



## SEASONAL SPECIES COMPOSITION AND RICHNESS OF TERRESTRIAL MOLLUSKS IN PROTECTED AREA (CROSS RIVER NATIONAL PARK) CROSS RIVER STATE.

<sup>\*1</sup>Osiele V.O, <sup>1</sup>Arimoro F.O, <sup>1</sup>Ayanwale, A.V., <sup>2</sup>Yahaya T., <sup>3</sup>Ronald W.I.A and <sup>3</sup>Danladi P.

<sup>1</sup>Department of Animal Biology, School of Life Sciences, Federal University of Technology,  
Minna – Niger State.

<sup>2</sup>Department of Geography, School of Physical Sciences, Federal University of Technology,  
Minna – Niger State

<sup>3</sup>Department of Biological Sciences, Federal University, Wukari, Taraba State – Nigeria

\*Corresponding author email: Vosiele1@gmail.com

### Abstract

Terrestrial snails are key indicators of climatic changes and ecosystem health. This study recorded 2456 land molluscs from 22 species in 6 families across 20 plots. The most abundant families were *Urocyclidae*, *Streptaxidae*, and *Archatinidae*, comprising 90.82% of the total collection. *Aillyidae*, *Cyclophoridae*, and *Succineidae* had the fewest species. *Gymnarion sp.* (*Subulinidae*) was the most numerous with 997 individuals, followed by *Gonaxis camerunensis*. Margalef's index indicated the highest species richness in the Buffer Zone (3.18). Shannon-Weiner's index revealed the highest diversity (2.26) in the Buffer Zone. Chao 2 and Jackknife estimators for Nkunaya were 22.13 and 21.13, respectively, while for the Buffer Zone they were 21.90 and 24.24. The Whittaker Index for the Buffer Zone was 1.47, showing low differentiation among plots.

**Keywords:** Molluscs; Biodiversity; Species; National Park; Conservation.

### Introduction

Land snails are crucial for conservation as many species are endangered, and

preserving them is vital for biodiversity and ecosystem health (Pearce-Kelly *et al.*, 2012). Terrestrial snails are highly sensitive

to environmental changes, which is further compounded by their limited ability to disperse or migrate quickly (Nunes and Santos 2012). In recent decades, work on the diversity of terrestrial and aquatic molluscs has become numerous, given the fact that they represent one of the most rapidly declining groups on a local as well as global scale, knowledge on their autecology species is indispensable, as they represent a rapidly declining group on both local and global scales (Cuttelod *et al.*, 2011) As indicators of climatic changes, including global warming, land snails play a significant role in ecosystem preservation (Beltramino *et al.*, 2015). They also possess medicinal properties used in treating various ailments (Chen *et al.*, 2018). The interest of researchers in Molluscs arise from the fact that aside being prey for other animals; they are decomposers and therefore participate in mineralization and soil fertilization (Abele *et al.*, 2013). The objective of this study is to determine the species abundance composition and

diversity of terrestrial snails in protected area (Cross river national park) Cross river state, Nigeria.

## **Materials and Methods.**

### **Description of Study area.**

Cross River National Park's Oban Hills sector was carved from the Oban Forest reserves in 1991. Located in Cross River State, Nigeria, between latitudes 5.0833° N and 6.4833° N, and longitudes 8.25° E and 9.5° E, it covers 3000 sq km of tropical humid forest, making it Nigeria's largest closed-canopy rainforest, sharing a border with Cameroon's Korup National Park (Oke and Alohan, 2009). The Oban Hills sector, divided into the Obong/Nsan and Oban corridors, spans Akamkpa and Etung Local Government Areas, with headquarters in Akamkpa, 42 km from Calabar. This sector features tropical high forest with hills and swamps, experiencing nine months of rainfall (March-November) and 1800mm - 3000mm annual rainfall (NiMet, 2022). Vegetation includes various

stages of tropical rainforest degradation and recovery, with species like *Berlina confusa*, *Coula edulis*, *Hannoa klaineana*, and oil palm plantations. Growing village

populations in the buffer zone are causing increased hunting, fishing, and arming, threatening the ecosystem (Sunday *et al.*, 2017).

