Forest degradation and its impact on anuran diversity and abundance in Arun Owun, Sapele, Delta State, Nigeria

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Abstract

The effects of vegetation degradation on the abundance and diversity of anuran species were investigated in Arun Owun, Delta State. Combinations of visual encounter survey (VES) and acoustic encounter survey (AES) were conducted to estimate the local anuran composition both prior to and after the clearing of vegetation at the study sites. These surveys were conducted during the wet season (June-August, 2008) and dry season (December-February, 2009). Adjacent sites were also surveyed as to ascertain the presence or absence of anuran species still in the vicinity, but not observed at the study sites. Mean totals of 27.69 and 6.53 anurans belonging to 26 species were recorded in 96 hours of combined VES and AES sampling during this study prior to the cutting of vegetation and after its cutting respectively. The highest number of species (26) was recorded during the rainy season prior to the cutting of vegetation, whereas the lowest (5) was during the dry season after the cutting of vegetation at the sites. At the adjacent sites, a total number of 64 anurans belonging to 9 species were observed in 10 hours of sampling which were no longer present at the study sites. Five (19.2%) species which could no longer be accounted for, both at the study and adjacent sites were: *Phrynobatrachus plicatus, Phrynobatrachus sp, Phlyctimantis boulengeri, Silurana tropicalis* and *Hylarana galamensis.* There was significant difference during the rainy, dry and entire seasons; at *t*-test calculated as 1.297, 0.793 and 1.039 respectively at ($p<0.05$, $df = 25$, $t_{cal} = 7.436$), between the time prior to vegetation cutting and post vegetation cutting. Similarly the Shannon-Wiener and Equitability indices also showed remarkable differences between these two regimes. Unfortunately, deforestation is extremely difficult to halt, as development of agriculture, infrastructure and oil exploration are seen as crucial steps to national development. Preventing the degradation of the forest fragments should be a priority and also monitoring the dynamics of anuran species in their response to habitat destruction is important. These are crucial steps in the conservation of biological diversity.

Keywords: anuran abundance, vegetation degradation, oil exploration, habitat destruction, conservation and biological diversity.

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Introduction

Throughout the history of civilization, human activities have been detrimental to the natural biota (Duellman and Trueb, 1986). These are driving an ever increasing number of plants and animals into extinction (Stebbins and Cohen, 1995). Amphibians are no exception to this scourge. There are lots of indication that amphibian populations have been experiencing catastrophic declines across many areas of the world within the last few decades (Houlahan *et al*, 2000; Lips *et al*, 2005a), declining at a faster rate than either mammals or birds (Stuart *et al*, 2004). The rapidity and extent of these declines forecast impending extinction of numerous amphibian species during the coming decades. Many of these declines have occurred in protected areas where the causes have remained enigmatic (Whittaker *et al,* 2013).

One of the major problems associated with flora and fauna decline is deforestation. Forest destruction caused by anthropogenic activities such as bush burning, farming, grazing and urbanization have over the millennia changed the original vegetation cover across the world especially the forest region (Schiotz, 1963; Adejuwon, 1976; Bakarr *et al*, 2001 and Boone and Bridges, 2003). Also habitat degradation from pollution, agricultural herbicides, insecticides and fertilizers impacts amphibian with aquatic life stages, either directly or by synergistic interactions with other factors (Hayes *et al,* 2010). This has had a negative impact on the ability of amphibians to thrive and reproduce successfully (Blaustein and Bancroft, 2007; Becker *et al*, 2007). Deforestation is a serious problem in Nigeria, which currently has one of the highest rates of forest loss (3.3 per cent) in the world. Between 2000 and 2010, Nigeria lost nearly a third (31 per cent) of its forest cover, while its primary forests suffered even worse: in just five years (2000 to 2005) over half of the nation's primary forests were destroyed, the highest rate in the world during that time (http://rainforests.mongabay.com/20nigeria.htm). Deforestation has tremendously threatened depleted or

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endangered biodiversity of the forest ecosystem. It also has negative ecological, genetic and socio-economic impact on the environment (Mfon *et al,* 2014).

