R	Giant sedge
10.	″	*C. esculentus*	O	Nutgrass
11.	Lentibulariaceae	*Utricularia stellaris*	R	Bladderwort
12.	Marantaceae	*Marantochloa cuspidata*	O	Soft cane
13.	Nymphaeaceae	*Nymphaea odorata*	C	Water lily
14.	Onagraceae	*Ludwigia longifolia*	O	Primrose willow
15.	Poaceae	*Echinocloa sp*	R	Water grass Nsai
16.	″	*Acroceras zizanioides*	C	Oat grass
17.	″	*Brachiaria lata*	O	Smart weeds
18.	Polygonaceae	*Polygonum salicifolium*	R	Float leaf
19.	Potamogetonaceae	*Potamogeton natans*	R	Pondweed

Note: C = Common; O = Occasional and R = Rare

Spatial abundance

Spatial distribution in the species of aquatic macrophyte community reveals that of the 302 individuals encountered, station 3 had the highest number of individuals while the lowest was observed in station 2 (Table 2). The correlation analysis indicated that the distribution and abundance of aquatic macrophyte composition were significantly ($P<0.05$) different. *A. zizanioides* was the most abundant specie in stations 1, 2 and 3. Macrophyte species having the lowest contributions in all the sampling stations were *C. benghalensis, Echinocloa spp.* and *P. salicifolium* in station 1, *P. salicifolium* and *C. dives* in station 2 and *P. salicifolium* and *P. natans* in station 3. The overall dominant species was *A. zizanioides* while the least was *P. salicifolium*. It was however noted that *U. stellaris* did not occur in two stations (i.e. 1 and 3).

Table 2: Spatial distribution of aquatic macrophyte species in a riparian stream in Odot, Nigeria.

Macrophyte species	Stations			
	1	2	3	Total
	Individuals (% composition)			
Acroceras zizanioides	22 (21.79)	15 (16.67)	29 (26.14)	66
Alisma subcordatum	4 (3.96)	3 (3.33)	4 (3.60)	11
Alternanthera philoxeroides	9 (8.91)	6 (6.67)	8 (7.21)	23
Brachiaria lata	5 (4.95)	2 (2.22)	3 (2.70)	10
Brasenia schreberi	4 (3.96)	3 (3.33)	5 (4.50)	12
Commelina benghalensis	2 (1.98)	5 (5.56)	2 (1.80)	9
Costus afer	6 (5.94)	5 (5.56)	4 (3.60)	15
Cyperus dives	3 (2.97)	1 (1.11)	4 (3.60)	8
C. esculentus	7 (6.93)	3 (3.33)	3 (2.70)	13
Diplazium sammati	3 (2.97)	2 (2.22)	5 (4.50)	10
Echinocloa sp	2 (1.98)	3 (3.33)	3 (2.70)	8
Eclipta prostata	3 (2.97)	3 (3.33)	6 (5.41)	12
Ludwigia longifolia	3 (2.97)	3 (3.33)	8 (7.21)	14
Marantochloa cuspidata	6 (5.94)	3 (3.33)	6 (5.41)	15
Nymphaea odorata	10 (9.90)	12 (13.33)	11 (9.91)	33
Polygonum salicifolium	2 (1.98)	1 (1.11)	1 (0.90)	4
Potamogeton natans	3 (2.97)	4 (4.44)	1 (0.90)	8
Sagittaria sagittifolia	7 (6.93)	10 (11.11)	8 (7.21)	25
Utricularia stellaris	0 (0.00)	6 (6.67)	0 (0.00)	6
Total	**101 (100)**	**90 (100)**	**111 (100)**	**302**

Monthly occurrence

The mean monthly occurrence of aquatic macrophyte species composition and their percentage frequencies were shown in Table 3. The highest number of species and percentage frequency in August the months of June and October had 45 species, July had species while the least number (41 individuals; 13.58 %) of species was observed in the months of (September, November and December) respectively. The family Poaceae had the highest number of species and frequency with *Acroceras zizanioides* while the family Polygonaceae and the species *Polygonum salicifolium* had the least percentage.

