



SPECIES RICHNESS AND DIVERSITY OF TERRESTRIAL MOLLUSCS IN GASHAKA GUMTI NATIONAL PARK, TARABA STATE, NIGERIA



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Abstract: Gashaka-Gumti National Park (GGNP), Taraba State, is one of the largest parks in Nigeria known for Biodiversity Conservation. It is characterized by a wide variety of habitats and species currently threatened by deforestation, poaching and effects of global warming. Terrestrial molluscs, Species Richness and Diversity in Gashaka-Gumti National Park were studied for the first time using a combination of direct search and leaf litter sieving technique. A twenty-four plot (20 x 20 m) each within the park were sampled. A total of 1594 specimens comprising 22 species belonging to six molluscan families were collected from four plots. Each plot yielded between 3 and 12 species (mean = 7.96 ± 3.06) and 3 to 688 individuals (Mean = 66.42 ± 34.82). The most abundant species was *Curvella feai* contributing about 60% of the total number of individuals occurring in Park. The most abundant family is Streptaxidae represented by 7 (32%) species and 82 (5%) individuals of the total sample. The Whittaker Index was 1.75, indicating low differentiation among plots. The rarefaction curve reached an asymptote as sampling stopped. The nonparametric estimator Chao 2 and jack-knife 2 were 22 and 22.96 of all samples collected, respectively. The dendrogram of similarity by plots using Bray-Curtis similarity of index divided the species collected into 3 distinct groups at 50% similarity. This study has succeeded in highlighting information on the state of abundance of the identified land snail species in the study area so that conservation agencies can swing into action with a view to protecting the integrity of these species that are of moderate abundance of which if steps are not taken may face extinction.

Keywords: Molluscs, biodiversity, species richness, conservation, National park, Taraba

Introduction

Gashaka-Gumti National Park (GGNP) is the largest park in Nigeria. It was gazetted from two game reserve in 1991. It is located in the Eastern provinces of Taraba and Adamawa to the border with Cameroon. The fauna of the National Park is very diverse. It ranges from the species of vertebrates (Mammals, Birds, Reptiles, and Amphibians) and invertebrates (Snails and Insects) in their large numbers.

The land mollusk (snail) is one of the numerous species of molluscs that live/dwell on land; as opposed to sea snails and freshwater snails, they are terrestrial gastropods that have shells (those without shells are known as Slugs). The exact number of living species of molluscs varies from 50,000 to a maximum of 120,000 species (Chapman, 2009). It is believed that the total number of mollusc species that ever existed, whether or not preserved, must be many times greater than the number alive today (Raup and Stanley, 1978).

Molluscs are extremely diverse in tropical and temperate regions but can be found at all latitudes (Giribet *et al.*, 2006). About 80% of all known mollusc species are gastropods (Ponder and Lindberg, 2008). The land molluscs (snails) species richness in some tropical rainforest has been accessed recently by several authors (Emberton, 1995; Tattersfield, 1996; Gargominy and Ripken, 1998; De Winters and Gittenberger, 1998; Schuilthuisen and Rutges, 2001). Tropical rainforest is faced with pressure and are threatened all over the world and African forest is not exempted. The loss of tropical forest and its biodiversity is the principal driver of modern extinction.

The loss of biodiversity is a major component of global change that cannot be reversed. The depletion of natural resources owing to destruction has set the pace for conservation minded agencies (e.g. Gashaka-Gumti National Park), stressing the inevitable need for conscious conservation practices, in order to curb the incessant predatory behaviour consciously or unconsciously guided by the pursuit of private benefit (Wilson, 1992; Vitousek *et al.*, 1997; Van Gerner *et al.*, 2005). Therefore, the need for sustainable development

of biodiversity which entails the acquaintance with species present in the ecosystem, their interdependence and how they react to disturbance. The purpose of conserving biological diversity is very important for sustainable development, continued functioning of biosphere and human survival. Highly diverse and narrowly distributed, land snails are good indicators of the areas of conservation of importance and endemism, when compared to widely distributed groups such as vertebrates (Moritz *et al.*, 2001). Hence there is urgent need to document these taxa (species of land molluscs) in Gashaka Gumti National Park which are undergoing rapid extinction.