Oil exploration is one of the greatest contributors to this present predicament especially in the Niger Delta region. The Delta contains distinct terrestrial and aquatic faunal zones, as well as species that are new to Nigeria; moreover, there is indication that the full range of species in the Niger Delta is still unknown (Ebeku, 2005). The World Bank states that the full significance of the Delta's biodiversity remains unknown because new ecological zones and species continue to be discovered, and major groups such as higher plants and birds remain unstudied in large areas (World Bank, 1995). According to Amadi *et al* (1993), environmental impact of oil exploration and exploitation is one of the inevitable consequences of economic development. Oil exploration by companies involves surveying, massive clearing of vegetation for oil and gas field development, construction of pipelines and dynamiting for geological excavation (Zabbey, 2009). These problems and other environmental threats associated also with site proposal of oil exploration tremendously impact on the natural existence of the anuran species in these localities owing mainly to vegetation loss. Sadly, due to oil pollution the area is now characterized by contaminated streams and rivers, forest destruction and biodiversity loss in general the area is an ecological wasteland (Kadafa, 2012). A thorough review of the environmental impacts of the oil industry in Nigeria would be significant because every aspect of oil exploration and exploitation has had deleterious effect on the ecosystem stability and local biodiversity.

Akinnibosun and Omatsola (2011) conducted an EIA (Environmental Impact Assessment) on a proposed crude oil exploration field in the Niger Delta and observed that a rich floral diversity (112 species) and vegetation composition existed. This point to the fact that the environment has a rich diversity of floral species which supports the thriving conditions of anuran species. But sadly these conditions will be destroyed if proper monitoring of oil exploration is not implemented.

There is paucity of data on tropical anuran population and communities owing to the degradation of vegetation which supports the existence of the faunal elements. The study documents the effect of vegetation clearing for an oil and gas field development site in Arun Owun, Delta State, on the abundance and diversity of anuran species.

Materials and methods

Study area

The study was conducted in a dereserved area approximately 2km by 1.1 km in dimension along an earth road to Arun Owun, Delta State, southern Nigeria. This was done in collaboration with an ongoing EIA assessment project for the possible establishment of an oil facility on a proposed site in the area.

Five Study Sites, 1, 4, 7, 10 and 13, of approximately 200 m by 200 m were chosen from those sites established for EIA assessment (Figure 1). These sites were chosen because they were bordering the road and will be subsequently cleared to widen the access to the exploration site. This will enable population monitoring to be carried out before and after the clearing has been done. To access the interior of these sites adequately, bush footpaths were cut through from east to west and south to north of about 50 m before embarking on the sampling. In the rainy season, vegetation growth was luxuriant and dense and the areas close to the river and creeks were full of water up to 1m high. Many temporary puddles/ponds of various magnitudes were observed. But in the dry season, these sites were dry and the vegetations were relatively sparse.

Each sample location was geo-referenced with a Magellan Sport Track global positioning system (GPS) with accuracy of a metre (Table 1).

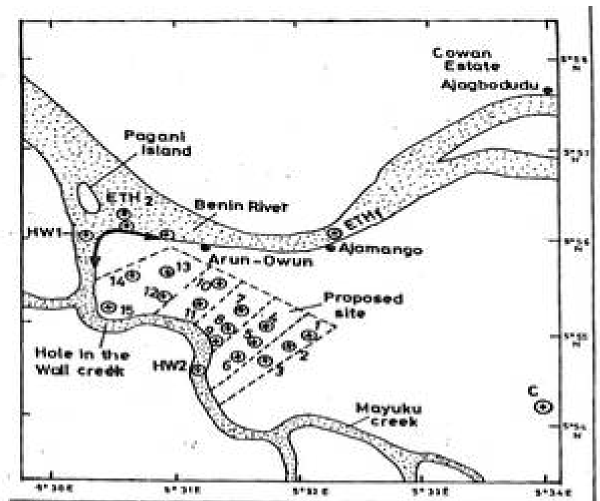

Figure 1. Proposed site for oil exploration at Arun Owun with study sites for Environmental Impact Assessment. Study Sites, 1, 4, 7, 10 and 11 were surveyed for anuran species prior to and after the cutting of vegetation. Adjacent Uncut Sites, 2, 5, 8, 11 and 12 were surveyed after the study-sites were cut.

