Species Richness and Diversity of Land Snails in Ngel-Nyaki Forest Reserve, Mambilla Plateau, Taraba State Nigeria

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Abstract

The need to identify and estimate the montane forest for bio-diversity conservation in Nigeria has become of utmost importance due to the fact that the tropics have faced massive biodiversity loss due to intensive anthropogenic activities. Molluscs are among the most ancient of animals on earth today. Nigeria Plateau has long been recognized for its faunal richness and diversity. This study established the molluscan compositions in relation to the soil content that influence the distribution of molluscs fauna of the plateau montane forest of Taraba State, Nigeria. The land snail richness and diversity of Mambilla plateau montane forest, Ngel- Nyaki, was studied using a combination of direct search and litter sieving techniques. Twenty-four plots of 20 x 20 m were randomly selected. A total of 18 species and 681 individuals in 7 molluscan families were recorded from 24 plots. The carnivores Streptaxidae and Subulinidae dominated the land molluscan fauna in the number of species. The non-parametric estimator of Chao 2 and jackknife were 17.985 and 18.10 of all sample collected. Nitrogen content in the soil of the montane forest was 7.25 gkg-1. Terrestrial mollusk with small populations and narrow distributional ranges are at a great risk of local extinction if forest destruction continues unabated. The land snail species inventory increased our knowledge of the molluscan fauna of the montane forest and also assisted in biodiversity conservation management in Nigeria.

Keywords: Mollusc, Biodiversity loss, Conservation, Diversity index, Montane forest.

1. Introduction

The tropics have faced massive biodiversity loss due to intensive anthropogenic activities such as changes in land use and degradation of the environment. Recent reports suggest that the tropics are losing biodiversity at an alarming rate (Sodhi, 2008). Much of this biodiversity loss has been reported for vertebrates and plants. However, there is very little knowledge on the extent of loss in lesser known groups, especially the invertebrates (Lydeard *et al.,* 2004).

Conservation of wildlife species are maintained at the optimum level commensurate with other forms of land use and human activities in order to ensure continued existence of wildlife for the benefit of the people (Nigeria National Park Service, 2006). Although individual nations designate their own national parks differently, there is a common idea; the conservation of wild nature for posterity and as a symbol of national pride (Nigeria National Park Service, 2006). Land snails include several distinct lineages of terrestrial gastropods and belong to the second largest phylum after arthropods in terms of number of species with more than one lack described species (Lydeard *et al*., 2004). Land snails constitute about six percent of the total species on Earth (Clark and May, 2002).

Land molluscs are damp atmosphere animals, found in habitats such as banks of water courses and ponds, marshes, damp meadows, especially such that have dead leaves, tree stumps, rotten wood and thickets of vegetation. Welter-Schultes and Williams (1999) reported that habitat diversity affected species' richness even after accounting for the effects of area. In calcium poor habitats, land snails can form an important source of calcium for other animals. They also serve as an indicator of ecological conditions and are very sensitive to climatic and ecological change (Čejka and Hamerlík, 2009). Thus, they are useful for reconstructing past environments (Bar-Yosef, 2002). Globally, nearly 35,000 species of land snails have been described and there may be 30,000 to 60, 000 additional species yet to be described (Lydeard *et al*., 2004). The documentation of the distribution and magnitude of biodiversity is an essential task for any program involving sustainable development and should be a fundamental part of each region's development (Mittermeier *et al*., 1998). Despite their ecological and economic importance, many species of molluscs are suffering from the threat of extinction (Lydeard *et al.,* 2004). There are more recorded extinctions of land snails than for all other animal groups (Naggs and Raheem, 2007). This makes land snails a key group for recognizing why and where extinctions are taking place and also means that snails might act as the sensitive indicators of environmental change that are needed to demonstrate that conservation measures are effective. The speed with which the current episode of extinctions happened and continued to take place means that natural processes are negligible and losses in biological diversity are due to human impact on the environment (Naggs and Raheem, 2007).

A large part of molluscan fauna in many tropical regions of the world is still poorly known. They form an important component of the forest ecosystem by recycling nutrients (Graveland *et al*. 1994; Dunk *et al*., 2004) and are the prey base for a number of small mammals, birds, reptiles, amphibians and other invertebrates, including carnivorous snails (Deepak *et al*., 2010).

