SEASONAL ANURAN SPECIES COMPOSITION AND DISTRIBUTION PATTERNS ON A DELTA LANDSCAPE, OKPARATOWN INLAND, DELTA STATE, NIGERIA

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ABSTRACT

The effect of seasonal difference and land use types on the composition and distribution of anuran assemblages were investigated in the Delta region of Nigeria. Overall, 27 anuran species and a mean total of 43.39 ± 12.21, 32.53 ± 20.3, 40.07 ± 1 and 26.56 ± 9.7 individuals were recorded in 96 hours of combined VES (visual encounter survey) and AES (acoustical encounter survey) sampling in Sites A, B, C and D respectively, that were representatives of the mosaic habitats in the area. The highest (20.5) and lowest (14) number of species were recorded in Site D (primary forest) and B (fallowed farmland and agricultural plots) respectively. Species richness was not significantly different across the study sites during the wet season ($F_{3,67} = 2.389$, $P > 0.05$) and also during the dry season ($F_{3,56} = 2.255$, $P > 0.05$). From the results of Sites A, B and D, calculated t-test was at 2.933, 4.085 and 3.204 respectively and showed that there was significant difference ($P < 0.05$) between the abundance of anurans in the wet and dry seasons while Site C showed no significant difference ($P < 0.05$) in both wet and dry seasons. Anthropogenic activities had an effect on the species richness and evenness of anurans. Site D that was characterized by the primary forest showed the highest species richness (1.19) and evenness (1.1) among the study sites. It is evident that the conversion of the native habitats of the anurans for agricultural purposes no doubt has a negative effect on its diversity. In every community, it is inevitable that agricultural land uses are necessary to provide the basic food for survival, but efforts should be made towards the conservation of some pristine forest land which will serve as an ecological pool of original animal species of that region.

Keywords: Seasonal difference, Delta region, Anthropogenic activities, Conservation, Pristine forest.

INTRODUCTION

Amphibians were the first tetrapods on land are a diverse group represented today by the caecilians (order Gymnophina), newts and salamanders (order Caudata) and frogs and toads (order Anura). The frogs and toads are commonly referred to as the anurans (Hickman *et al.*, 2001).

Nigeria being a country in the tropical zone with conducive climatic conditions and vegetation has a significant diversity of anuran population. According to Bakarr *et al.* (2004), from a biogeographic point of view, Nigeria is situated between West and Central Africa, and hence between the biodiversity hotspots of the Upper and Lower Guinea forest. Therefore the country is expected to harbor high biological diversity composed of West and Central African species alike.

The country also has a great variety of ecosystems comprising varied landscapes which determines to some extent the spatial and temporal distributions of anuran species with special effect from hydrological periods resulting from seasonal difference. The wet and dry seasons have a profound effect on the composition and distribution of anuran species which is exacerbated by the different land use types, mainly agricultural. Forest reserves are increasingly becoming islands as a result of the matrix of human-modified habitats due to various land use types (Rathod and Rathod, 2013). These are now forming a significant part of the landscape pattern in the Delta region which has a profound effect on anuran assemblages.

According to Gomez-Rodrigue *et al.* (2010), it was highlighted that ecological theory implicitly assumes that environmental variables determines, at least in part, species distributions across space and thereby promotes the existence of different species assemblages along environmental gradient. Different habitats are occupied by different anuran species both on a larger scale eg. forest and smaller scale eg breeding pond (Rodel, 2000, Amiet, 1989 and Lamotte, 1983) and these are expressed by differences in their temporal appearance and or spatial distribution (Begon *et al.*, 1990).

Several studies have reported that temporal variation in amphibian assemblages results from inter-annual variability in meteorological/hydrological conditions (Jakob *et al.*, 2003). Usually majority of the landscapes are flooded or many existing ponds/puddles of various magnitudes and depths are observed during the rainy season and contrastingly these areas are completely dry with the presence of baked earth and dust during the dry season. These environmental characteristics are as a result of seasonal difference which brings about variation in anuran species assemblages. This results from either gain or loss of some species or by replacement of some species by others. Based on seasonal difference and land use types, this present study describes the patterns of anuran species composition and distribution in Okparatown Inland, Delta State. Also a comprehensive list of anuran species will be produce for the area from the result of this study.

MATERIALS AND METHODS

Study Area

Field studies were undertaken around Okparatown Inland, Warri, Delta State which is situated in the Niger Delta region (see Figure 1). Four survey sites were selected around the town that were characterised mainly by swamp forest with patches of secondary or mature lowland forest and leaf litter habitats (see Table 1).

