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Full Length Research Paper

Diversity and distribution of amphibians in the Kakum National Park and its surroundings

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This study investigated amphibian distribution and diversity in Kakum National Park and its surrounding communities. Sampling was carried out in lowland swampy areas and upland zones of both locations; thus totalling four main habitat types as areas of survey. A total of 1434 specimens belonging to four Families comprising 12 species of anurans were recorded. The 12 species were irregularly distributed in the four habitat types. The Arthroleptidae and Ranidae were localized with low levels of abundance and richness while *Phrynobatrachus alleni* was widespread. There were no significant differences in both diversity and distribution between the reserve and its surrounding communities. This is a probable indication that the current anthropogenic disturbances off-reserve may have little or no effect on the amphibians; or may affect them in both the reserve and off-reserve together in the same way. However, the park's upland forests favoured amphibian distribution and diversity most and the results support the hypothesis that elevation may affect the distribution and diversity of some species of amphibians. Nevertheless, the results of the study calls for a critical consideration for efficient amphibian conservation in both in- and off-reserve of the study area as the number of species recorded is lower than expected.

Key words: Kakum National Park, lowland, upland, amphibian distribution, diversity, anurans, surrounding communities, decline, extinction, herpetofauna, environs.

INTRODUCTION

Currently, there is expression of great concern about extinction of amphibians globally (Reid and Zippel, 2008); as one in three amphibian species is threatened with extinction (Norris, 2007). This concern is justified on the grounds that worldwide, amphibians are crucially important in their ecosystems. The general ecological importance of amphibians lies in their being predators; acting as primary and secondary carnivores on insects some of which are crop pests or disease vectors (Behangana, 2004). The known important roles amphibians play in the food webs of most biological communities cannot therefore be overemphasized. For example a detailed study of upland streams in the Central Panamanian Highlands revealed that ecological effects of amphibian decline could not just be taken for granted. The effects included changes in algal community structure and primary production, altered organic matter dynamics, negative impacts on aquatic insect predators, such as snakes and reduced energy transfer between streams and associated riparian habitats (Ranvestel et al., 2004). The probable causes of the amphibian decline are established to be multi-faceted involving various complex combinations of obvious ones such as habitat destruction, habitat fragmentation or loss, pollution (industrial, agricultural and pharmaceutical) over-harvesting and invasive species (Beebee and Griffiths, 2005; Moore and Church, 2008). A rather non-traditional cause is realized to be the growing ecological impacts of climate change (Araújo et al., 2006). The causative factors are even suspected to be acting in synergy in some instances (Blaustein and Kiesecher, 2002; Davidson and Knapp, 2007). Quite recently, a disease

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caused by a chytrid fungus, *Batrachochytrium dendrobatidis* has been implicated as the factor most commonly associated with enigmatic declines and catastrophic extinctions of amphibian populations and species (Moore and Church, 2008).

Even though habitat loss may evidently remain the most significant threat overall (impacting 90% of those species currently considered threatened), it is believed that amphibians are more sensitive than other organisms to environmental deterioration and that the decimation of amphibians is a warning sign of an ever increasing poisoned environment. It is observed that many small mammals and herpetofauna species generally have relatively short generation time and a quick response to habitat and microclimatic variations within forest fragments (Cain et al., 2007). Thus, amphibians as biomonitors can be used to measure this feature (Wasonga et al., 2006). An alteration of microclimatic conditions is also thought to be of major importance to plants and animals generally in fragmented forests (Harper et al., 2005). The global extinction threats of amphibians have generated calls for proactive conservation activities (Stuart et al., 2004) and has even prompted a 5-year strategic plan by the Amphibian Conservation Action Plan (ACAP) in 11-pronged thematic areas. The strategy has designed a network of conservation sites for amphibians taking into consideration freshwater resources and associated terrestrial landscapes, climate change, biodiversity loss, amphibian declines and captive programmes (Moore and Church, 2008). The 11 thematic areas also translate into 4 phases of activities (Moore and Church, 2008). In the ensuing activities, it appears there is a favour for breeding programmes; but Pounds et al. (2007) for example have expressed reservations about the utility of breeding in zoos in favour of field oriented conservation programmes for amphibians. The World Zoo and Aquarium Conservation Strategy (WZACS, 2005) of the World Association of Zoos and Aquariums (WAZA) have suggested a compromise strategy through all the foregoing complexities and are trying to bridge the gap between conservation activities in nature (*in situ*) and work in zoos and aquariums (*ex situ*). Their line of action demonstrates potential for fully integrated and sophisticated approaches that are truly complementary.