The major threats to the native land snail fauna include habitat loss and fragmentation as a result of anthropogenic activities such as intense land-use, construction of roads, dams, plantations, pollution and the spread of invasive species (Aravind, 2005). These reduce diversity and change the community structure of land snails (Rajashekhar and Aravind, 2012). Poor dispersal and narrow distribution ranges of many land snails have undoubtedly contributed to high levels of their extinction. Furthermore, because of their habitat preference, any disturbance could affect their gene flow. For instance, roads construction within a protected area system could fragment snail population. On one hand, for many forest snail species, man-made habitats such as gardens, parks, and plantations can act as either refugia or corridors between forest patches (Raheem *et al.,* 2008).

Climate change is also considered a threat to many species (Thomas *et al.,* 2004) including land snails (Bezemer and Knight, 2001; Gerlach, 2007). Changes in rainfall patterns and fluctuation in soil temperature could lead to the death of juvenile snails and impair mobility across a segmented mosaic of natural and transformed habitats in response to climate change. Extinction of land snail species due to change in climatic conditions such as a decrease in rainfall and global warming has also been reported (Baur and Baur, 1993; Gerlach, 2007).

Mambilla plateau is the highest plateau in Nigeria, with a mean altitude of about 1524metres (5000feets) above sea level. The Plateau covers an area of 9389 square kilometers, found in South-eastern part of Taraba State of Nigeria, sharing border with Cameroon. It contains several afro-montane forest fringes scattered and spread across the Plateau and also harboring a lot of wildlife. With the increasing threats to biodiversity on the Mambilla Plateau conserving and restoring Ngel-Nyaki Forest Reserve is more important now than it has ever

been. Yet despite its Forest Reserve Status the forest continues to be seriously threatened by cattle grazing, burning and other illegal activities (Ezealor, 2002).

The objective of this research was to study the land mollusc abundance and species richness in Mambilla plateau, Ngelyaki, Taraba state, Nigeria and compare the results obtained with those from other ecosystems in Nigeria and other countries.

2. Materials and methods

Description of the study area

Ngel-Nyaki forest reserve (henceforth NNFR) is located on the Mambilla Plateau ($07^{°}14^{'}N/11^{°}04^{'}E$) of Taraba State, Nigeria (Fig. 1). It lies on an altitude of 1,800 meters above sea level, having Afromontane climate. The NNFR is a mosaic of habitat containing grassland, forest, streams, valleys and gorges. The climate is seasonal with dry season lasting from November to March and rainy season from April to October with a mean annual rainfall of 1780 mm. The NNFR is considered as a critical site for biodiversity conservation in Nigeria and globally (Ezealor, 2002), providing an opportunity for research studies on tropical biology and conservation.
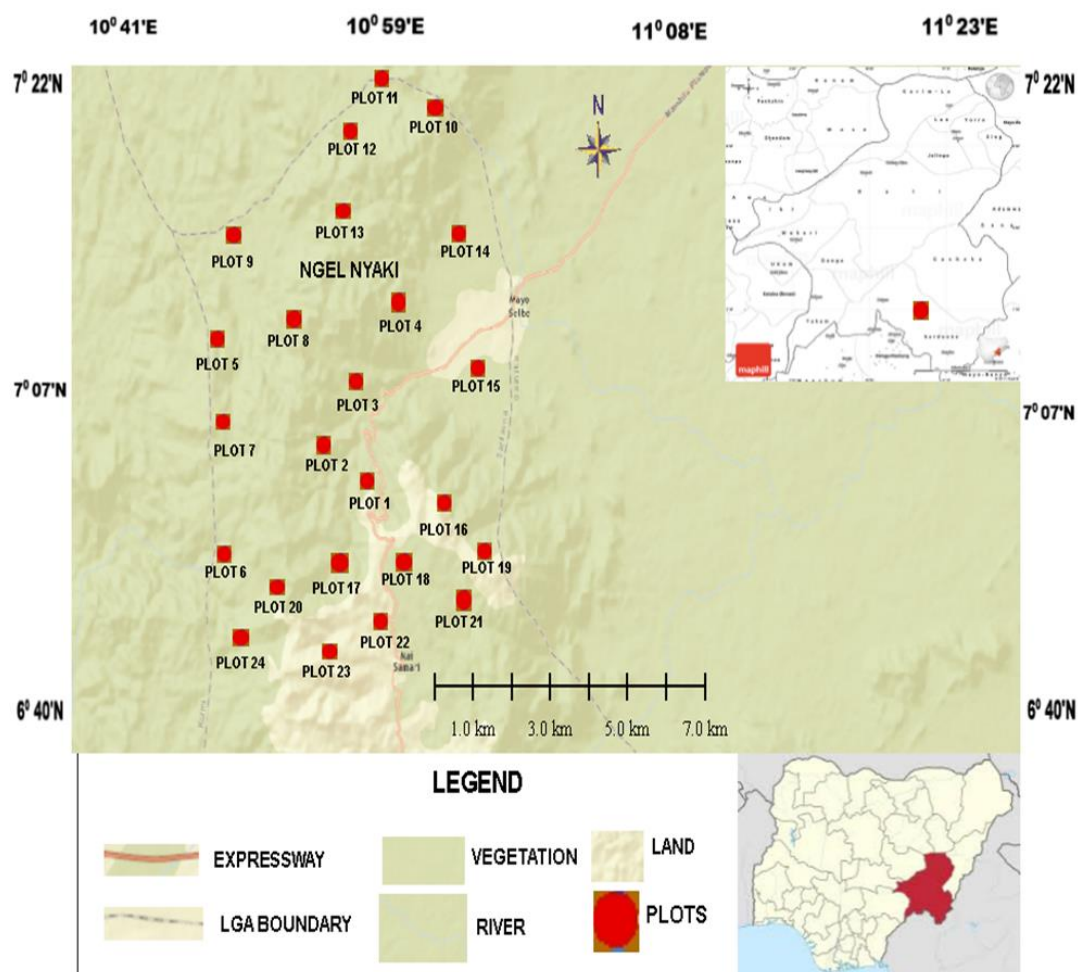
Figure 1: Map of Mambilla Plateau, Ngel yaki, Taraba state showing the 24 plots sampled.