Table 1. Geographic co-ordinates of sampling locations.

Study Sites	GPS Locations		Elevation (m)
	Latitude	Longitude	
1	N 05º 54′ 056″	E 005 º 32′ 001″	5
4	N 05 º 55′ 007″	E 005 º 31′ 049″	4
7	N 05 º 55′ 019″	E 005 º 31′ 038″	7
10	N 05 º 55′ 026″	E 005 º 31′ 029″	9
13	N 05 º 55′ 036″	E 005 º 31′ 002″	3
Ajacent Sites			
2	N 05º 54′ 050″	E 005 º 31′ 059″	5
5	N 05 º 55′ 009″	E 005 º 31′ 049″	5
8	N 05 º 54′ 018″	E 005 º 31′ 035″	1
11	N 05 º 55′ 037″	E 005 º 31′ 020″	4
12	N 05 º 55′ 031″	E 005 º 31′ 016″	4

Figure 2. Clearing of vegetation in part of Study Site 1.

Amphibian sampling

From 2004 to 2005, prior to the clearing of vegetation at the study-sites, intensive 3-day surveys were conducted monthly at each of the five study-sites: wet season (July-September, 2004) and dry season (January-March, 2005). Combinations of visual encounter survey (VES) and acoustic encounter survey (AES) (Rodel and Ernst, 2004) were conducted to estimate the local anuran composition. Each survey was carried out for a period of 90 minutes. After the clearing of vegetation (Figure 2) for the establishment of the oil facility, surveys were again conducted: wet season (June-August, 2008) and dry season (December-February, 2009). Five adjacent Sites, 2, 5, 8, 11 and 12 still containing uncut vegetation were also surveyed as to ascertain the presence or absence of anuran species still in the vicinity, but not observed at the study-sites. These surveys were carried out five days (each 1800-2000 hr) in the month of May, 2009. Each day had duration of 120 minutes, in order to estimate the anuran absent in the study sites.

Amphibian species were located opportunistically during visual survey of all habitats and microhabitats. During the survey, various habitats such as temporary and permanent ponds, banks of ponds and rivers, vegetation surrounding water bodies, termite hills, cracks or crevices in rocks or dried up water bodies, in shrubs, grasses forest floor, under leaf litters were searched and species observed were noted. Larval sampling was complemented with visual surveys in and around some ponds to detect eggs, larvae and metamorphic individuals. Dipnetting techniques were used (Heyer *et al,* 1994) to collect larvae and the sampling units were separated at least 5m apart to avoid interference between surveys.

Species identification

The specimens were identified by Professor Mark Oliver Rodel from the Museum für Naturkunde, Berlin. The treefrogs were identified through courtesy of Dr. Arne Schiotz. Identification was also carried out using literature by Schiotz (1963 and 1999) and Rodel (2000).

Data analysis

Variations between the period of non-vegetation cutting and post vegetation cutting in the relative diversity and abundance of anuran species were tested by paired *t*-test using the SPSS (version 18.0), with the first sample being prior to the cutting of vegetation and the second sample being post vegetation cutting. This will determine if the change in species composition is significant or not. The Shannon-Weiner (H) and Equitability (E_H) indices were determined using the Past (version 3.08) programme which measured the diversity of anuran assemblages.