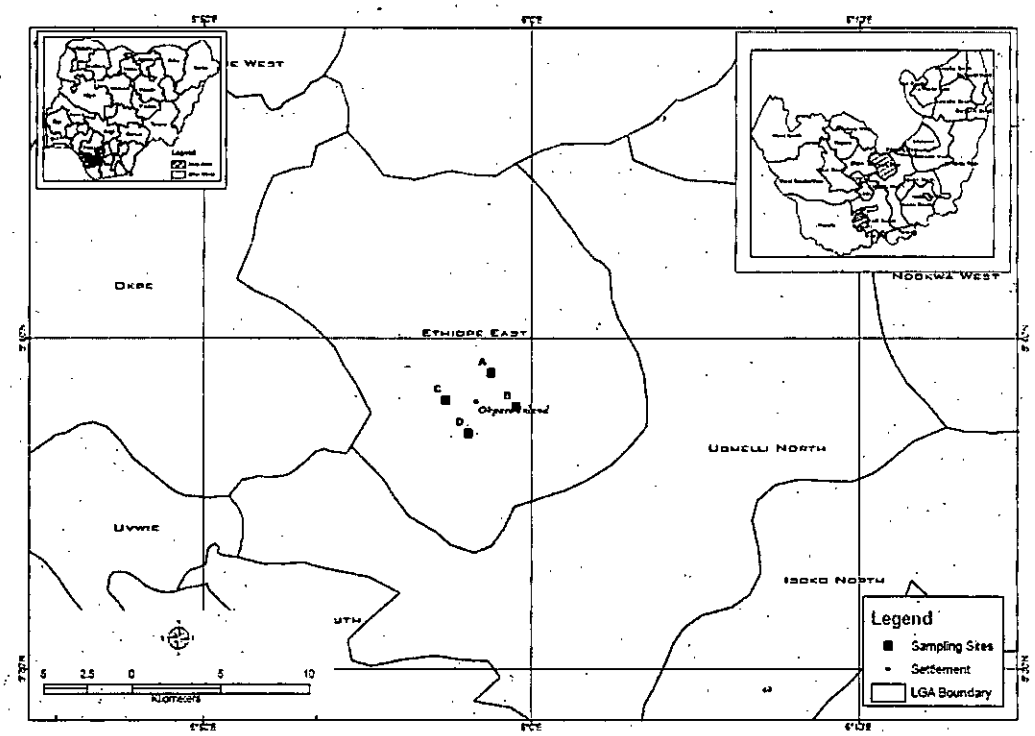

Fig. 1. Geographic position of Okparatown Inland (white star), Delta State, Nigeria. Source: Department of Geography, University of Lagos

Table 1: Habitat characterization and coordinates of the study sites.

Sites	Names	Habitat	GPS Location	
			Latitude	Longitude
A	Okpara-A	Tertiary succession with rubber trees in swampy region	N 05° 37 919''	E 005° 58 514''
B	Okpara-B	Fallowed farmlands and agricultural plots e.g. cassava, rice (swampy region) and maize	N 05° 37 865''	E 005° 59 677''
C	Okpara-C	Secondary succession/swampy region and leaf litter	N 05° 37 446''	E 005° 57 339''
D	Okpara-D	Primary forest and swampy region	N 05° 37 301''	E 005° 57 364''

Each of these sites was about 300m^2, some separated from each other by a matrix of cassava, oil palm and yam farms. These sites are completely dry during the dry season with the exception of few water holes which can dry up during extremely dry conditions. However during the rainy season, about 80% of these study sites are submerged under

water and in extremely wet conditions, over 90% are submerged (personal communication). Areas around the sites (including part of the sites) are generally owned by the villagers where very small scale farming is carried out during the dry season. These areas get submerged during the rainy season and can be used as fishing grounds where fishes, reptiles and even amphibians (mainly *Hoplobatrachus occipitalis*) are caught (personal communication). See Plate 1.

Plate 1: Part of the survey site during the dry season. This area is submerged during the rainy season.