Table 3: Aquatic macrophyte species composition showing mean monthly variation and percentage frequency of individuals in a riparian stream in Odot, Nigeria.

Macrophyte species	Months								
	Individuals (N)								
	Jun	Jul	Aug	Sept	Oct	Nov	Dec	FO	% F
Alismataceae									
Sagittaria sagittifolia	5	4	7	2	4	2	1	25	8.28
Alisma subcordatum	2	0	1	2	2	2	2	11	3.64
Amaranthaceae									
Alternanthera hiloxeroides		4	5	4	2	3	3	23	7.62
Asteraceae									
Eclipta prostata	2	1	0	2	1	3	3	12	3.97
Athyriaceae									
Diplazium sammati	2	0	0	1	3	3	1	10	3.31
Cabombaceae									
Brasenia schreberi	1	4	1	3	3	0	0	12	3.97
Commelinaceace									
Commelina benghalensis	0	0	2	2	3	2	0	9	2.98
Costaceae									
Costus afer	3	2	3	2	2	1	2	15	4.97
Cyperaceae									
Cyperus dives	1	2	1	0	1	2	1	8	2.65
Cyperus esculentus	2	3	0	1	2	3	2	13	4.31
Lentibulariaceae									
Utriculari stellaris	1	1	0	0	2	2	0	6	1.99
Marantaceae									
Marantochloa cuspidata	1	4	4	1	4	1	0	15	4.97
Nymphaeaceae									
Nymphaea odorata	6	5	5	7	4	3	3	33	10.93
Onagraceae									
Ludwigia longifolia	4	2	3	2	0	0	3	14	4.64
Potamogetonaceae									
Potamogeton natans	2	0	0	1	1	1	3	8	2.65
Poaceae									
Acroceras zizanioides	8	8	11	7	9	10	13	66	21.85
Brachiaria lata	1	1	0	2	1	2	3	10	3.31
Echinocloa sp	1	2	1	1	1	1	1	8	2.65
Polygonaceae									
Polygonum salicifolium	1	0	2	1	0	0	0	4	1.33
Grand total	**45**	**43**	**46**	**41**	**45**	**41**	**41**	**302**	**100**
% occurrence	**14.90**	**14.24**	**15.23**	**13.58**	**14.90**	**13.58**	**13.58**		

Seasonal abundance

Seasonal variations of aquatic macrophytes revealed that more species were found in the wet season than in the dry season (Table 4). However, in the dry season, *A. zizaniodes* had the highest mean value of 3.83±0.79) whereas the least was observed in *M. cuspidata* (0.17±0.17). Two species (*B. schreberi* and *P. salicifolium*) *did* not occur at all in dry season. In the wet season, the highest mean value was also observed in *A. zizaniodes* (2.87±0.39) while the least value (0.27±0.12) was observed in *P. natans* and *P. salicifolium*.

Table 4: Seasonal variation of aquatic macrophytes species of Odot Stream, Southeastern Nigeria

Species	Seasons	Mean±SE
Acroceras zizanioides	Wet season	2.87±0.39
	Dry season	3.83±0.79
Alisma subcordatum	Wet season	0.47±0.17
	Dry season	0.67±0.42
Alternanthera philoxeroides	Wet season	1.13±0.31
	Dry season	1±0.52
Brachiaria lata	Wet season	0.33±0.13
	Dry season	0.83±0.31
Brasenia schreberi	Wet season	0.80±0.20
	Dry season	0
Commelina bengkalensis	Wet season	0.47±0.13
	Dry season	0.33±0.33
Costus afer	Wet season	0.80±0.18
	Dry season	0.50±0.34
Cyperus dives	Wet season	0.33±0.13
	Dry season	0.50±0.22
Cyperus esculentus	Wet season	0.53±0.24
	Dry season	0.83±0.17
Diplazium sammati	Wet season	0.53±0.19
	Dry season	0.67±0.21
Echinocloa sp	Wet season	0.40±0.13
	Dry season	0.33±0.21
Eclipta prostate	Wet season	0.40±0.16
	Dry season	1
Ludwigia longifolia	Wet season	0.73±0.18
	Dry season	0.50±0.34
Marantochloa cuspidata	Wet season	0.93±0.23
	Dry season	0.17±0.17
Nymphaea odorata	Wet season	1.80±0.20
	Dry season	1
Polygonum salicifolium	Wet season	0.27±0.12
	Dry season	0
Potamogeton natans	Wet season	0.27±0.12
	Dry season	0.67±0.21
Sagittaria sagittifolia	Wet season	1.47±0.29
	Dry season	0.50±0.22
Utriculari stellaris	Wet season	0.27±0.15
	Dry season	0.33±0.33