The aim of this research was to evaluate the species richness, abundance and composition of land molluscs Gashaka-Gumti National Park, Taraba State. The objectives of the study are: (1) to identify the species types of land molluscs in Gashaka-Gumti National Park; and (2) to estimate the species richness, species abundance and species composition of land molluscs in Gashaka-Gumti National Park.

Materials and Methods

Study area

The Study was conducted in Gashaka-Gumti National Park with a total area cover of 6,402 km² with a coordinate of 6°55'N, 11°E3'E / 6.9170N, 11.2170E (Fig. 1). Gashaka is a local Government area in Taraba State with its headquarters in Serti. The Northern Gumti sector of the park is relatively flat and covered with woodlands and grass lands while the southern Gashaka sector is a more mountainous and contains vast expanses of rainforest as well as area of woodland and montane grassland. The altitude ranges from 457 metres (1499 ft) in the North and 2419 m (7936 ft) in the south. The Gashaka Local Government area has an area of 87,8393 km² with a population of 87,781 at the 2006 census. Some of the villages in the area are: Adagoro, Azoratar, Balewa Border Burta, Usman Goje Gumti Injawai, Jamtari, Karamti Kobaje and Kwano.

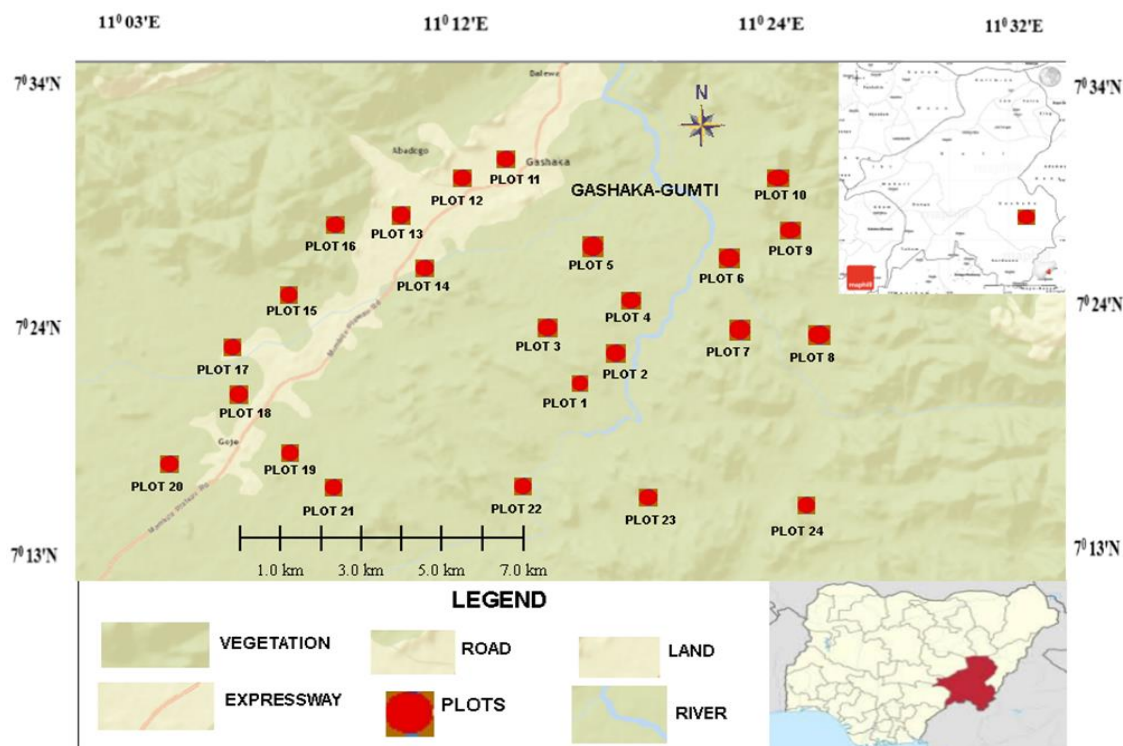


Fig. 1: Map of Ghasaka-Gumti National Park, Taraba State showing the 24 plots sampled

Sampling methods

Land mollusc samples were collected from the study areas using a combination of direct search and litter sieving techniques (Tatters field, 1996). This was carried out between June, 2016, September 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).