Sampling

Land mollusc samples were collected from the study areas using a combination of direct search and litter sieving techniques (Tattersfield, 1996). This was carried out in June, 2016, November 2016, April 2017, June 2017, October 2017 and February 2018. This method was designed to detect both large sized molluscs that often occur in low density and micro species that are often cryptic and litter dwelling (Winter and Gutten Berger, 1998).

Selected locations in the study area were sampled, and land snails were searched intensively by team members by a length of time. Litters and top soil were collected in bags, from randomly selected locations (1m x 1m each) and was labeled with date and area of collection, and tied to prevent life snails from escaping.

All land snails, slugs and shell fragments encountered as well as those collected both alive and dead in the field were preserved in 70% ethanol after drowning. This was stored for future anatomical studies.

IDENTIFICATION OF SPECIMEN

Laboratory Procedures

Samples were slowly and completely dried in either a low-temperature soil oven (ca. 50-60 °C) or in full sun in a greenhouse. Dried samples were then be soaked in water for 3-24 hours, and subjected to careful but vigorous water disaggregation through a standard sieve series (ASTME 3/8" (9.5 mm), 10 (2.0 mm), 20 (0.85), and 40 (0.425 mm) mesh screens). Sieved sample fractions were then dried and passed again through the same sieve series. These dry, resorted fractions were handpicked against a neutral brown background using a binocular microscope and a small sable brush. All shells and shell fragments were removed. The samples were archived in the University collections based in the ABM Egborge Museum, Department of Animal and Environmental Biology, university of Benin, Benin City, Nigeria. Identifiable shells were assigned to species (or subspecies). From this, the total number of taxa per plot was determined.

Data analysis

The diversity was measured as overall Species Richness (*S*) and Whittaker's index (*I*), which is the total number of species recorded (*S*) divided by the mean number of species per site (α), providing a measure of diversity difference between sites (Schilthuizen and Rutjes, 2001). The true diversity was estimated by performing 100 randomizations on the data and calculating *S* using the Chao2 and second-order jackknife richness estimators in the program Estimate *S* 7.5 (Colwell, 2006). Sample-based rarefaction curves were used to produce a smooth curve that estimated the number of species that would be observed for any smaller number of samples, assuming random mixing of sample order (Colwell and Coddington, 1994; Gotelli and Colwell, 2001). Statistical analyses were performed using the PAST software (Hammer *et al*., 2001).