It is in the light of concerns about worldwide amphibian declines that the need has been expressed about gathering base-line and long-term information. Base-line information on amphibians would be needed for at least most future monitoring and conservation efforts.

Proposals of WZACS emphasize the urgent need for more studies of the ecological impacts of amphibian declines and extinctions and there has been a call for accumulation of data on amphibian population biology and habitat viability in the wild. Furthermore, to ensure the appropriate husbandry conditions and management protocols in zoos, it cannot be denied that there also has to be sufficient knowledge of population biology and habitat viability in the wild (Reid and Zippel, 2008). However, such information about the natural history and conservation status of a very large number of tropical species is lacking in mainland Africa (Halliday, 2008). As it is in West Africa generally, the herpetofauna of Ghana remains largely uninvestigated and ecological research of amphibians linked to conservation activities has generally lagged behind in West Africa. The high biological significance of protected areas, the escalating human exploitation and the negative impact that human exploitations have on wildlife all suggest that there is the need for a detailed herpetofaunal investigation to document information we can gather now before some disappear. Data on the number of species of amphibians found in any one locality in Ghana remain unexplored. Since few detailed studies on the herpetofauna of Ghana have been carried out, this study was undertaken mainly to contribute to the scanty literature on Ghana's herpetofauna and to provide background data against which analyses such as amphibian declines, among other parameters, will be measured in future. Such information is vital for conservation priorities and the study focuses on diversity of amphibians in Kakum National Park (KNP) and its surroundings as a baseline for analyzing trends of changes and predictability, as well as setting up recovery goals in future as the need arises. The two main null hypotheses tested were that, there is no significant difference between the species diversity of amphibians in the Kakum National Park and its surrounding communities; and elevation does not affect the distribution of amphibians in the Kakum National Park.

Study area

The investigation was carried out in the 210 km^2 Kakum National Park (KNP) and its surrounding communities. The KNP is a protected area but part of the irregular remnant of the fast dwindling Ghana's portion of the moist evergreen Upper Guinea Forest and dominated by *Celtis zenkeri* and *Triplochiton scleroxylon* (Hall and Swaine, 1976) although there are about 100 tree species. The KNP spans the Twifo Praso, Assin and Abura districts of the Central Region of Ghana (1°30' - 1°51' W; 5°20'- 5°40' N) and is sited about 165 km west of Accra, the national capital. The general climatic conditions of the country characterized by bimodal rainfall and two dry seasons (Durand and Skubich, 1982) prevail in the park. A heavy rainy season from April to July is followed by a light dry season from August to September. A light rainy season from October to early December is then followed by a heavy dry season from December to March (Kouadio et al., 2008). The fauna may concentrate in and around the few water spots available in the park during the dry harmattan from December to March; that is the heavy dry season. The average annual rainfall is about