Aquatic macrophyte species diversity indices

Pooled monthly relationships between the number of species and individuals were shown in Table 5 and Fig. 3. The highest number of species was recorded in June while the lowest was in August. In terms of individuals, the highest number was observed in August whereas the least was obtained in three months (September, November and December). The highest and lowest Shannon-Weiner index values were recorded in June and August respectively. Margalef index was high in June and low in August. Evenness index had highest value in

July and lowest value (0.72) in December. Simpson's index was in June and in October.

Table 5: Aquatic macrophyte indices in a riparian stream in Odot, Nigeria

S/N	Biotic indices	Months						
		Jun	Jul	Aug	Sept	Oct	Nov	Dec
1.	Species diversity (S)	18	14	13	17	17	16	14
2.	Abundance	45	43	46	41	45	41	41
3.	Shannon-Wiener Index (H)	2.64	2.47	2.29	2.60	2.62	2.55	2.30
4.	Margalef Index (di)	4.47	3.46	3.13	4.31	4.20	4.04	3.50
5.	Evenness (E)	0.78	0.84	0.76	0.79	0.81	0.80	0.72
6.	Simpson's index (D)	0.91	0.10	0.13	0.09	0.09	0.10	0.14

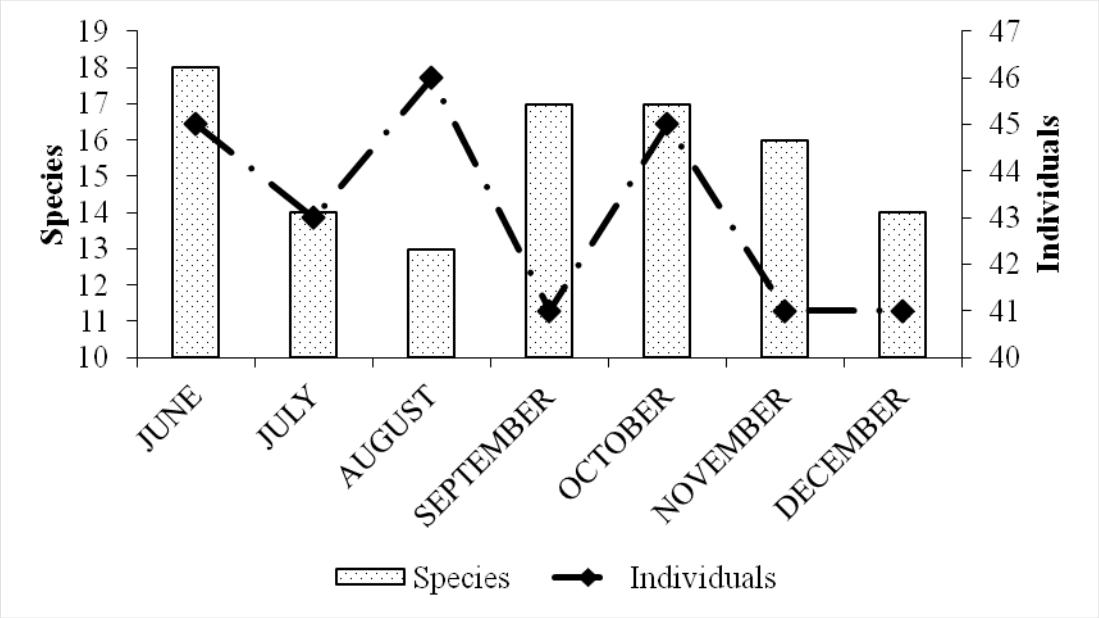

Fig. 3: Monthly relationships between macrophyte species and individuals' abundance in a riparian stream in Odot, Nigeria.