3. Results

The study recorded 681 individuals of molluscs of 18 species belonging to seven families. The most dominant families are Streptaxidae and Subulinidae containing five species each, while the least species rich are Allyidae, Urocyclidae, and Veronicellidae with one species each. Table 1 shows the occurrence of land mollusc species from the 24 plots recorded in the

study area. This ranged from 9 to 70 individuals per plot (mean = 28.38 ± 14.01) and 3 to 12 species per plot (mean = 6.96 ± 2.05).

Table 2 shows the quality of the soil analysed from Mambilla Plateau Montane forest (MPMF), the pH value of the water was 5.3, slightly acidic while the nitrogen content was 7.25g/kg. The calcium and phosphorus content were 0.07mol/kg ad 130mg/kg respectively.

Figure 2 below shows the rank abundance plot of land molluscs in Ngel- Nyaki forest reserve. The plot showed that a few species were very abundant, a few very rare, but most species had relative abundance. Two species had more than 100 individuals; three species with over 50 individuals, eight species with more than 10 individuals, while the remaining five species had less than ten individuals.

The dendogram showed the similarities/dissimilarities between land snail species recorded from Ngel-Nyaki forest reserve. Based on the dendogram, the species are divided into two main groups as shown in figure 3.

Table 1: **List of mollusc species collected from Ngel-Nyaki forest reserve during the study period**

FAMILY/ SPECIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
ACHATINIDAE																									
Callistoplepa sp.	-	2	2	-	-	-	2	1	-	1	2	1	1	1	2	-	4	-	7	6	-	9	1	3	45
Limicolaria aurora	-	1	1	-	-	-	1	-	1	-	-	-	-	-	-	1	-	-	-	-	1	-	1	-	7
Limicolaria sp	-	2	2	-	-	2	-	2	-	1	-	-	2	-	-	-	-	2	-	-	2	-	-	2	17
ALLYIDAE																									
Aillyia camerunensis	1	-	-	-	2	-	-	2	-	-	-	1	-	-	1	-	-	2	-	3	-	2	-	2	16
STREPTAXIDAE																									
Gulella cf. gemma	1	-	-	1	-	-	1	-	-	2	-	-	-	1	-	-	2	-	-	-	1	-	2	-	11
Gulella cf. monodon	-	-	-	-	-	-	1	-	2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	6
Ptychotrema anceyi	-	-	-	-	-	-	-	-	-	1	-	-	-	2	5	5	6	2	4	5	4	-	5	-	39
Streptostele sp.	1	-	2	-	-	2	-	-	1	-	-	2	-	-	-	-	2	-	-	-	-	-	3	2	15
Tomostele musaecola	-	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2	-	-	2	-	-	2	2	12
SUBULINIDAE																									
Curvella cf. feai.	-	-	-	-	-	-	-	3	-	-	1	-	3	4	1	-	4	-	6	5	-	3	4	-	34
Kempioconchia stuhlmanni	2	5	5	-	-	-	-	-	5	-	-	-	2	-	-	-	5	-	2	-	-	5	-	-	31
Pseudoglessula sp.	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	-	1	-	-	1	-	7
Subulina sp.	12	43	19	-	-	1	-	-	-	5	-	-	-	-	-	12	-	-	-	11	-	-	-	13	116
Subulona cf inroluta	1	-	24	2	1	1	-	9	-	-	-	5	-	6	-	8	-	9	-	-	5	-	7	-	78

UROCYCLIDAE

Gymnarion sp.	4	8	8	10	9	7	9	5	4	5	4	9	1	6	2	9	8	10	12	19	7	9	10	12	187
Thapsia oscitans	4	5	5	-	-	-	1	3	5	4	-	-	-	-	-	4	-	-	-	-	3	5	5	-	44
VERONICELLIDAE																									
Pseudoveronicella liberiana	1	-	-	-	-	1	-	-	-	-	1	-	-	-	1	-	-	-	2	1	-	-	-	1	8
RACHISTIDAE																									
Bulunaloid cunella (large)	-	-	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	1	-	-	2	8
Total No. of ind. Per plot	29	68	70	13	12	14	15	25	18	20	9	19	11	18	9	39	32	33	31	51	26	37	35	47	681
Total No. of sp. Per plot	10	8	10	3	3	6	6	7	6	7	5	6	7	5	6	6	8	7	6	8	9	7	9	12	