Anuran Sampling

The study sites surveyed were representatives of the mosaic of habitats found in the area; swamp forest (Site A) with patches of secondary (Site C) and mature forests (Site D), leaf litter habitat, abandoned farmlands and agricultural plots (Site B). Surveys were conducted at these sites between June, 2011 and January, 2013. During the dry (November, 2011 - January, 2012 and November, 2012 –January, 2013) and rainy (June, 2011 – August, 2011 and June, 2012 – August, 2012) seasons. Intensive 4-day surveys were conducted monthly and each survey was carried out for a period of 120 minutes; (1800-2000 hr). Anuran specimens were located opportunistically using the VES (visual encounter survey) and AES (acoustical encounter survey) methods (Rodel and Ernst, 2004). In order to standardize field efforts, the man-hour count in each study site was regularized to obtain a uniform survey time (Luiselli and Akanni, 2002). Specimens caught were identified, photographed and released. Voucher specimens were collected and kept for further identification at the Department of Zoology Laboratory, University of Lagos.

Statistical Analysis

Statistics analysis was carried out using the one way analysis of variance (ANOVA) with the SPSS version 18.0 (SPSS, 2008). This was used to ascertain if species richness differ significantly among the study sites seasonally (each during the wet and dry seasons). Variations between seasons in the relative abundance of the various anuran species in each study site were tested by paired t-test with the first sample being the rainy season and the second sample being the dry season. The Shannon-Weiner (H) and Equitability (E_H) indices were applied to measure the diversity of anuran assemblages.

RESULTS

Anuran Species Richness and Abundance

Sites A, B, C and D recorded an average of 43.39 ± 12.21, 32.53 ± 20.3, 40.07 ± 1 and 26.56 ± 9.7 anuran species respectively in 96 hours using both VES and AES sampling methods. In all, 27 and 24 species were sampled in the wet and dry seasons respectively. The highest (22) and least (11) number of species were recorded at Site D during the rainy season and Site B during the dry season (Table 2).

Anuran species richness was not significantly different across the study sites in the wet season ($F_{3,67} = 2.389$, $P > 0.05$) and dry season ($F_{3,56} = 2.255$, $P > 0.05$).

From the results of Sites A, B and D, calculated t-test was at 2.933, 4.085 and 3.204 respectively and showed that there was significant difference ($P<0.05$) between the abundance of anurans in the wet and dry seasons while Site C showed no significant difference ($P< 0.05$) in both wet and dry seasons. (See Appendix 1)

Shannon-Wiener and Equitability Indices

The results indicated that sites D and C during the wet season had the highest (Hs =1.19) and lowest (Hs =1.04) diversity of anurans respectively (Fig. 2). During the dry season, the highest (Hs =1.10) and least (Hs = 0.82) values were observed at sites D and B respectively. Similar trend in the results was revealed in the Equitability Index (j) indicating the highest (0.83) and lowest (0.57) values for Sites D and B during the wet and dry seasons respectively in all the sites (Fig. 3).

Amietophrynus regularis, A. maculatus, Hylarana albolabris, Ptychadena pumilio, P. oxyrhynchus, P. muscareniensis, Phrynobatrachus accraensis, Leptopelis boulengeri, and *Hyperolius guttulatus* were species observed in all the sites both during the wet and dry periods. *Ptychadena pumilio* was the most abundant species followed by *Amietophrynus regularis* while the least abundant was *Phlyctimantis boulengeri.* Anuran species observed only in one site include; *Phrynobatrachus sp* (Site A), *Hymenochirus sp* (Site C), *Nectophryne afra, Ptychadena retropunctata, Ptychadena aequiplicata, Arthroleptis poecilonotus* and *Phlyctimantis boulengeri* (all found in Site D only). Plates 2-5 display some anuran species observed at the study sites.

Table 2. Relative abundance of anuran species at the study sites.
(I) rainy season only (II) dry season only (III) mean of rainy and dry seasons