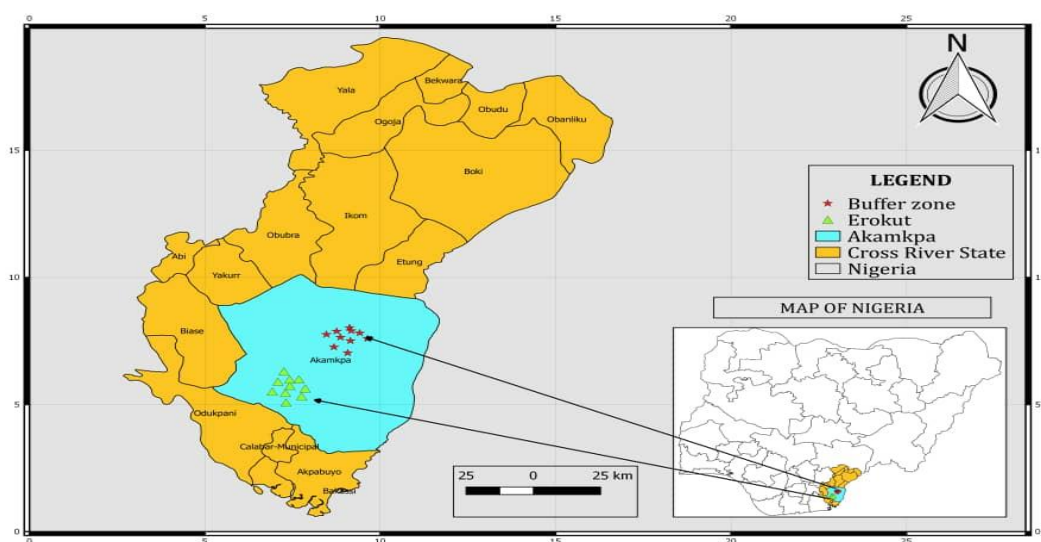


Figure 1: Map showing Cross River National Park, Akamkpa, cross river state, Nigeria.

## Sampling.

### Collection of Snails

Land molluscs were sampled in Cross River National Park (Akamkpa) from June 2021 to May 2022 during the rainy season and November 2021 to March 2022 in the dry season. Researchers used direct search techniques to examine microhabitats such as fallen trunks, rotten logs, tree bark, and litter beds across 30 plots (20m x 20m

each). Litter and topsoil were collected using a hand fork, with 10 litres taken from randomly selected sites within each plot. Samples were labelled with locality, date, and plot details to prevent escape and preserved in 70% ethanol for future anatomical studies (Osiele *et al.*, 2022).

- Simpson's Diversity Index measures diversity by considering the number of species and their relative abundance.

- Shannon's Index accounts for both species' abundance and evenness, assuming random sampling. It is commonly used in ecological studies.
- Margalef Index assesses species evenness or dominance (how individual species are distributed).
- Whittaker's Index (I) and overall Species Richness (S) evaluate diversity by dividing the total number of species recorded (S) by the mean number of species per site ( $\alpha$ ), indicating the extent of the difference in diversity between sites (Ogbeide *et al.*, 2018).

36.36%, and 343 individuals, 18.45%), *Subulinidae* (7 species, 31.82%, and 121 individuals, 6.51%), and *Urocyclidae* (4 species, 18.18%, and 1315 individuals, 70.74%) (Table 2, Figures 2 & 3). *Urocyclidae* had the highest number of individuals, with *Gymnarrion sp.* being the most abundant species at 55.19% of the total. The sample rarefaction curve (Figure 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 Jackknife estimator was 22.13 and 21.13 of all samples collected, respectively the Whittaker Index was 0.84, indicating low differentiation among plots.