Relationship between the biotic indices

The graphical representation in Fig. 4 showed that dominance was inversely related to equitability, Margalef, Simpson and Shannon-Wiener indices. This implied that when dominance was high in August and December and low in the rest of the months, all others were low in August and December and high in the remaining months.

DISCUSSION

Nigerian rivers, like other tropical rivers, are endowed with diverse populations of riparian vegetations which vary in nature, density, types and functions according to locations. Those encountered in this study are similar or vary from those reported elsewhere in both lotic and lentic systems globally. Aquatic macrophyte species composition revealed that there were 15 families, 18 genera and 19 species. However, similar or less number had been documented; viz Daddy *et al*., (1993) reported of 13 families and 31 species in the herbarium of Kainji and Jebba Lakes, Roger *et al*., (2010) recorded 37 species and 34 families in Brazil;

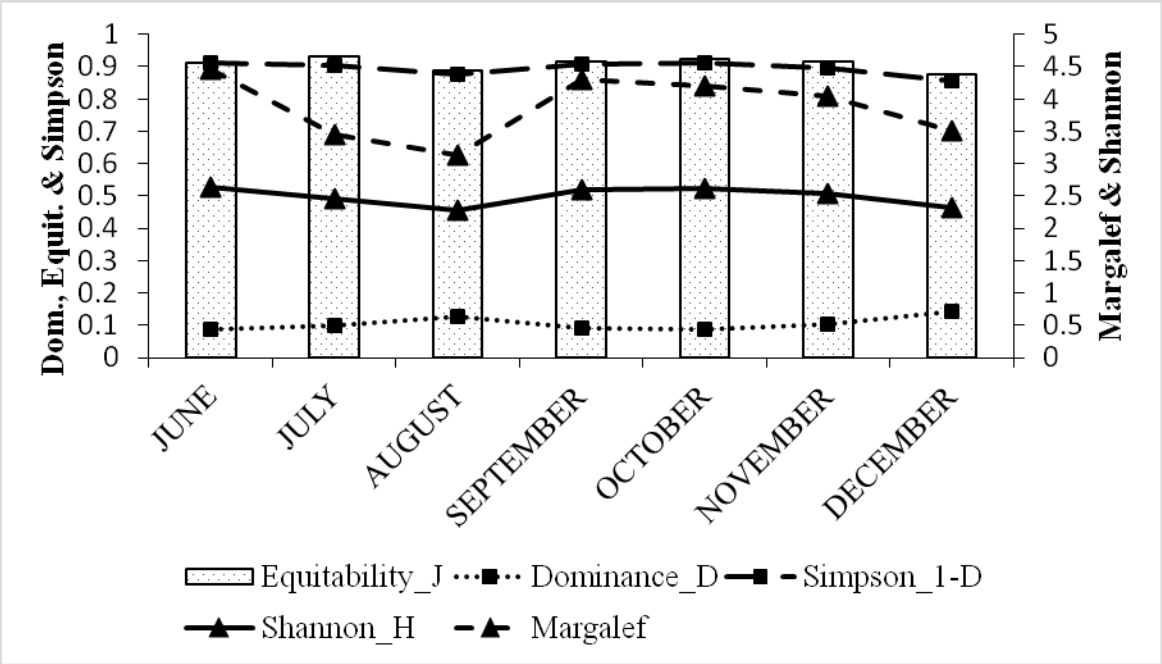

Fig. 4: Relationship between Dominance, Simpson, Shannon, Margalef and Equitability indices in a riparian stream in Odot, Nigeria.

Ikenweiwe (2005) revealed 10 families and 9 species in Oyan Lake; Ekpo *et al.*, (2014) identified 33 families and 98 species of macrophyte while Dienye (2015) noted that there were 10 families of macrophytes representing 12 species in the New Calabar River, among others.