Anuran species	Sites											
	A			B			C			D		
	I	II	III	I	II	III	I	II	III	I	II	III
Xenopus nuelleri	0	0	0	1.56	0	0.78±1.1	1.22	1.94	1.58±0.51	0.72	2	1.36±0.91
Hymenochirus sp	0	0	0	0	0	0	0.17	1.83	1±1.17	0	0	0
Hemisus marmoratus	1.17	0.83	1±0.24	2.67	0	1.34±1.89	0	0	0	0	0.11	0.06±0.08
Amietophrynus regularis	6.11	5.28	5.69±0.59	7.78	4.06	5.92±2.63	6.83	8.17	7.5±0.95	2.11	1.56	1.84±0.39
A. maculatus	3.17	4.28	3.73±0.78	3.44	2.61	3.03±0.59	1.56	2.89	2.23±0.94	1.39	1.83	1.61±0.31
Nectophryne afra	0	0	0	0	0	0	0	0	0	1.06	0.17	0.62±0.63
Hoplobatrachus occipitalis	1.83	0	0.92±1.29	2.28	0	1.14±1.61	4.28	0.17	2.23±2.91	0.17	0	0.09±0.12
Hylarana albolabris	1.67	0.17	0.92±1.06	1.83	0.17	1±1.17	1.17	0.11	0.64±0.75	3	1.22	2.11±1.26
H. galamensis	1.11	0	0.56±0.78	0	0	0	0	0	0	1.83	0.89	1.36±0.66
Ptychadena pumilio	9.06	6.11	8.75±2.09	7.17	1.44	4.31±4.05	8	5.06	6.53±2.08	4.06	2.11	3.09±1.38
P. oxyrhynchus	4.5	2.06	3.28±1.73	1.28	0.67	0.98±0.43	1.17	0.44	0.81±0.52	3.61	2.06	2.84±1.1
P. retropunctata	0	0	0	0	0	0	0	0	0	0.17	0.11	0.14±0.04
P. mascareniensis	5.11	3.17	4.14±1.37	3.44	2.61	3.03±0.59	3	1.94	2.47±0.75	0.94	0.78	0.86±0.11
P. aequiplicata	0	0	0	0	0	0	0	0	0	1.33	0.94	1.14±0.28
Phrynobatrachus accraensis	5.83	7.39	6.61±1.1	5.94	4.56	5.25±0.98	3.61	6.22	4.92±1.85	1.67	1.28	1.48±0.28
P. rainerguenheri	0	0	0	1.22	0.67	0.95±0.39	0.44	1.56	1±0.79	0	0	0
P. auritus	0	0	0	2.61	0.44	1.53±1.53	3.67	5.11	4.39±1.02	0.39	0.11	0.25±0.2
P. francisci	0	0	0	1.17	0	0.59±0.82	0.44	0.89	0.67±0.32	0	0	0
P. plicatus	0	0	0	0.22	0	0.11±0.16	0	0.17	0.09±0.12	0.28	0	0.14±0.2
Phrynobatrachus sp	0.94	0	0.47±0.66	0	0	0	0	0	0	0	0	0
Arthroleptis variabilis	0.17	0.11	0.14±0.04	0	0	0	0	0	0	3.06	1.06	2.06±1.41
A. poecilonotus	0	0	0	0	0	0	0	0	0	0.44	0	0.22±0.31
Leptopelis boulengeri	2.61	1	1.81±1.14	2.11	0.44	1.28±1.18	1.67	0.78	1.23±0.63	2	2.11	2.09±0.08
Afrixalus dorsalis	1.22	0.94	1.08±0.2	0	0	0	0	0	0	1.17	0.67	0.92±0.35
Hyperolius riggenbachi	2.06	1.17	1.62±0.63	0.67	0	0.34±0.47	1	1.06	1.03±0.04	1	0.22	0.61±0.55
H. guttulatus	4.78	1.06	2.67±2.78	1.5	0.39	0.95±0.78	7.56	0.94	1.75±1.15	7.83	0.33	1.58±1.77
Phlyctimantis boulengeri	0	0	0	0	0	0	0	0	0	0.17	0	0.09±0.12
Total no. of species	16	13	14.5±2.12	17	11	14±4.24	16	17	16.5±0.7	22	19	20.5±2.12
Total mean no. of individuals	50.84	33.57	43.39±12.21	46.89	18.06	32.53±20.3	40.79	39.28	40.07±1.0	33.4	19.56	26.56±9.7