Results

On the average, 27.69 and 6.53 anurans belonging to 26 species were recorded in 135 hours of combined VES and AES sampling during this study prior to the cutting of vegetation and after its cutting respectively (Table 2). There were 1,372 [919 (67%) males and 453 (33%) females] individuals observed during the rainy season prior to the degradation of the study-site, while 332 [176 (53%) males and 156 (47%) females] individuals were observed during the dry season. After the site's degradation, 85 [48 (56%) males and 29 (44%) females] and 14 [9 (65%) males and 5 (35%) females] individuals were observed during the rainy and dry seasons respectively. The highest number of species (26) was recorded during the rainy season prior to the cutting of vegetation, whereas the lowest (5) was during the dry season after the cutting of vegetation at the sites. At the adjacent sites, a total number of 64 anurans belonging to 9 species were observed in 10 hours of sampling which are no longer present at the study sites (Figure 3). Anuran species that were no longer observed both at the study and adjacent sites include; *P. plicatus, Phrynobatrachus sp, P. boulengeri* and *H. galamensis.* The results of the sites during the rainy, dry and entire seasons; at *t*-test calculated as 1.297, 0.793 and 1.039 respectively at ($p<0.05$, $df = 25$, $t_{cal} = 7.436$), showed that there is significant difference between the time prior to vegetation cutting and post vegetation cutting.

The Shannon-Wiener index (Hs) indicates a remarkable difference in the diversity of anuran species during the wet season prior to the cutting of vegetation (1.28) and after the cutting of the vegetation (0.78) at the sites (Figure 4). Similar trend in the results showed that for the dry season; prior to vegetation cutting (1.05) and post vegetation cutting (0.55). Also remarkable difference is observed in the Equitability Index (Figure 5) where higher values are indicated prior to vegetation cutting as against lower values after the cutting of vegetation. Figure 6 (a-d) display some anuran species observed during the study.

Table 2. Relative abundance of anuran species at the study-sites prior and after the cutting of vegetation.

Families	Species	Prior to vegetation cutting			Post-vegetation cutting		
		A	B	C	A	B	C
Pipidae	*Silurana tropicalis*	0.67	0	0.34	0	0	0
	Xenopus muelleri	1.17	0	0.59	0.44	0	0.22
Hemisotidae	*Hemisus marmoratus*	0.44	0.56	0.5	0	0.05	0.03
Bufonidae	*Amietophrynus regularis*	3.72	2.83	3.28	1.72	1.22	1.47
	A. maculatus	2.11	1.72	1.92	1.11	0.89	1
	Nectophryne afra	0.44	0	0.22	0	0	0
Dicroglossidae	*Hoplobatrachus occipitalis*	0.94	0.5	0.72	0	0	0
Ranidae	*Hylarana albolabris*	2.17	1.56	1.87	0	0	0
	H. galamensis	0.78	0	0.39	0	0	0
	Aubria subsigillata	1.22	0.44	0.83	0.33	0	0.17
Ptychadenidae	*Ptychadena pumilio*	4.33	2.17	3.25	2.28	0.72	1.5
	P. oxyrhynchus	1.00	0	0.5	0.11	0	0.06
	P. muscareniensis	1.44	0.33	0.89	0.39	0	0.2
	P. aequiplicata	1.61	0.67	1.14	0	0	0
Phrynobatrachidae	*Phrynobatrachus accraensis*	3.39	1.72	2.56	1.78	0.89	1.34
	P. francisci	0.67	0.39	0.53	0	0	0
	P. plicatus	0.67	0.33	0.5	0	0	0
	Phrynobatrachus sp	0.33	0	0.17	0	0	0
Arthroleptidae	*Arthroleptis variabilis*	2.56	2.11	2.34	0.61	0	0.31
	A. poecilonotus	1.33	1	1.17	0	0	0
	Arthroleptis sp.	0.44	0	0.22	0	0	0
	Leptopelis boulengeri	1.06	0.61	0.84	0.11	0	0.06
Hyperolidae	*Afrixalus dorsalis*	1.5	0.72	1.11	0	0	0
	Hyperolius riggenbachi	0.72	0	0.36	0	0	0
	H. guttulatus	1.89	0.56	1.23	0.33	0	0.17
	Phlyctimantis boulengeri	0.44	0	0.22	0	0	0
Total number of species		**26**	**17**	**26**	**11**	**5**	**11**
Total number of individuals		**37.04**	**18.22**	**27.69**	**9.21**	**3.77**	**6.53**

(A) wet season only. (B) dry season only. (C) mean of wet and dry seasons.