Litter and top soil samples collected from the field were sorted within two weeks of arrival, for land snails. The samples were sun dried, after which they were fractioned by means of 0.5m mesh sieve. Fractions were sorted thoroughly until further search yielded nothing. The leaf litters were also searched for the presence of attaching snails in the laboratory, and the relatively few snails spotted were included in the previous data obtained. All land snails encountered alive and dead were preserved in 70% alcohol.

Identification of specimen

Most of the specimens were duly identified to species level (Oke and Alohan, 2002, 2004; Oke *et al.*, 2007). The specimen were classified and identified according to shell characteristics such as the whorls, Aperture and lip, parietal wall, sutures and body characteristics. This sometimes required the use of magnification to examine micro-structural details. The species were grouped into families (Boucher and Rocroi, 2005), and assigned to possible genus or species

Data analysis

The measures of diversity used in this study are overall species richness and Whittaker's index. Whittaker's index was used to estimate within-site (beta) diversity for plots in each area/reserve (Whittaker, 1972).

Two indices of species diversity were used: Simpson's index (DS), and the Shannon index (H), (Magurran, 2004; Keylock, 2005). These two indices are commonly used in ecological studies; their efficacy and robustness are well known. (Magurran, 2004) and they allow comparison of the data from

this study and other studies. Estimation of true diversity was carried out by calculating S using the Chao 2 and second order Jack-knife richness estimators (Colwell and Coddington, 1994). Hierarchical clustering (Bray-Curtis similarity measure) was used to identify natural groupings amongst the sampled points according to similarities in their species composition.

Cluster analysis is the arrangement of samples into groups (cluster), so those samples within the same cluster are more similar to each other than to samples from different clusters (Gauch and Whittaker, 1981). The nonparametric one way analysis of similarity (ANOSIM, Clarke, 1993) was used to test for statistical difference in species composition between clusters. Similarity percentage (SIMPER, Clarke, 1993) analysis using the Bray-Curtis similarity measure was used to assess which taxa are responsible for an observed difference between groups of samples. All the ecological statistics were performed using software programme PAST (Hammer *et al.*, 2001) and Estimate S8.

Results and Discussion

In total, 1594 individuals belonging to 22 species in 6 families of pulmonate molluscs were collected in this study as shown in Table 1. Each plot yielded between 3 and 688 individuals (Mean = 66.42 ± 34.82) and between 3 and 12 species (mean = 7.96 ± 3.06).

In Table 2, Margalef's species richness index (d) showed the richest plot as plot 12 with a value of 3.09, followed closely by plot 4 with a value of 2.77. Shannon-Weiner's diversity index (H1) showed a relative uniformity of data with the highest value of 2.13 for plot 12 which was the most diverse plot while the lowest value of 0.56 was from plot 15. Evenness (€) showed the most equitable plot in Gashaka to be plot 5 with a value of 0.97 while the least equitable plot was plot 15 with a value of 0.15.

Table 1: List of Molluscs collected in Gashaka-Gumti National Park from the twenty four plots between 2016 and 2018