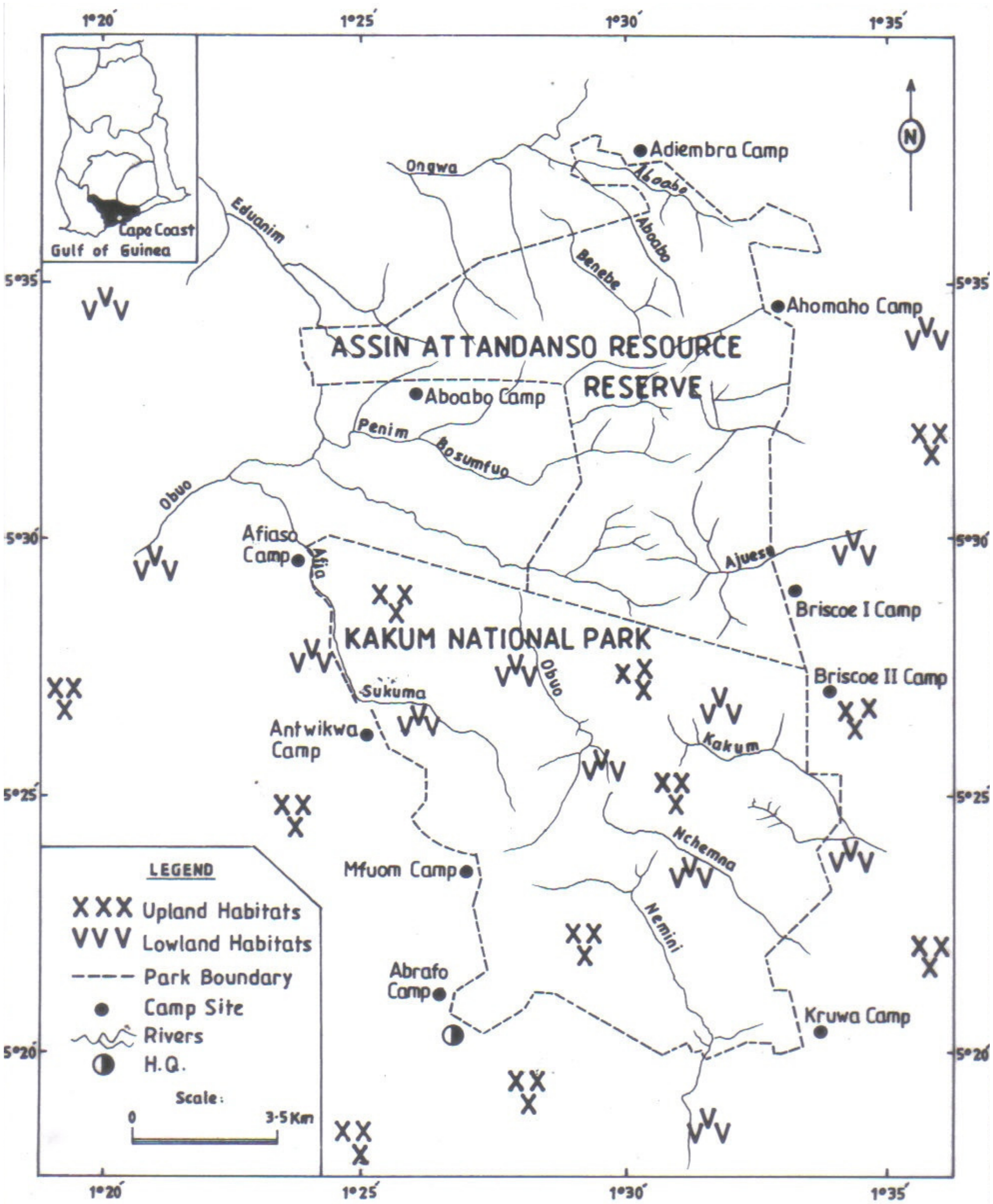

Figure 1. Map of study area.

1600 mm (Forestry Commission, 2007).

The park protects the headwaters of permanent rivers such as Kakum, Obuo and Nemini and rivulets like Ajuesu which may dry up in the heavy dry season (Figure 1). The average relative humidity is about 80% throughout the year while temperature ranges from 18.2 to 32.1°C. The terrain is flat to slightly undulating with an elevation of between 15 to 250 m above sea level (asl) (Forestry Commission, 2007). Most of the elevations occur in the south-western portion of the park. Light south westerly winds blow over the area almost throughout the year. The park is fringed by about 50 communities; six of which are designated by the Wildlife Division of Ghana as camps where park guards are stationed. The majority of the inhabitants in the communities engage in subsistence agriculture with poor farming methods such as slash and burn and small land holdings sometimes right down to the park's boundary. On the other hand, the park itself is increasingly being developed to a holiday resort offering great potential for both tourists and holidaymakers locally, nationally and internationally.

METHODOLOGY

The study area was classified into two land use types and sampled during the period of October 2008 to March 2009. The two land use types were the protected area i.e. the reserve and its recreation area; and the other was the surrounding communities, i.e. the human settlements with their adjacent farmlands. The farmlands consisted mainly of cash crops like cocoa, orange or oil palm and food crops such as cassava, cocoyam, plantain and vegetables (pepper, tomato, garden egg). Some parts of the human settlements consisted of permanently dry pond beds. Each land use type was further sub-divided into lowland which consisted of swampy areas adjacent to watercourses and elevations of dry terrain. We considered the lowland as terrain from sea level up to 25 m asl and elevations as 25-250 m asl. Thus four habitat types were studied, namely in-reserve lowland, in-reserve upland, off-reserve lowland and off-reserve upland. In each land use type sixteen 100x200 m zones were randomly selected out of about twenty five demarcated plots (Figure 1). Visual Encounter Surveys (VES) as defined by Crump and Scott (1994) was the detection technique used in all the habitats because our main aim was to maximize the man hour available. For each sampling, a team of at least six people were employed to search thoroughly for about one hour (at least 6 members were available out of 10 crew for 6 man hours/plot) in cracks and crevices, under deadwood, under leaf litter and around stagnant water bodies. There were 3-5 plot searches/day. Anuran calls were followed to locate male specimens early in the morning at about 05.30 GMT on about 10 occasions after it had rained in the night. Some incidental observations and opportunistic encounters (in which case amphibians encountered in the study area outside search times) were also encouraged, though these yielded no different results.