### **Cross River National Park (Akamkpa) Nsam Community, Nkunaya Station**

In total, 1859 pulmonate molluscs from 22 species in 5 families were collected (Table 1). Each plot yielded 116 to 263 individuals (mean =  $185.9 \pm 15.53$ ) and 10 to 15 species (mean =  $11.89 \pm 0.54$ ). The most species-rich families were *Streptaxidae* (8 species,

Figure 5 shows a dendrogram clustering species into 3 groups at 50% similarity: *Ptychotrema cf. complicatum*, *Gulella cf. monodon* and *Ptychotrema sp.*, and all remaining species. The rank abundance curve (Figure 2) revealed that some species were very abundant, others rare, and most of intermediate abundance. Four species had more than 100 individuals, two had more than 50, three had more than 20, and 12 had fewer than 20 individuals. Figure 8 illustrates the relationship between geographical position and molluscs species richness.

#### **Cross River National Park (Akamkpa) Buffer Zone, Erokut Station**

Table 3 shows the occurrence of land molluscs species from 10 plots in the Buffer Zone, Erokut Station, Cross River National Park (Akamkpa). A total of 597 individuals from 22 species in 6 families were collected. The number of individuals per plot ranged from 17 to 45 (mean =  $28 \pm$

3.85), and species per plot ranged from 6 to 11 (mean =  $8.67 \pm 0.65$ ). The fauna was dominated by *Achatinidae*, *Streptaxidae*, *Subulinidae*, and *Urocyclidae* (Table 3). Figure 6 illustrates the percentage abundance of species and individuals collected.

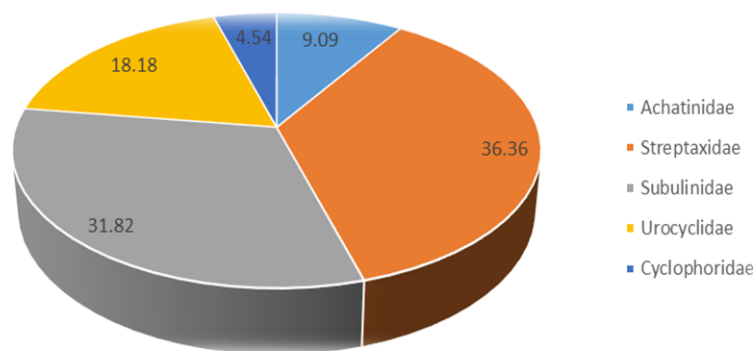
Figure 9 shows the rank abundance plot, with a few species being very abundant, some very rare, and most of intermediate abundance. Specifically, one species had over 50 individuals, two had over 40, two had over 20, three had over 10, and ten had fewer than 5 individuals. Figure 7 depicts a dendrogram clustering species into three main groups. Chao 2 and Jackknife estimators were 21.90 and 24.24, respectively, reflecting species richness. The Whittaker Index was 1.47, indicating low differentiation among plots. Figure 5 displays the Principal Component Analysis Scree plot for land molluscs in the Akamkpa Buffer Zone, Erokut Station, Cross River National Park.

**Table 1:** List of Molluscs collected in Cross River National Park (Akamkpa) Nsam Community, Nkunaya Station from the Ten Plots between June, 2021 and March, 2022.