Family and 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	Total	
ACHATINIDAE																										
<i>Limicolaria flammea</i>	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	8	4	-	5	6	8	10	-	13	-	58
<i>Limicolaria sp.</i>	-	-	-	-	2	-	-	-	1	-	-	-	-	-	2	-	-	-	3	-	-	4	-	2	-	14
STREPTAXIDAE																										
<i>Gulella gemma</i>	-	-	-	1	-	-	-	-	-	-	-	2	-	-	2	-	-	-	-	1	-	2	2	-	-	10
<i>Gulella cf. monodon</i>	-	-	-	-	-	-	1	-	-	-	-	-	5	1	-	-	1	3	2	-	3	-	-	-	-	16
<i>Ptychotrema complicatum</i>	1	-	-	-	-	-	-	1	3	1	-	-	1	-	-	-	3	-	2	-	1	-	-	3	-	16
<i>P. martense</i>	2	1	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	2	-	1	-	-	2	-	-	11
<i>P. cf. anceyi</i>	-	-	-	-	-	1	-	4	-	-	-	-	4	-	-	-	3	-	-	-	4	-	-	2	-	18
<i>Streptosteles sp.</i>	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	-	4
<i>Tomosteles musaecola</i>	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1	-	-	1	-	-	2	-	1	-	7
UROCYCLIDAE																										
<i>Trochozonites sp.</i>	2	1	-	-	-	-	-	-	1	-	1	-	-	-	-	-	1	2	-	1	-	-	1	1	-	11
<i>T. talcosus</i>	1	1	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	6
<i>T. hystrix</i>	-	-	-	-	-	-	3	1	1	1	3	-	3	-	-	-	-	-	2	-	3	-	3	-	-	20
<i>T. suturalis</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Gymnarion sp.</i>	-	4	3	2	2	-	-	-	-	-	4	3	4	3	3	-	2	-	4	-	3	4	-	-	-	41
<i>Thapsia oscitan</i>	-	-	4	4	2	-	1	-	-	-	4	-	-	-	24	-	2	-	2	-	23	-	21	24	-	111
SUBULINIDAE																										
<i>Subulona cf. involuta</i>	1	2	-	1	-	-	-	-	-	-	1	2	24	5	4	-	3	-	21	-	6	-	3	-	-	73
<i>Curvella cf. feai</i>	17	24	-	-	3	5	2	1	1	-	-	16	26	609	13	12	11	22	31	23	12	12	123	-	-	963
<i>Kempioconchia stuhlmanni</i>	-	2	-	1	1	-	-	-	-	2	2	-	2	2	4	-	5	-	7	-	3	-	4	-	-	35
<i>Pseudoglossula sp.</i>	-	3	-	2	-	-	-	-	-	-	2	-	3	-	-	2	4	3	-	2	-	-	1	-	-	22
<i>Subulina sp.</i>	-	-	-	5	2	3	2	-	-	-	-	12	-	-	29	-	21	-	10	-	14	-	-	8	-	106
VERONICELLIDAE																										
<i>Pseudoveronicella liberiana</i>	-	2	7	1	-	-	-	-	-	-	2	-	2	-	7	2	-	3	4	-	1	-	2	-	-	33
RACHISTIDAE																										
<i>Opeas sp.</i>	1	1	-	-	-	-	-	2	2	-	1	1	-	2	1	-	2	-	1	-	2	2	-	-	-	18
Total No. of individual plots	27	41	14	18	9	7	8	16	8	6	3	35	31	71	688	37	46	37	57	81	80	38	62	174	-	1594
Total No. of species per plot	8	10	3	9	5	3	3	8	5	5	2	12	8	10	12	8	8	10	11	11	8	10	10	12	-	

Table 2: Species diversity, species richness and evenness of the 24 plots in Ghasaka Gumti Game Reserve, Taraba State

Plots	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Margalef sp (d)	2.12	2.42	0.76	2.77	1.82	1.03	0.96	2.52	1.92	2.23	1.24	3.09	2.04	2.11	1.68	1.94	1.83	2.49	2.47	2.28	1.60	2.47	2.18	2.13
Shannon-Wei's In(H)	1.36	1.54	1.04	1.98	1.58	1.00	0.90	1.93	1.49	1.56	1.06	2.13	1.58	1.67	0.56	1.80	1.56	2.07	1.95	1.76	1.70	2.05	1.85	1.13
Evenness €	0.49	0.46	0.94	0.81	0.97	0.91	0.82	0.86	0.89	0.95	0.96	0.70	0.61	0.53	0.15	0.76	0.59	0.80	0.64	0.53	0.69	0.78	0.63	0.26

Table 3: Values of soil parameters analysed from Gashaka Gumti Game Reserve

Code	pH	Org	Total N	Avail P	Exc Acidity	K	Ca	Mg	Na	ECEC	BS	% Clay
	H ₂ O	g/kg	g/kg	mg/kg	Cmol/kg	Cmol/Kg	Cmol/Kg	Cmol/Kg	Cmol/Kg			
Gashaka	4.8	65.54	2.27	153.75	0.33	8.03	0.01	0.02	0.08	8.47	96.06	6.71

Table 3 shows the analysis of the soil In GGNP, pH content was 4.8, total nitrogen present was 2.27 and Calcium 0.01 respectively.

Three families were most species rich and abundant, namely: Streptaxidae represented by 7 (32%) and 82 (5%) individuals, Urocyclidae with 6 (27%) and 190 (12%) individuals and the family Subulinidae with 5 (23%) and 1199 (75%) individuals as shown in Table 4. The carnivorous Streptaxidae had the highest number of identified species while Subulinidae had the highest number of individual molluscs collected. The most abundant species was *Curvella feai* contributing about 60% of the total number of individuals occurring in Gashaka Gumti National Park.