Table 2: Values of Soil Parameters Analysed from Mambilla Plateau Montane Forest, Ngel Nyaki

| Parameters	pH H$_2$O	Org g/kg	Total N g/kg	Avail P mg/kg	Exc Acidity Cmol/kg	K	Ca Cmol/Kg	Mg	Na Cmol/Kg	ECEC	BS Cmol/Kg	% Clay
Values	5.3	59.33	7.25	130	3.83	9.52	0.07	0.05	0.05	13.53	71.67	6.5

Table 3: **Abundance, percent individuals and number of mollusc species collected from Ngel-Nyaki forest reserve during the study period.**

Family	Number of Species	% Species	Number of Individual	% Individuals
Achatinidae	3	16.67	69	10.13
Allyidae	1	5.56	16	2.35
Streptaxidae	5	27.78	83	12.19
Urocyclidae	2	11.11	231	33.92
Subulinidae	5	27.78	266	39.06
Veronicellidae	1	5.56	8	1.17
Rachistidae	1	5.56	8	1.17
Total	**18**		**681**	
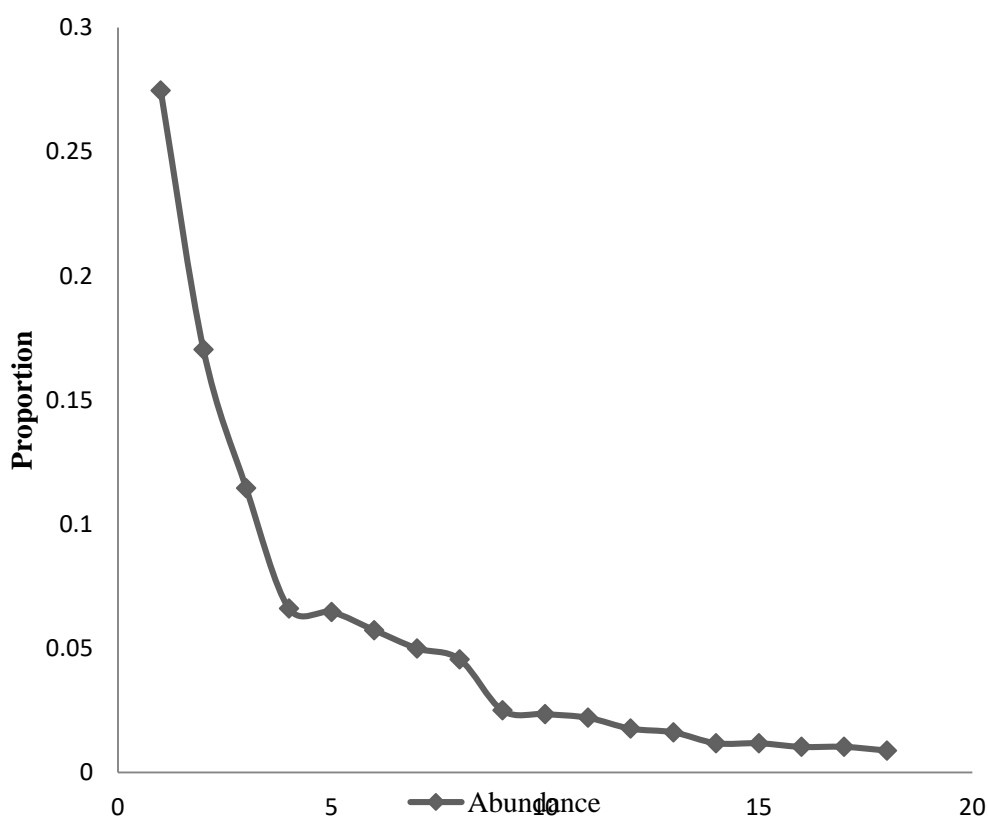
Figure 2: Rank abundance curve of land molluscs recorded from Ngel-Nyaki forest reserve during the study period
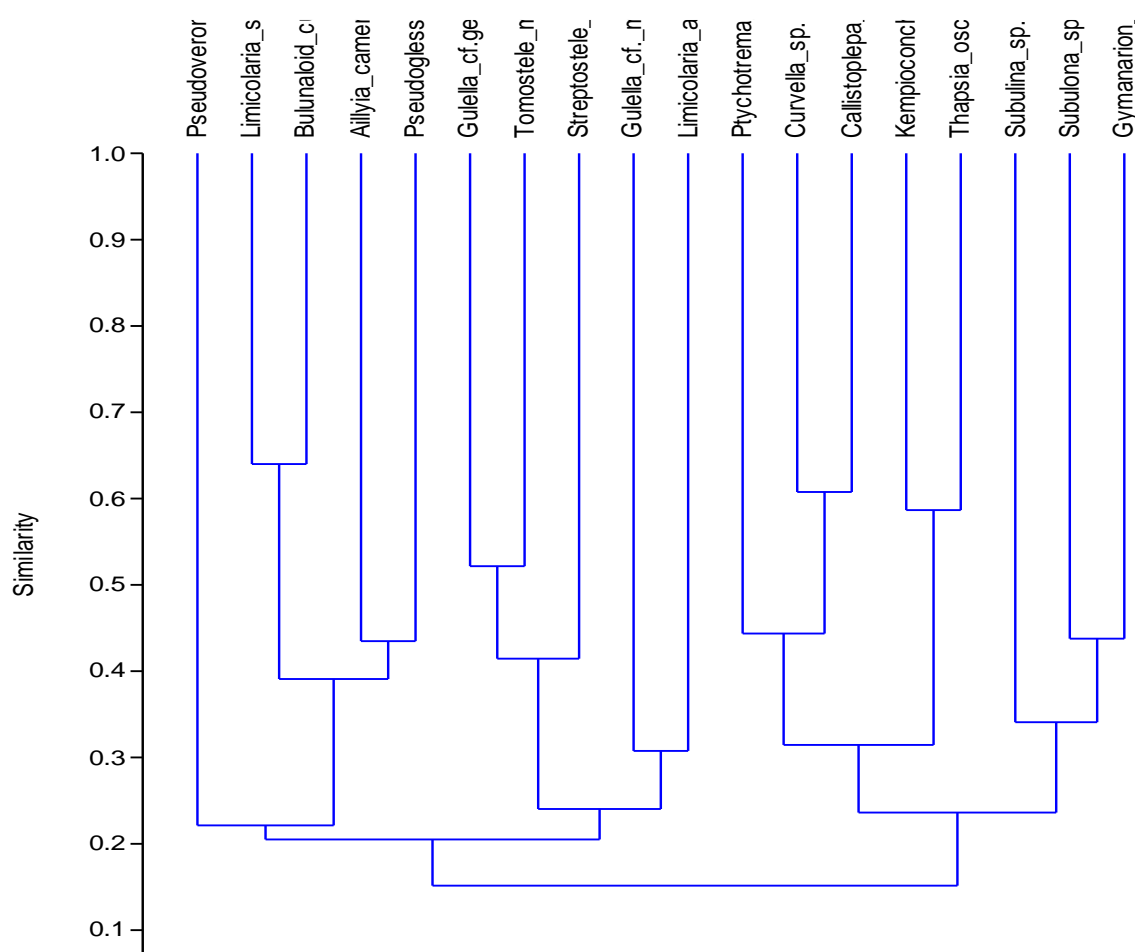
Figure 3: Dendogram of similarities/dissimilarities using Bray-Curtis index between land Mollusc recorded from Ngel- Nyaki forest reserve during the study

4. Discussion and Conclusions

This study describes the species richness and diversity of land snails in NNFR. A total of 681 specimens comprising of 18 species belonging to seven molluscan families were collected. The plots yielded 3 to 12 species. This showed that the molluscs were moderately diverse in the study sites. The families Streptaxidae (carnivores) and Family Subulinidae (herbivores) dominated the mollusc fauna in Mambilla Plateau montane forest with 5 species each. At the Mambilla Plateau Montane forest, the Chao 2 and Jackknife estimator were 17.99 and 18.10, respectively of all sample collected and the Whittaker Index was 1.587, also indicating a low amount of differentiation in species composition among the plots.