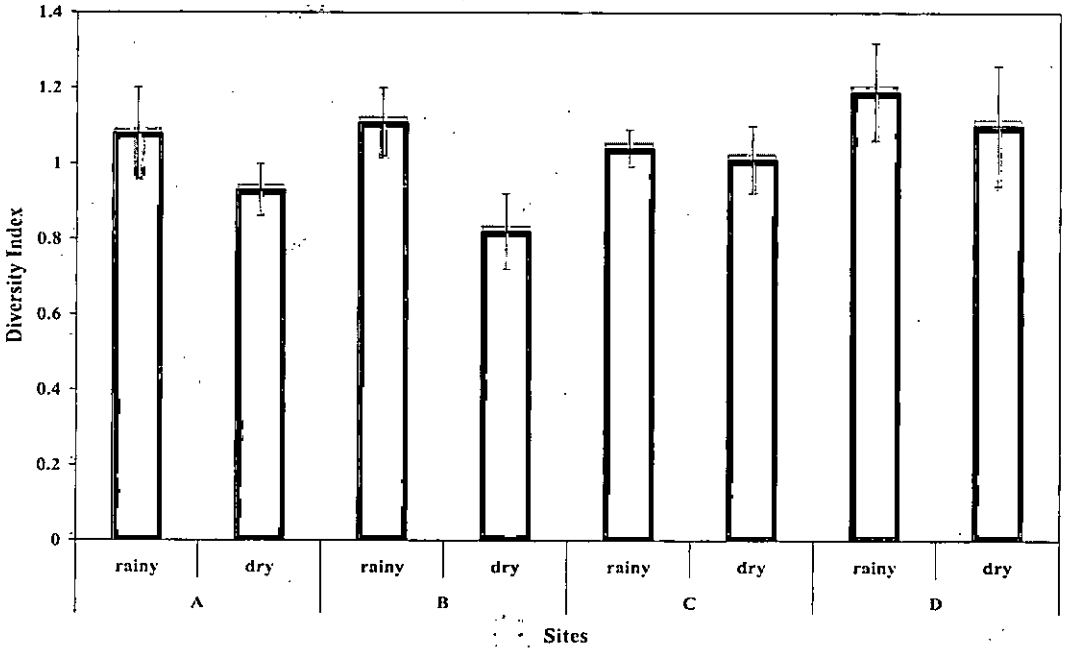

Fig. 2: Diversity index across the various sites.

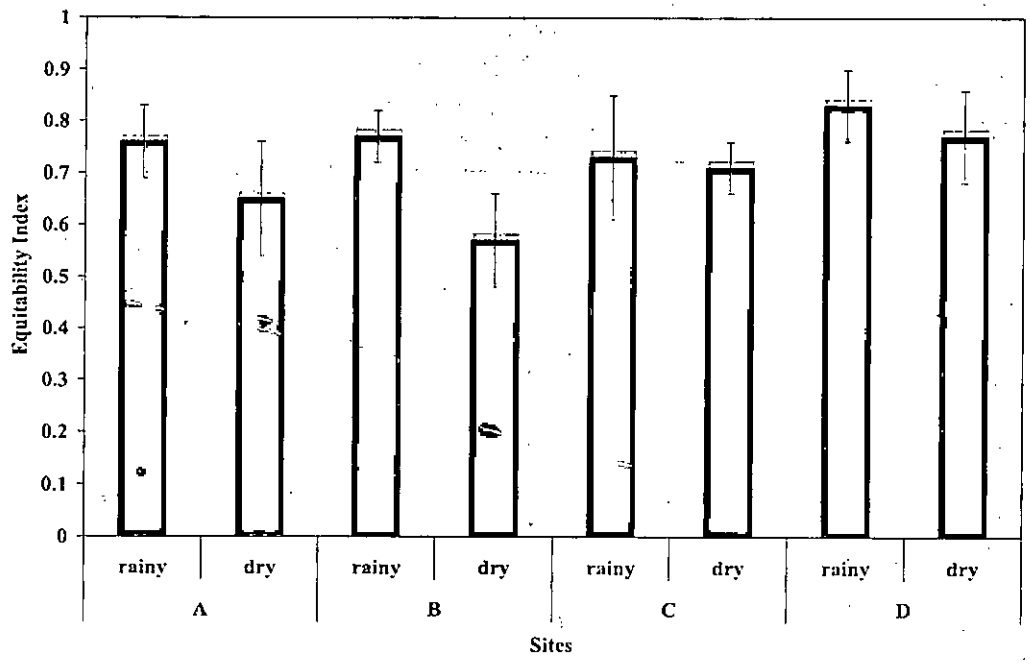

Fig. 3: Equitability index across the various sites.

Plate 2: *Hymenochirus* sp

Plate 3: *Hylarana galamensis*

Plate 4: *Phrynobatrachus auritus*

Plate 5: *Ptychadena pumilio*

DISCUSSION

This study was an attempt to understand anuran species community level pattern within four different habitats in the same ecological zone. Though not significant, the results showed differences in species diversity across habitat sites. The site of primary forest had the greatest species richness compared to other sites affected with anthropogenic activities. Reduction in the composition of vegetation and or monoculture might have been the possible cause of anuran species reduction in other sites. Primary vegetation has been lost leading to decrease in canopy cover. This results into higher temperature, decreasing atmospheric humidity and increased wind velocity (Saunders *et al.*, 1991; Murcia 1995; Pineda & Halffter, 2004) which could account for the decreased species richness.