Table 4: Percentage abundance of species and individual molluscs at the Gashaka Gumti National Park

Family	No. of Species	% Species	No. of Individual	% Individual
Achatinidae	2	9.09	72	4.52
Streptaxidae	7	31.82	82	5.14
Urocyclidae	6	27.28	190	11.92
Subulinidae	5	22.73	1199	75.22
Veronicellidae	1	4.55	33	2.07
Rachistidae	1	4.55	18	1.13
Total	22		1594	

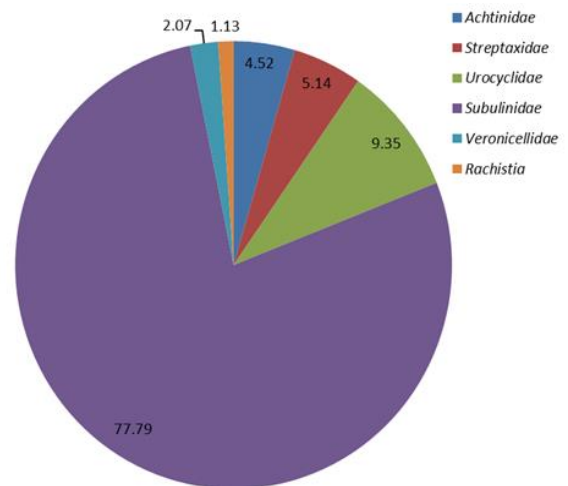


Fig. 2: Graphical illustration of percentage abundance of individual mollusc collected from Gashaka Gumti National Park, Taraba State, between 2016 and 2018

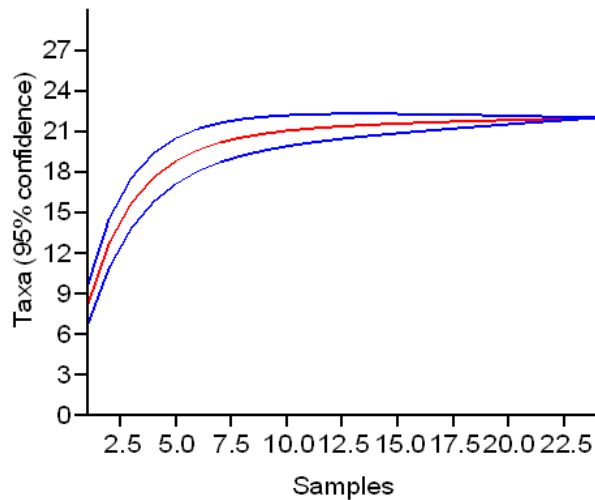


Fig. 3: Rarefaction Curve showing the rate of sample-based Species accumulation curve of Sampling Plots in Gashaka Gumti National Park, Taraba State, Nigeria. Plotted values are means based on 100 randomizations of sample accumulation order (without replacement) 95% confidence limit

Figure 2 shows the graphical representation of percentage abundance of individual mollusc identified from Ghasaka Gumti National Park, Taraba State; Family Subulinidae had the highest percentage abundance of individuals (77.79%) while the least percentage abundance was recorded in Family Veronicellidae (2.07%). The sample rarefaction curve (Fig. 3) reached an asymptote when sampling stopped and the number of species was not different from that obtained by non-parametric estimator. Chao 2 and Jack-knife estimator was 22 and 22.96 of all samples collected, respectively. The Whittaker Index was 1.75, indicating low differentiation among plots.

Figure 4 shows the dendrogram of similarity, dividing the species collected into 3 distinct groups at 50% similarity. *Curvella* sp. made up the first group, *Streptostele* sp, *Trochozonites talcosus* and *Trochozonites suturalis* made up the second group while all the remaining species made up the third group. The rank abundance curve of the land mollusc in Ghasaka Gumti National Park is shown in Fig. 5 which showed that a few species were very abundant, a few were very rare while most were of intermediate abundance. Five species occurred with more than 50 individuals and 8 species with less than 15 individuals.