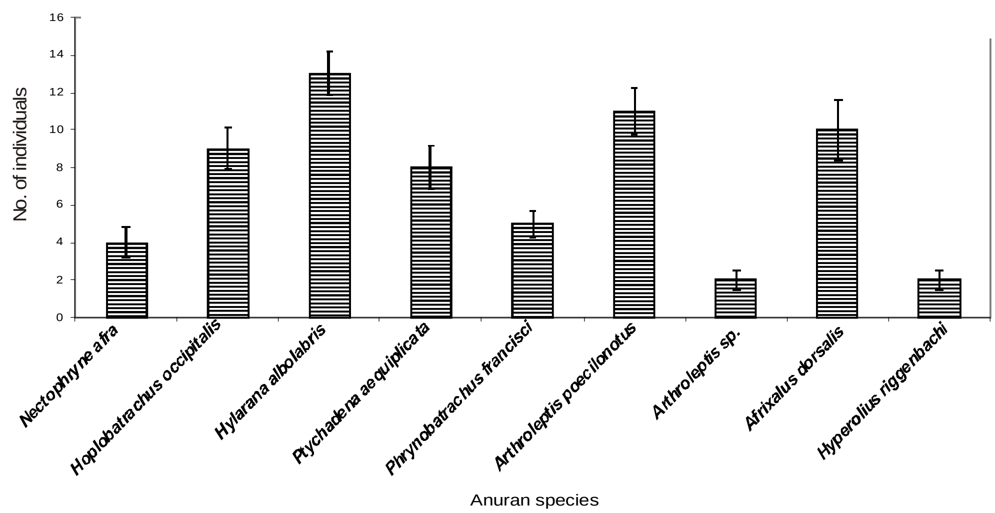

Figure 3. Mean number of anuran species observed at the adjacent sites but absent at the study sites.

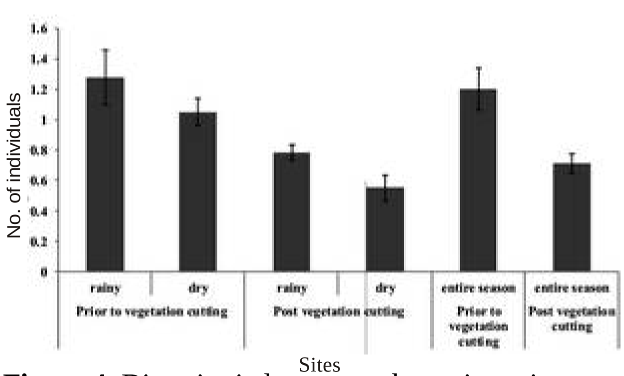

Figure 4. Diversity index across the various sites.

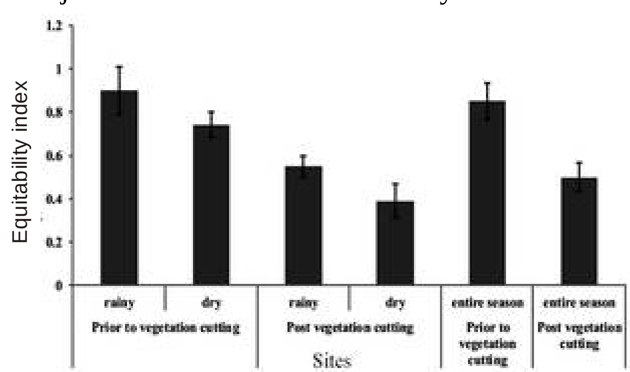

Figure 5. Equitability index across the various sites.