All individuals collected were identified directly in the field after Rödel (2007) and then released. Initial toe clipping to avoid double counting was discontinued because no specimen was caught twice even in adjacent sampling sites and it was feared that the clipping might introduce infection. Also, mark-recapture techniques were irrelevant for the purposes of this study. The intensive search method adopted favoured diurnal sampling and produced better results than nocturnal sampling and so the latter was discontinued after some time. Also, October which falls in the minor rainy season in Ghana was very wet with heavy rains during the study period and therefore both dry and wet conditions which normally influence amphibian abundance and distribution were adequately represented during the period of study. Voucher specimens were killed with chlorobutanol solution and preserved in 10% formaldehyde and kept in the Department of Entomology and Wildlife Museum, University of Cape Coast. It is obvious that some human activities have effects on amphibian diversity, distribution and abundance. While such activities like farming and spraying chemicals of any kind is not allowed in the reserve, the study sought to know the extent of such activities in the off-reserve sites of the study area through interviews with people in the communities studied.

A one-way ANOVA at 0.05 alpha level was used to test whether there was any significant difference in the means of population of the amphibians in the four habitat types. Variance among the populations in the four habitats was tested with Levene's test for homogeneity, and a Mann-Whitney U test was conducted to evaluate population distribution between swampy lowland and upland habitats in the reserve. Also, Simpson's and Shannon-Weiner's indices were calculated for diversity t-test by the use of SPSS to compare the diversity of the amphibians in the four habitat types.

RESULTS

A total of 1434 individual anurans were recorded during the study. These comprised 12 species, which belong to 5 genera of 4 families (Figures 2 and 3). Apart from the family Ranidae which occurred in off-reserve only, the others, namely: Arthroleptidae, Bufonidae, and Petropedetidae occurred in both in and off-reserves of the study area with Petropedetidae recording the highest encounter rate (Figure 3). The highest number of 963 amphibians was recorded in the upland habitats within the reserve as compared to the least of 67 in lowland swampy habitats in the reserve. The upland and lowland swampy habitats off-reserve recorded 237 and 167 amphibians respectively (Table 1). None of the four habitat types of the study area recorded all the 12 species but results of the off reserve upland habitat was most represented with 11 species contrasted with the least of 6 species in off-reserve swampy lowland habitats (Table 1).

Thus, amphibians are more fairly distributed in the upland habitats within the reserve than other habitat types (Figure 2). *Phrynobatrachus alleni* recorded the highest mean abundance of 113.8 (S.D.=165.6) though *Phrynobatrachus calcaratus, Phrynobatrachus. liberiensis* and *Phrynobatrachus poecilonotus* also occurred in fairly high abundance and the other species occurring at very low abundance in the study area, the least of 1.0 (S.D. = 1.4) being *Phrynobatrachus bibroni* (Figure 4). The data indicate clumped distribution of the anurans in almost all the habitats sampled. The means of amphibian population that occurred in all the four habitat types differed significantly ($F=3.71$, $p=0.02$). Furthermore, homogeneity test indicated a significant difference between the populations of amphibians in all the four habitat types. This therefore supports the hypothesis that amphibian species population differs for each of the four habitat types of amphibian distribution in the study area. Evaluation of the amphibian population distribution revealed an insignificant difference between swampy lowland in the reserve and upland habitats in the reserve that is, $U=49.5$, $p=0.20$; between upland habitats in the reserve and upland habitats off-reserve, $U=60.5$, $p=0.52$; and between lowland habitats in the reserve and off-reserve lowland habitats, $U=61$, $p=0.54$. In contrast, there was significant difference between the populations of amphibians in the off-reserve upland habitats and off-reserve lowland habitats ($U=35.50$, $p=0.04$).