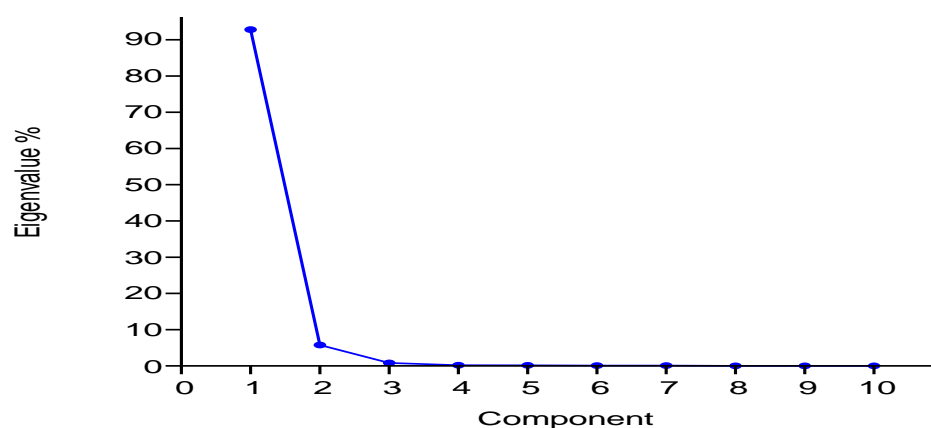
<b>FAMILY AND SPECIES</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>Total</b>
<b>ACHATINIDAE</b>											
<i>Archachatina marginate</i>	9	5	3	3	4	10	10	3	5	6	58
<i>Lignus auaripigmentum</i>	3	0	0	2	0	4	4	0	3	2	18
<b>STREPTAXIDAE</b>											
<i>Gonaxis camerunensis</i>	69	16	37	26	15	14	20	18	29	18	262
<i>Gulella</i> sp.	0	0	0	1	0	5	0	0	0	0	6
<i>Gulella io</i>	0	0	0	1	3	0	0	0	0	0	4
<i>Gulella cf. monodon</i>	0	0	0	0	0	0	0	1	0	0	1
<i>Ptychotrema</i> sp.	0	0	0	0	0	0	0	0	1	0	1
<i>Ptychotrema collumelaris</i>	2	1	0	0	0	0	0	0	0	0	3
<i>Ptychotremacf. Complicatum</i>	5	4	2	3	6	8	3	18	7	5	61
<i>Ptychotrema anceyi</i>	0	0	0	0	0	1	0	4	0	0	5
<b>SUBULINIDAE</b>											
<i>Curvella</i> sp.	3	3	0	9	8	2	2	3	5	3	38
<i>Curvella ovata</i>	0	0	0	4	1	1	0	0	2	0	8
<i>Subulina involvita</i>	1	6	5	0	0	0	7	0	1	1	21
<i>Subulina striatella</i>	0	4	12	2	2	0	0	2	8	0	30
<i>Subulina pattalus</i>	4	2	1	3	0	0	4	0	1	0	15
<i>Pseudopeas</i> sp.	1	1	0	0	0	0	0	0	0	0	2
<i>Subulina</i> sp.	0	0	0	2	3	1	0	1	0	0	7
<b>UROCYCLIDAE</b>											
<i>Thapsia</i> sp.	69	15	30	14	20	2	3	8	0	1	162
<i>Trochozonites</i> sp.	13	7	7	16	4	4	23	15	13	9	111
<i>Trochozonites lysterix</i>	0	4	5	5	1	0	1	0	0	0	16
<i>Gymnarion</i> sp.	84	138	59	91	165	64	56	171	77	121	1026
<b>CsYCLOPHORIDAE</b>											
<i>Cyclophorus</i> sp.	0	0	0	0	1	0	0	0	0	3	4
<b>Total No. of Individual Plots</b>	<b>263</b>	<b>206</b>	<b>161</b>	<b>182</b>	<b>233</b>	<b>116</b>	<b>133</b>	<b>244</b>	<b>152</b>	<b>169</b>	<b>1859</b>
<b>Total No. of Species per Plot</b>	<b>12</b>	<b>13</b>	<b>10</b>	<b>15</b>	<b>13</b>	<b>12</b>	<b>9</b>	<b>11</b>	<b>12</b>	<b>10</b>	<b>117</b>

**Table 2:** Percentage Abundance of Species and Individual Molluscs at the Cross River National Park (Akamkpa) Nsam Community, Nkunaya Station.