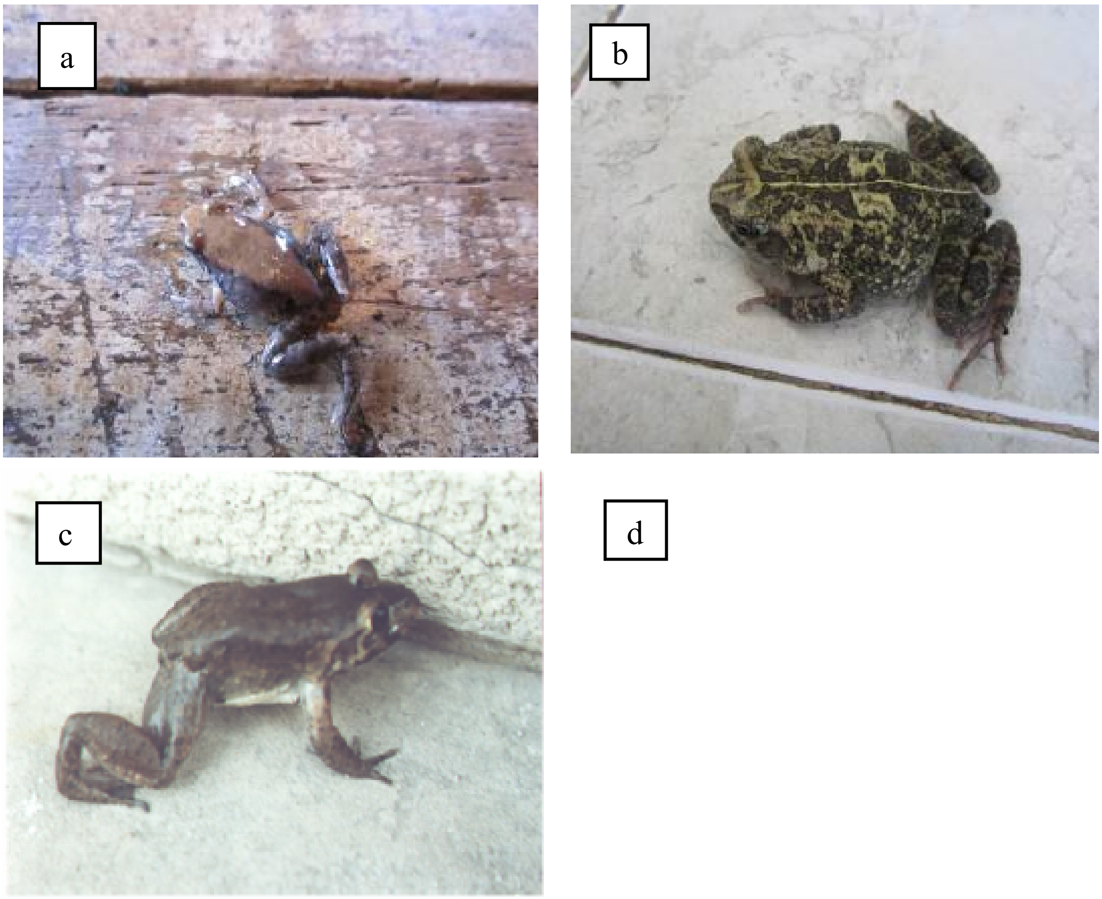

Figure 6 (a-d). Some anuran species observed during the study. **a.** *Arthroleptis sp.,* **b.** *Amietophrynus maculatus,* **c.** *Aubria subsigillata,* **d.** *Afrixalus dorsalis.*

Discussion

This study describes the effect of deforestation on the assemblage of anuran species in Arun Owun town which is part of the Delta Region of Nigeria. Oil exploration covers a million hectres of forested land and this involve deforestation, which results to the loss of habitat to a diversity of organisms including many anuran species. Deforestation is clearly the principal cause of habitat loss and this is concentrated in the tropical regions where biodiversity is greatest (Brooks *et al*, 2002). Brooks *et al* (1999) and Pringle (2001) observed that extensive clearing in the tropics is concentrated in lowland areas with coastal areas being particularly vulnerable.