This study has revealed that the land mollusc fauna of NNFR are relatively diverse with low densities. It has shown that not all the sampling areas of the reserves had much species. Most of the species recorded in this study had been recorded elsewhere in Nigeria and comparatively, the numbers of species recorded are lower than those recorded in other parts of Nigeria. For example, Oke and Chokor (2010) recorded 36 species from 9 molluscan families. In an earlier study at Ehor, Edo State, Nigeria by Oke and Alohan (2004), 38 species and 1258 individuals were recorded from nine 20 metres squared plots in a tropical rainforest. In another study at the Okomu National Park, Edo State, Nigeria, Oke and Alohan (2002) collected 35 species and 316 individuals from five 20 metre squared plots. In an investigation

carried out at Odukpani in Cross River State, 52 species and 425 individuals were collected during one study (Oke *et al*., 2007). This shows that the diversity of molluscs found in Taraba State is low compared to those from the southern part of Nigeria.

Gymnarion sp. was the most abundant species with 187 individuals belonging to the family Urocyclidae in Ngel-Nyaki. In contrast, other studies on mollusc fauna in Nigeria reported that family Urocyclidae rarely dominates other species, as observed in an Oil palm and rubber plantations in Edo State. In a secondary forest at Ekpoma, Edo State and in a Cocoa plantation at Usen Edo State, the family Streptaxidae dominated while Subulinidae and Streptaxidae were the dominant mollusc fauna in the Agro-forest in Ile-Oluji, Ondo State and at Omo Forest Reserve in Ogun State (Oke *et al*., 2007, 2008 and Oke, 2013).

The number of land snail individuals recorded in Ngel-Nyaki were however, higher than that recorded in some locations in the southern part of Nigeria. For instance, 242 individuals were recorded in Obudu Cattle Ranch, 425 in Odukpani and 636 in Oban Hills Sector, all in Cross River State, Nigeria (Oke *et al*., 2004, 2007). This difference could be attributed to the fact the number of sampling plots were more in this study compared to the plots examined in those locations, except in Oban Hills, where samples were collected from 24 sampling plots. All the species named and identified in this study are common or have been recorded in the southern and western part of Nigeria and also Africa in general. It could be that the species that were not recorded are inhabitants of other areas in the park and montane forest, which were not sampled.

The rank abundance curve showed that there was a dramatic reduction in the number of species in the study areas and a marked increase in the dominance of a few species and unevenness of the overall distribution..

With regards to the quality of soil from the sites studied, the pH of the soil at NNFR was a little less acidic (5.3) similar to the value (5.19) recorded at Idanre (Oke, 2012). Studies have shown that land snail faunas in acidic habitat are more depauperate in species and individual numbers compared to those in neutral or calcerous soils (Emberton *et al*., 1997; Winter-De and Gittenberger, 1998; Nekola, 2010). Although the calcium content of the soil of MPMF was 0.69 molkg^{-1}. This shows that other factors other than calcium content were responsible for snail abundance because, some studies have shown that, the higher the soil calcium content the more the snail abundance. For example, in studies undertaken by various investigators (Baker and Mayhill, 1999; Nekola and Smith, 1999; Hotopp, 2002; Lange, 2003; Terbraak, 1994 and Ondina *et al*, 1998) snail abundance correlated significantly and positively with soil calcium. Based on Detrended Correspondence Analysis (DCA), the most important soil factors affecting the abundance and distribution of snails are calcium, pH and texture. Several authors have however noted that pH and calcium are the most important factors (Lange, 2003).

This study has provided information on the species richness and diversity pattern of land mollusc in NNFR. This information will assist conservation agencies in protecting the integrity of the species recorded, especially those that are of moderate abundance, of which, if steps are not taken may face extinction.

5. Conclusion

The findings of this study have provided the first inventory of land molluscs in NNFR. One species from MPMF was being recorded for the first time in Nigeria, and it may possibly be a new species. Furthermore, it has provided basic data on diversity and abundance of species,

and revealed species present. This knowledge will help reserve managers to monitor the populations of various species that may be threatened in the future as well as assist conservation planners in incorporating invertebrates, particularly land snails in reserve selection and management.

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