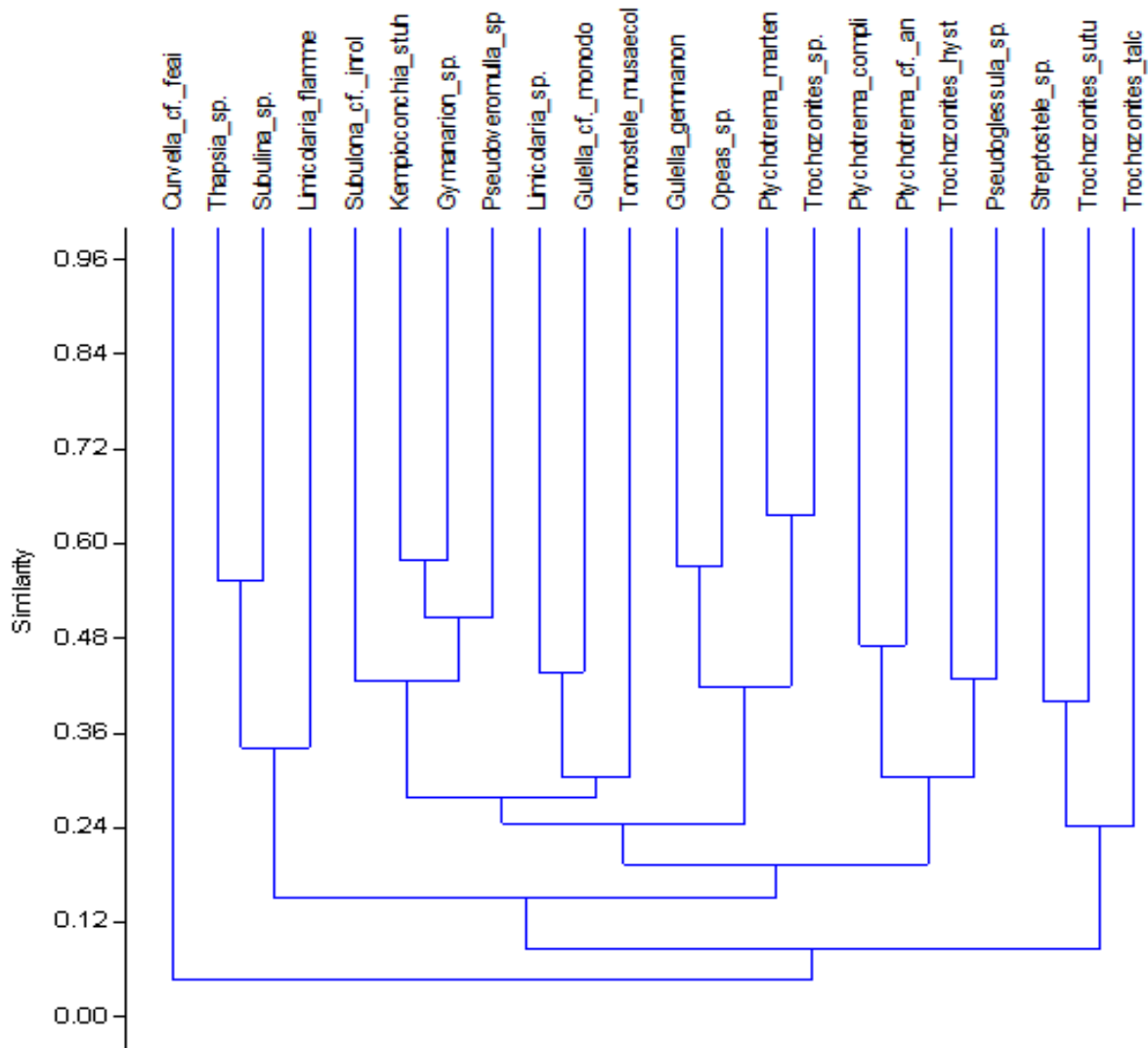


Fig. 4: Dendrogram of similarity of species using Bray-Curtis similarity index in Gashaka Gumti National Park, Taraba State, Nigeria