Various diversity indices have been provided (Table 1) and diversity t-test conducted between lowland and upland habitats in the reserve indicated a significant difference between them as $t = -3.29$, $p=0.001$. Similarly, a significant difference was found in the diversity between off-reserve lowland and off-reserve upland habitats as t=-

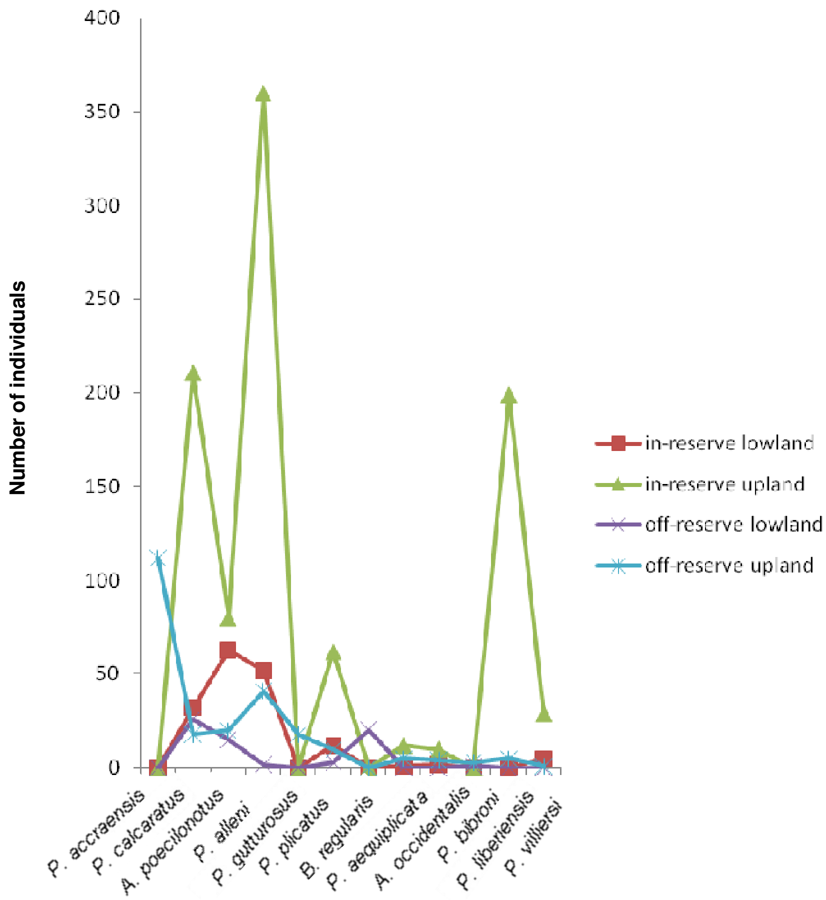

Figure 2. Distribution of amphibians in the study area.

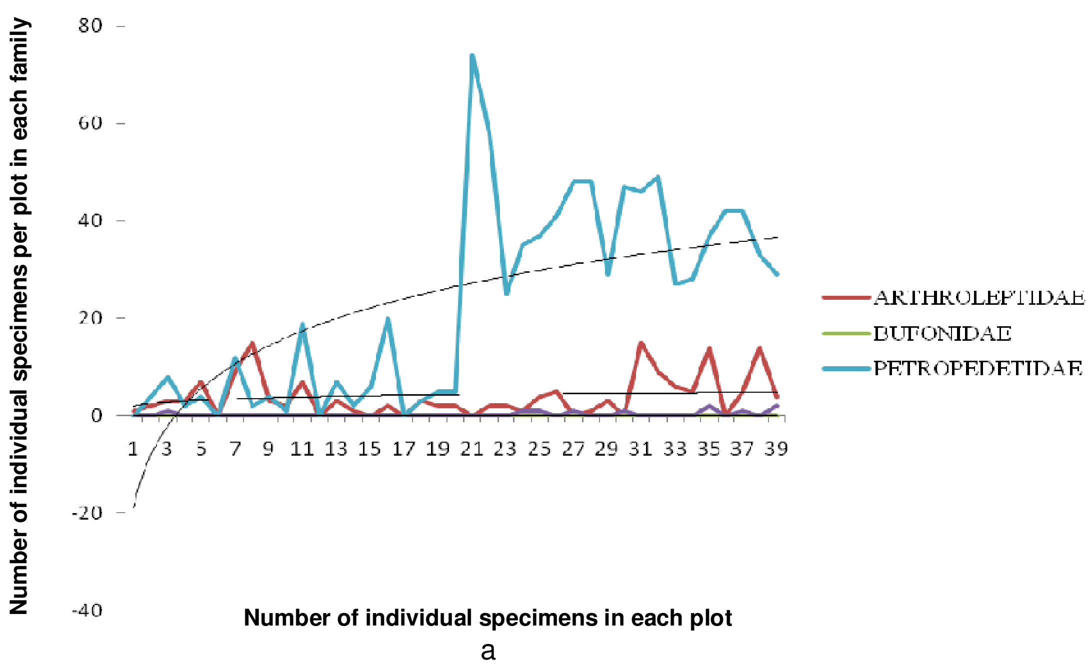

Figure 3. a) Encounter curve of amphibians in the reserve.