Results from this study showed that there was significant difference between the number of anuran species and their abundance prior to the cutting of vegetation and after the cutting of vegetation at the study sites. A total of 26 anuran species was observed before the vegetation was cleared. After clearing, a total of 12 anuran species was observed. Definitely the clearing of vegetation had a great impact on the anuran assemblage. According to Dodd and Smith (2003), habitat loss, alteration and fragmentation are likely the primary cause of amphibian population decline and species extinction worldwide. In Australia, habitat modification is associated with declines in 18 of the 40 threatened species and is the primary cause of population declines in lowland frogs, negatively impacting 11 out of the 12 threatened lowland species (Hero and Morrison, 2004). Habitat loss and fragmentation are important factors determining animal population dynamics and spatial distribution and such landscape changes can lead to the deleterious impact of a significant drop in the number of species, caused by critically reduced survival rates for organisms (Niebuhr *et al,* 2015).

The cutting of vegetation directly resulted into the reduction of the composition of vegetation, thereby leading to decrease or lost of canopy cover. The situation also results to higher temperature, lower humidity and increased wind velocity which do not favour the thriving conditions of most anuran species. These are direct consequences of habitat alteration. Habitat alteration can directly remove amphibian breeding and feeding areas or block access to them (Hazell *et al*, 2003). The consequence of habitat alteration is evident in the results, as less than 50% (11 out of 26 species) of anuran species were observed after the cutting of vegetation at the study sites. Fonseca *et al* (2013) observed that habitat split resulting from habitat degradation is also a major force behind the worldwide decline of amphibian species causing community change in richness and species composition which is able to generate extinctions thresholds.

Results also showed that out of the 14 species no longer seen at the study site, nine (34.6%) were observed at adjacent sites. Five (19.2%) species were no longer accounted for both at the study sites and adjacent sites. These species may physiologically or morphologically be incapable of adapting to the changes brought about by the change in vegetation structure. They might have died or migrated to more favourable habitats or distant ones depending on the species. Therefore, this may lead to the probability of some species becoming locally extinct due to such habitat destruction. Similar observation made by Ash (1988), Petranka *et al* (1993) and Parris (2001) revealed that although some amphibian species decline rapidly when the forest cover is removed, most species suffer a gradual depletion of populations and the over impacts are not realized until the species has disappeared from a significant part of its former geographic range (Beebee, 1977; Gillespie and Hollis, 1996). This local loss of anuran species due to constant destruction of habitats (e.g. more oil exploration) may also lead to loss of genetic diversity. Species may no longer be able to adapt to environmental changes which may have been possible through genetic variability and diversity. Consequently as a result of vegetation cutting, the diversity and equitability indices were remarkably lower when compared to the status of the study sites before the cutting. As discussed earlier, this is due to the effect habitat destruction of these species which eventually lead to their death or migration.

Conclusion

Removal of large tracks of native vegetation changes physical processes, which affect the thriving conditions of anuran species. The micro-climate at the cleared land and at the forest edges adjacent to clear land differs from that of the forest interior in attributes such as light, humidity, ground and air temperature, and wind speed. These physical changes affect biological processes such as nutrient cycling and the structure and composition of vegetation. In turn these lead to biodiversity loss (e.g. loss of insect population on which the anuran feed on) which directly affect the anuran population and survival. Preventing the degradation of the forest fragments should be a priority and also monitoring the dynamics of anuran species in their response to habitat destruction is important. These are crucial steps in the conservation of biological diversity.

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