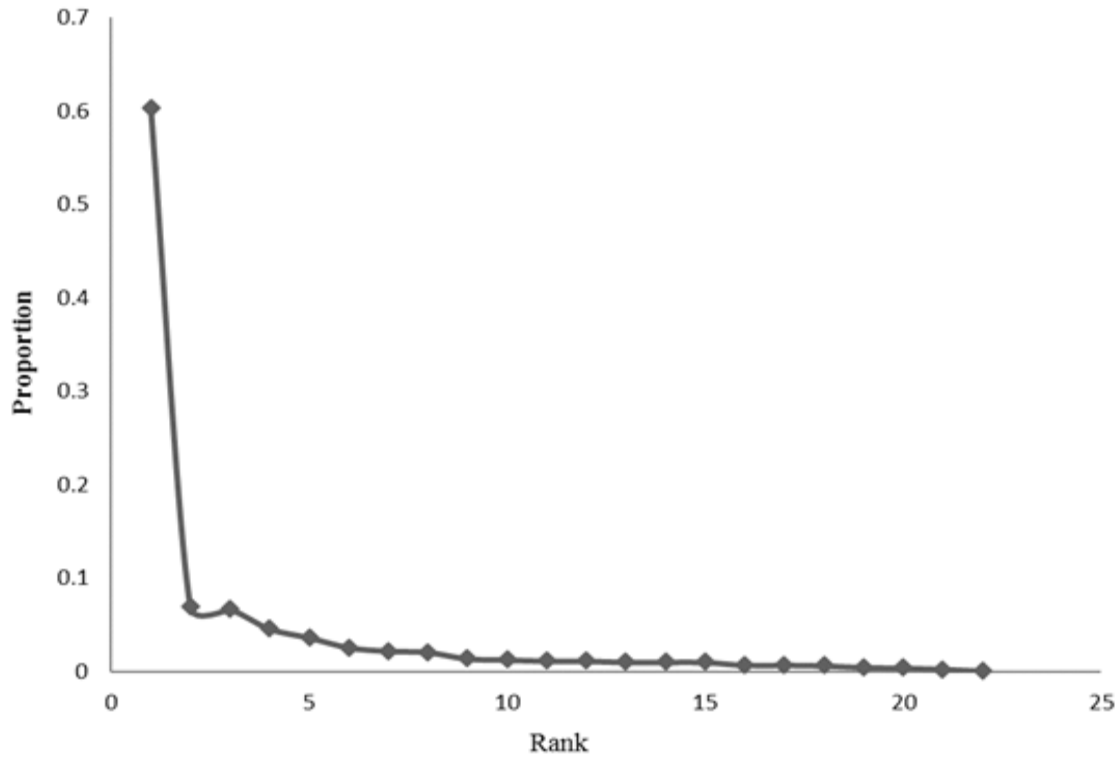
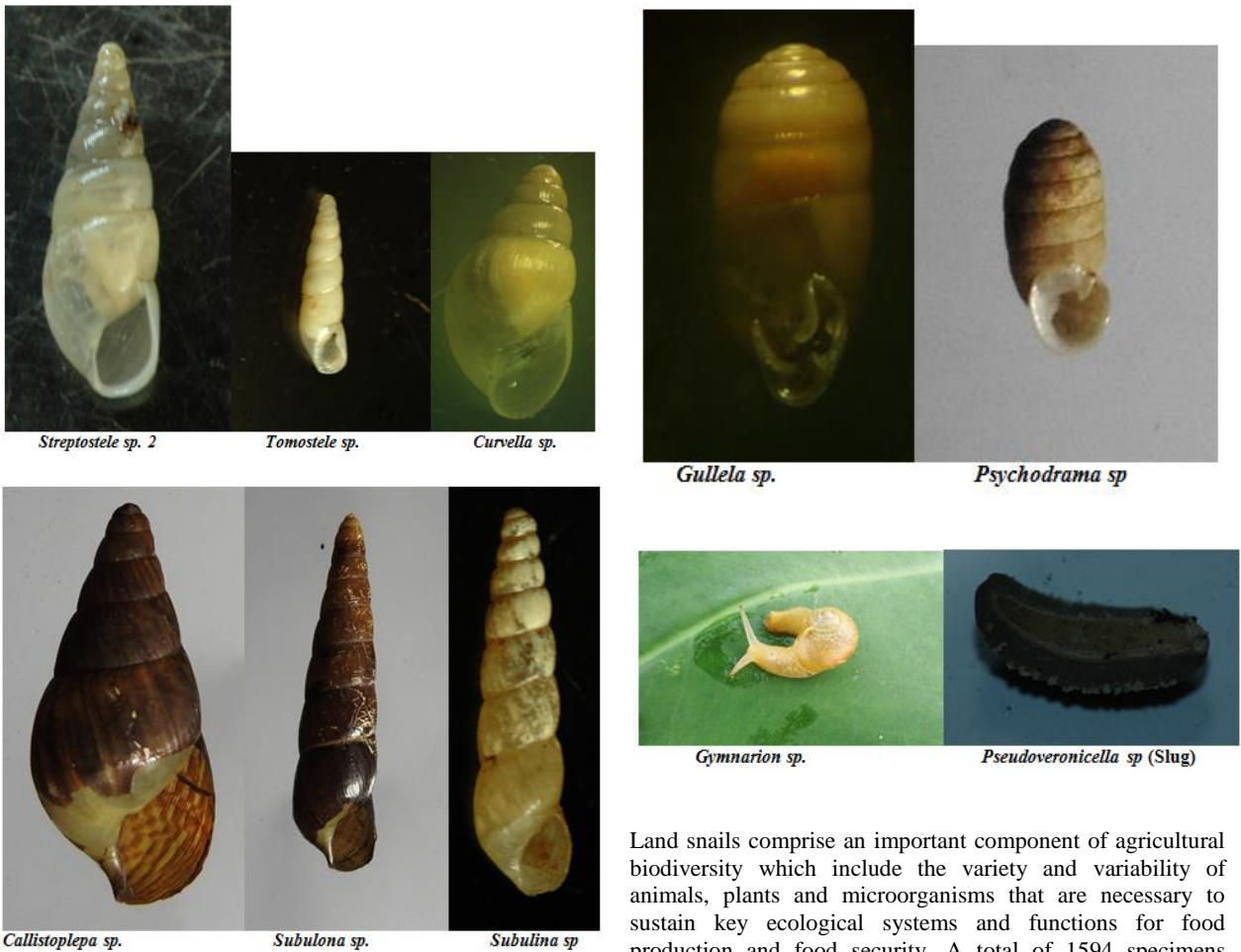