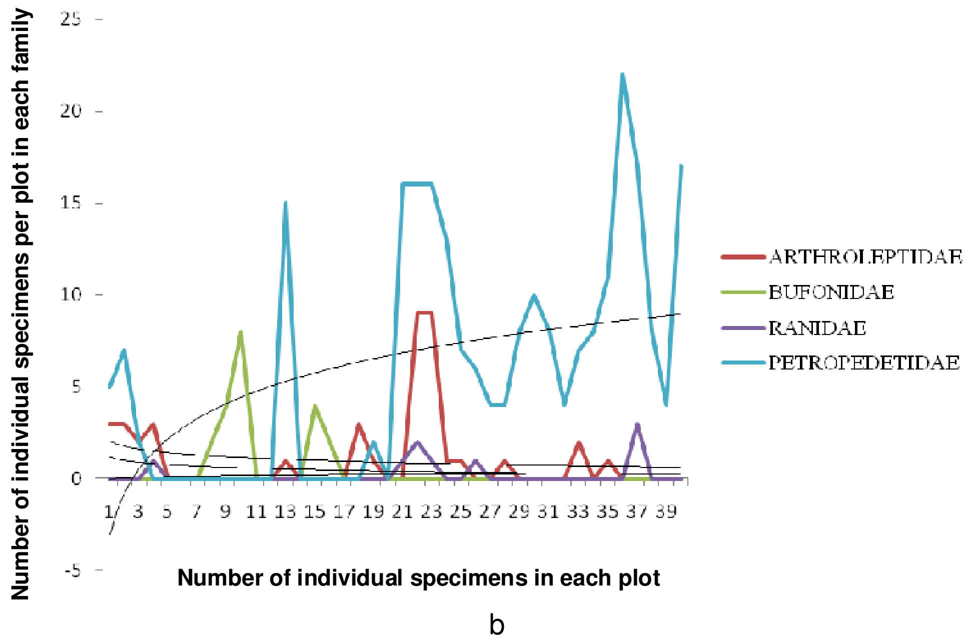

Figure 3. b) Encounter curve of amphibians in the off-reserve area.

Table 1. Diversity indices of the amphibians in the study area.

Parameter	In-reserve lowland	In-reserve upland	Off-reserve lowland	Off-reserve upland
Taxon (species)	7	8	6	11
Individuals	167	963	67	237
Dominance	0.2822	0.2427	0.2929	0.2717
Shannon-Weiner index (H)	1.426	1.617	1.37	1.709
Simpson’s index (D)	0.7178	0.7573	0.7071	0.7283
Equitability/evenness	0.7326	0.7777	0.7646	0.7128

3.12, p=0.002. However, there was no significant difference in diversity between in- and off-reserve lowland habitats (t = 0.72, p=0.474) as well as between in- and off-reserve upland habitats (t = -0.91, p=0.366). These therefore support the hypothesis that diversity of species of amphibians could be altered by elevation. Figure 5 displays the species percentage composition at the four habitat types and only four species namely, *Arthroleptis poecilonotus, P. alleni, P. calcaratus, and P. plicatus* occurred in all the habitat types studied at different population levels. *Bufo regularis* and *Phrynobatrachus accraensis* occurred abundantly in only a single habitat type while the remaining six species occurred in two or three of the four habitat types at different population levels. Casual observation of the landscape of the study area pointed to a trend, allowing a few inconsistencies, that the uplands were more of a closed canopy forest type. Interviews with farmers in the communities indicated frequent and indiscriminate use of agrochemicals, especially on vegetables and on cocoa farms off-reserve.