Also species composition often varies across different land use types and regimes and species that requires specific ecological conditions that are not available in modified land uses maybe more affected than others (Waltert *et al.*, 2004) as cited by Rathod and Rathod (2013). This may be true for forest species such as *Phlyctimantis boulengeri, Arthroleptis poecilonotus, Nectophryne afra, Ptychadena retropunctata* and *P. aequiplicata* that were absent from the disturbed sites in this study. Certain environmental conditions and structures for example, temperature, humidity, vegetation and canopy that are present in the forest regime maybe lacking in the other sites that may not favour the existence of these species. Gardner *et al.* (2007), also observed that sites in cultivated habitats are likely to be less diversed than elsewhere and harbor only a subset of the wider species pool found in more natural sites. Hence the diversity and evenness of the undisturbed habitat (primary forest) are much higher than the other disturbed sites.

It was observed that there was greater abundance of species occurring at the disturbed sites, which also had lesser evenness values than the undisturbed site. This may be due to the easy accessibility through these sites, hence the higher recording of individuals as against the forest of which some parts were not easily accessible. Lower evenness values in the disturbed sites accounted for high populations of *Amietophrynus regularis, Ptychadena pumilio,* and *Phrynobatrachus accarensis* which were not observed in the primary forest. These species had lower populations in the primary forest giving a relative even distribution of species which resulted into higher equitability values.

The abundance of anuran species was significantly higher during the wet season than the dry season. This is due mainly to the availability of water and moisture conditions which favours the thriving conditions of the anuran species. Other researchers have also observed a peak in anuran abundance during the wet season (Scott, 1976; Allmon, 1991; Vonesh, 2001), and in particular during periods of heavy rainfall (Duellman 1995), a phenomenon that is related to the phenology of reproductive activity as well as the environmental tolerance of individual species. However, particularly in this study, it was observed that there were a greater number of anurans at Site C during the dry season which may be due to the topography of this site. Over 80% of the site is usually submerged during the wet season, leading to the migration of the individuals of some

species to other less flooded or adjacent areas. During the dry season, the flooding disappears leaving a terrain of leaf litter and stagnant pools of water which favours the thriving conditions of many anuran species especially the *Phrynobatrachus sp* that congregate around the drying up water sources. At Site C, there were significantly greater abundance of species such as *Phyrnobatrachus accraensis, P. rainerguentheri, P.auritus* and *P. francisci* during the dry season. Also there were greater abundance of *Xenopus* and *Hymenochirus spp* submerged in the muddy bottom of small stagnant pools. According to report cited by Gardner *et al.,* 2007, other researchers have also reported increases in the abundance of some amphibian during the dry season (Toft, 1980a; Lieberman, 1986; Allmon, 1991). The abundance of amphibians maybe particularly promoted during short dry seasons, when sudden leaf fall promotes an increase in arthropods abundance (Toft,1980a; Fauth, *et al.,* 1989; Watling and Donnelly, 2002) as was also observed in this study.

Generally as observed, comparison of the species richness of seasonal difference in the Delta region is relatively not as significant as other regions in Nigeria. The Delta region consists of many tributaries of the Niger River coupled with many marshy swamps. Therefore even during the dry season, there is availability of water existing from swamps, many temporary and permanent pools of water left from the drying streams existing as a result of the division of the Niger River. This landscape conditions favours the thriving conditions of the anurans, when compared to other regions of Nigeria that are very dry with low moisture conditions during the dry season, supporting very limited number of anuran species.

CONCLUSION

The conversion of the native habitats of the anurans for agricultural purposes no doubt has a negative effect on its diversity. In every community, it is inevitable that agricultural land uses are necessary to provide the basic food for survival of humans, but efforts should be made to preserve some pristine forest land which will serve as an ecological pool of endemic animal species of that region. This area would retain animal species that could be used as future reference point in establishing the original species diversity of that region.

This study shows an evident of seasonal variation on the anuran species composition. Land types, topography and microhabitats also play an important role in the determination of species assemblages and distribution. These ecological phenomena are important tools for conservation of biodiversity.

However the total number of species reported in this study does not really reflect the species richness of the Delta region. More surveys and monitoring need to be carried out. The recent description of a new species in this area (Rodel *et al.,* 2012) is a clear indication that the possibility of other species still exists.

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