The family Poaceae had the highest number of species while Polygonaceae had the least. This result is in consonance with the report of Dienye (2005). Two families and six species were completely absent during the dry season. The dominant macrophyte families were Poaceae and Cyperaceae as previously reported by Ekpo *et al.,* (2011). Also, Ali and Kushi (2001) reported that Poaceae and Cyperaceae were most represented with 19 and 13 species in the wet season and 9 and 6 in the dry season respectively. Some terrestrial macrophyte species also occur in the aquatic environment. This may probably be due to dispersal by wind and other agents or the fact that both ecosystems have similar factors required by such plants. Depending on the season, some of these plants had flowers and seeds of diverse types (Ekpo *et al.,* 2011).

Submerged aquatic macrophytes are defined as plants that are usually rooted in the bottom soil with the vegetative parts predominantly submerged. Most submerged aquatic macrophytes belong to the families Ceratophyllaceae, Haloragaceae, Hydrocharitaceae, Nymphaeaceae and Potamogetonaceae.

A. zizanioides was the species with the highest number of individuals while *P. salicifolium* had the least. Dienye (2015) showed that *Rhynchospora corymbosa* had the highest abundance (richness), followed by *C. difformis* while the species' lowest abundance (richness) was *Eichhornia crassipes*. *Nymphaea lotus* was the lowest in evenness index (distribution) followed by *Aneilema beniniense* and *Platostoma africana* having the same level of distribution, but *Aspilia africana* had the highest evenness. Adesina *et al*., (2011) identified reduction in the hydraulic water turnover in Jebba Lake which

allows for extended water retention period to be the factor responsible for new plant development.

The highest number of species was recorded in August while the least number of species was recorded in September, November and December. The species indices indicated that *R. corymbosa* had the highest taxa value 65, Shannon Weiner 4.01, Simpsons 0.98 and Margalef 7.60 while *E. crassipes* recorded the lowest taxa of 17, Shannon Weiner had 2.72, Simpsons 0.92 and Margalef 2.30 respectively for macrophytes. The slight difference may be attributed to the fact that the author worked on individual macrophyte species as against the grouped indices in the present study. Dienye (2015) reporting on the macrophyte biotic indices of Margalef's species richness, Shannon - Wiener information function, evenness and Simpson's dominance said they were fairly distributed in the river. This shows that the macrophyte in the study area were stable.

Seasonal variations of aquatic macrophyte species revealed that there were more species occurring in the wet season than dry season. *A. zizaniodes* and *A. subcoriatum* were more abundant in dry season than in wet season. Two species (*B. schreberi* and *P. salicifolium*) *did* not occur at all in the dry season. The absence of these species may be attributed to their fragile nature of their stems and shallow root system. The highest number of individual macrophyte species was recorded in August whereas the least was obtained in the three following months: September, November and December. These are dry months, when the water level in the stream has reduced due to factors such as lack of precipitation, increased evapo-transpiration, absorption by plant roots, increased temperature, human utilization, drinking by cattle, among others.

The spatial distribution of the aquatic macrophyte spatially revealed a non-progressive increase since of the 302 individuals encountered, station 3 had the highest number while the lowest was recorded in station 2. This observation, however, differs from that Vannote *et al*., (1980) and Lowe-McConnell (1987) who reported that in unpolluted systems, ecological indicators show discrete arrangement or pattern downstream with the concentrations of most number of species tending to increase progressively downstream. Such deviations could be attributed to anthropogenic perturbations in station 2 which alter the ecosystem stability and cause a shift in the longitudinal pattern downstream. The pool of loads from the source through the transitional zone of lotic systems brings about increased nutrient and this together with the increased width and depth of the meandering channel lead to increased productivity downstream. Moses (1987) made similar observations when reported of the high productivity of the lower Cross River system.

CONCLUSION

The abundance of aquatic macrophyte species in Odot stream parallels those in any other in similar systems. With respect to spatial patterns, they are not progressively distributed which may be attributed to pollution effect. Seasonal variation showed a higher wet season than dry-season abundance which was subsequently followed by biotic indices. The multiple diverse natures of these species is an indicator of the high productivity of the ecosystem due to high species variety and numbers of individuals among the species. This important component of the aquatic system should be maintained and prevented from further pollution through introduction of nutrient impulses. Hence, there should be frequent monitoring through surveillance and maximum utilization of these macrophytes.

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