DISCUSSION

Wildlife inventories form the foundation for selecting priority sites and thereby help to identify priority species (Daily et al., 2003; Pineda and Halffter, 2004) and the relevance has become even more paramount because of the alarming rate of species extinction (Santos-Barrera et al., 2008). Amphibians hold vital positions in forest and aquatic food webs; they are also important for nutrient cycling (Hanlin et al., 2000), as indicators of ecosystem health (Gibbons et al., 2000) and compose an important portion of the vertebrate biomass (Hutchens and DePerno, 2009). Rather unfortunately the lack of

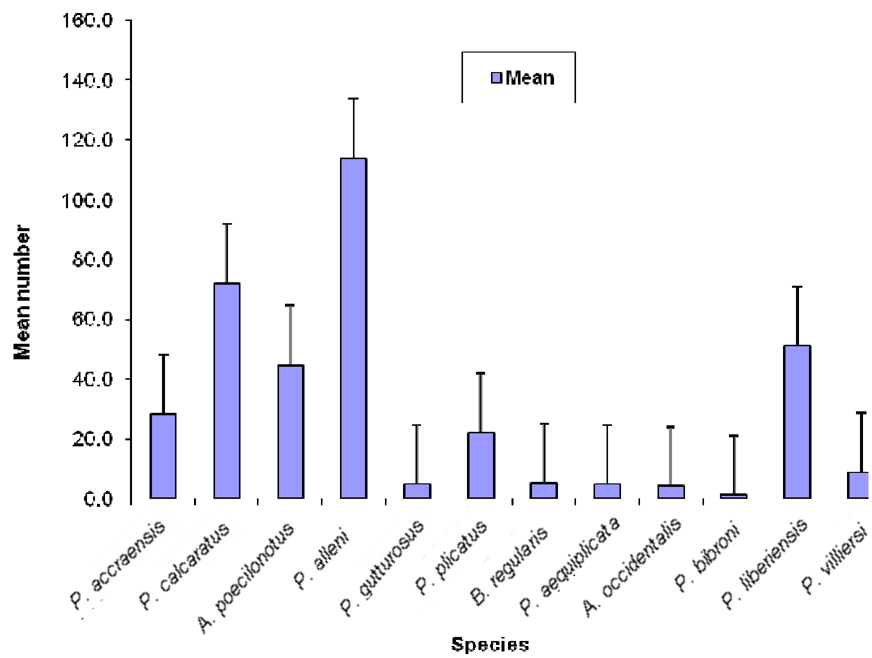

Figure 4. Mean abundance of amphibians in the study area.

systematic inventories precludes the solid evaluation of the possible trends documented.

Amphibians particularly have not attracted much attention in Africa and most information in that regard is conjectural. For example, it is estimated that there are about 221 species of amphibians and reptiles in Ghana (MES, 2002) and so this report may be the first attempt to make an inventory about amphibians for a specific location in a certain part of Ghana. The survey may represent the best natural diversity, abundance and distribution of vertebrates in the KNP since human predation for consumption and trade in amphibians is not known in Ghana. The results give a high conservation value to the amphibians of the KNP and its surrounding communities as reported for parts of Africa where similar studies have been undertaken (Behangana, 2004; Behangana and Arusi, 2004; Wasonga et al., 2006). It is noteworthy that the species present in the reserve are also represented in the surrounding communities.

Little or virtually nothing is known about the effects of pesticides or other agrotoxic chemicals, climate change or invasive species on amphibians in the study area; even though there is indiscriminate use of agrochemicals especially on vegetables and on cocoa farms off-reserve. However, the results reveal in some ways that such chemicals may have little or no effect on the amphibians considering that the distribution and diversity of these animals in and off reserve show no significant difference and that some other factors may account for the low diversity in both in- and off-reserve areas. While it is agreeable that forestry practices can negatively affect local habitat quality for selected herpetofaunal species, at least in the short-term (deMaynadier and Hunter, 1995), or for a long-term (Petranka et al., 1993) the results of this study did not show any significant difference in distribution, diversity or abundance of the amphibians between the intact habitats in the reserve and the cultivated and logged off-reserve habitats. Scott (1983) observed that even when extensive deforestation and developing land for agriculture have occurred in south western Costa Rica, a high diversity of historically known herpetofauna was still present. It is therefore not too clear why only 12 species were recorded for a total of 1434 individuals after an intensive and extensive search in the study area whereas about 76 species of amphibians are believed to be housed in the African rain forest (Poynton, 1999; IUCN and NatureServe, 2004). About 17 valid species of *Phrynobatrachus* alone are recognized in West African forests (Schiotz, 1964; Rödel and Ernst, 2002; Rödel et al., 2005) but only 7 species were encountered in this study area.