Fig. 5: Rank abundance curve of land molluscs in Ghasaka Gumti National Park, Taraba State, Nigeria



Land snails comprise an important component of agricultural biodiversity which include the variety and variability of animals, plants and microorganisms that are necessary to sustain key ecological systems and functions for food production and food security. A total of 1594 specimens comprising 22 species belonging to six molluscan families were collected from twenty-four plots in Gashaka Gumti National Park. Each plot yielded between 8 and 14 Species.

Comparatively, the number of land snail species recorded in GGNP, North Eastern Nigeria is higher compared to other part of Nigeria with 242 individuals in Obudu Cattle Ranch, 425 individuals in Odukpani and 636 individuals in Oban Hills Sector, all in Cross River State, Nigeria (Oke *et al.*, 2004 & 2007). Also, the species from Oban were collected from 24 sampling plots in Ehor, Edo State, Nigeria. (Oke and Alohan, 2004), 38 species and 1258 individuals were recorded from nine 20 metres squared plot in a tropical rainforest (Oke and Alohan, 2002). Moreover, 35 species and 316 individuals were collected from five 20 metre squared plots in Okomu National Park, Edo State, Nigeria. It was found that the Same range were recorded from 36 plots for Sebah, Malaysian Burneo (Schilthuizen and Rutjes, 2001) and more than half of the species recorded for Cameroon (Winter and Gittenberger, 1998). It is therefore believed that this is one of the richest States in Northern Nigeria with high biodiversity site and may be compared with other places in the world.

The most abundant species in the park was *Curvella* sp. reported by 683 individuals (79.4%) and most dominant family was Streptaxidae reported by 8 species. The dominance of the Carnivorous Streptaxidae in various biodiversity location has been established, 23 species, 159 individuals from 52 species and 425 individuals in Odukpani, Cross River State, Nigeria (Oke *et al.*, 2007).

This study has succeeded in highlighting information on the state of abundance of the identified land snail species in the study area so that conservation agencies can swing into action with a view to protecting the integrity of these species that are of moderate and abundance of which if steps are not taken may face extinction.

Also, this study has provided information on the species richness and diversity pattern of land mollusc in GGNP.

This study will help to provide an annotated checklist of land molluscs collected from GGNP.

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Conflict of Interest

The authors declare that there is no conflict of interest related to this work.

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