In a study carried out in the relatively undisturbed rain-forest tract of Kalakad-Mundanthurai Tiger Reserve, of the Western Ghats, India, a total of 509 individuals belonging to 20 species were captured (Karthikeyan et al., 2008). But also in the temperate region, Strojny and Hunter (2010) reported amphibian representation of only 12 species for 9,069 individuals over 1,540 ha in the Penobscot Experimental Forest (PEF) in Penobscot County, Maine, USA. Thus, expectation for more species than listed cannot be substantiated by mere logic, but habitat conditions in the study area favour high

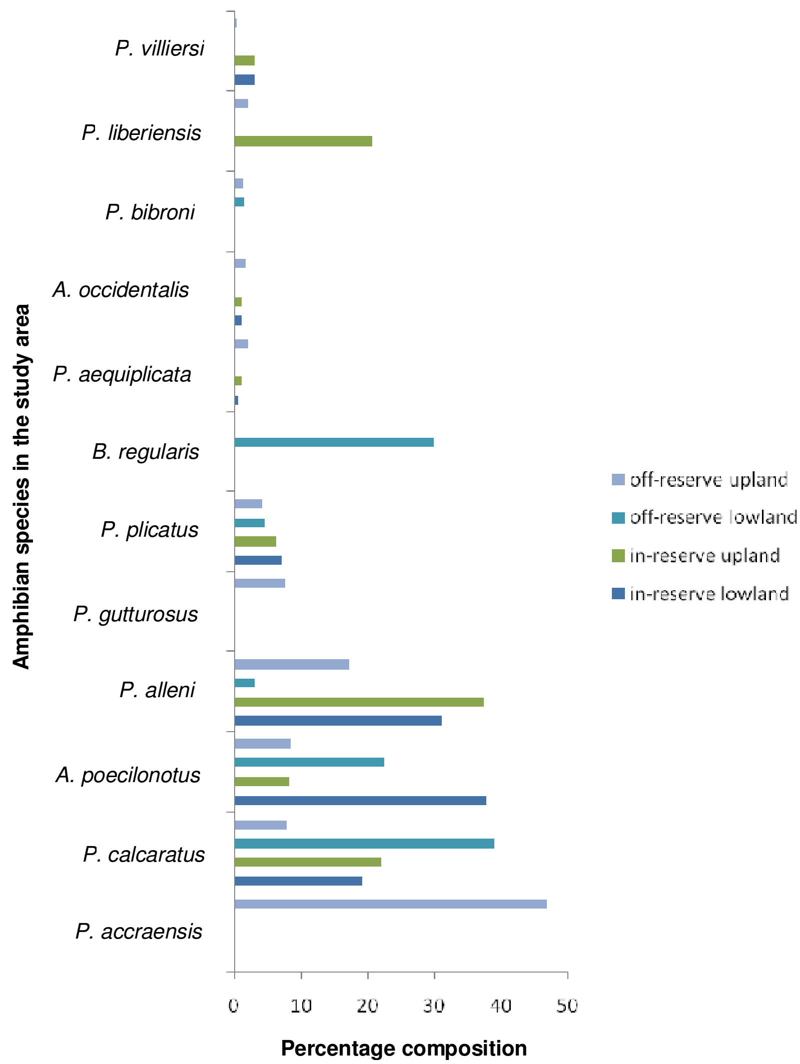

Figure 5. Percentage composition of various species of amphibians in the study area.

amphibian diversity. The study reveals that amphibian species population differs for each of the four habitat types of amphibian distribution in the study area and that uplands are more favourable habitats than lowlands for amphibians in KNP. Thus landscape is a major factor responsible for the distribution and diversity of amphibians in the study area. It is possible that the closed canopies of the uplands provided a more favourable condition for the anurans.

It is possible also that the animals have evolved to avoid predation by occupying upland habitats as their predators have learnt to associate them with lowland swampy areas over the years. The study did not take into account the effect of dispersal of juvenile amphibians on the distribution in the study area. Further studies are likely to show that the presence of juveniles contributed to the results in the lowland habitats as they dispersed to the uplands from the lowland habitats. Many authors such as Alford and Richards (1999) and Houlahan et al. (2000) have reported that amphibians are in decline worldwide, although the reasons for this decline have not been agreed upon (Collins and Storfer, 2003). The situation at the KNP and its surrounding communities predicts loss of species over time and this raises legitimate caution by reason of the fact that causes of species disappearances have not been studied and are unknown in this area.

Conclusion

We conclude that the number of species revealed by this study is low and lends credence to the fear that there is a global decline in amphibian diversity and express the urgent need to map out effective strategy for the conservation of amphibians worldwide. We report that any strategy adopted should include investigation into any possible cause of amphibian decline in the study area and also recognize the importance of uplands in- and off- reserves as a good habitat for amphibian survival.

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