Family	Number of Species	% Species	Number of Individual	% Individuals
Archatinidae	2	9.09	76	4.09
Streptaxidae	8	36.36	343	18.45
Subulinidae	7	31.82	121	6.51
Urocyclidae	4	18.18	1315	70.74
Cyclophoridae	1	4.54	4	0.22
<b>Total</b>	<b>22</b>	<b>100</b>	<b>1859</b>	<b>100</b>

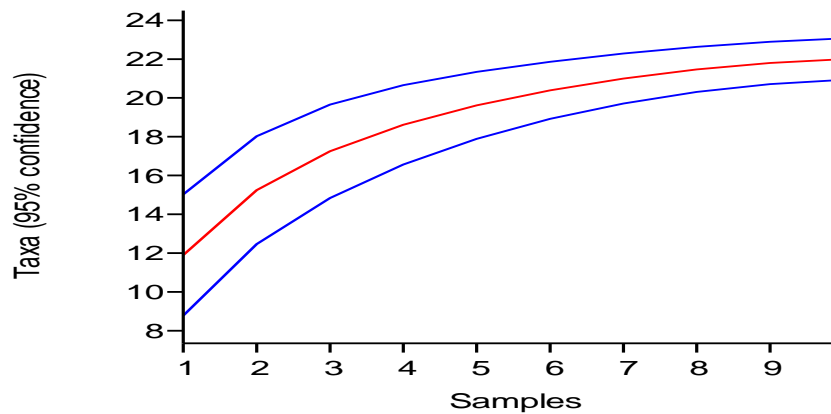


**Figure 2:** Percentage Abundance of Species Mollusc collected from Cross River National Park (Akamkpa) Nsam Community, Nkunaya Station between October, 2021 to December, 2022.

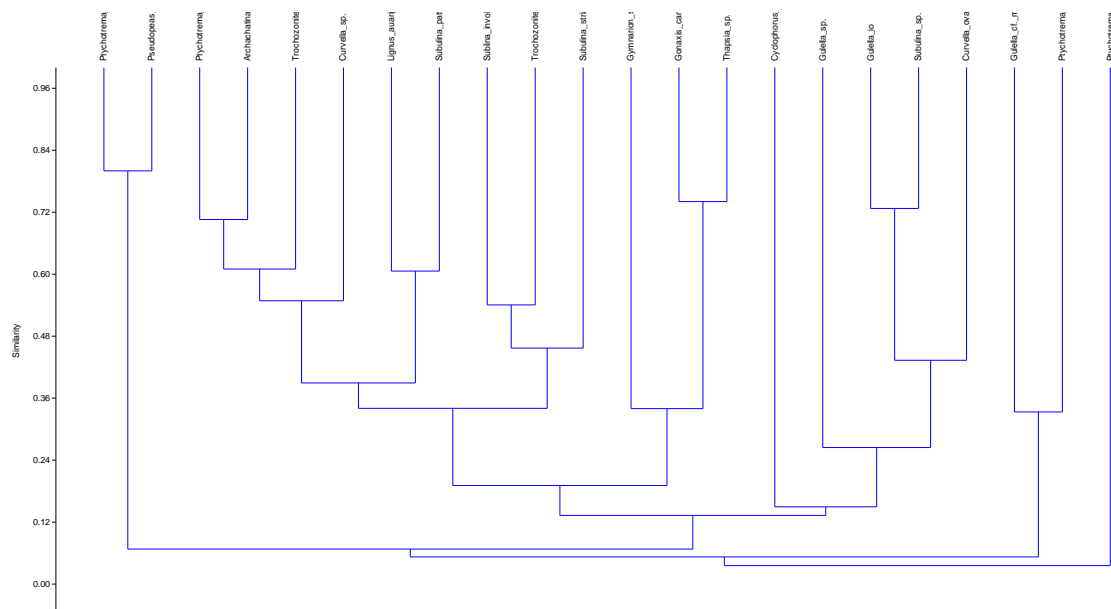


**Figure 3:** Rate of sample-based Species accumulation curve of Sampling Plots in CrossRiver National Park (Akamkpa) Nsam Community, Nkunaya Station, Cross river

State, Nigeria. Plotted values are means based on 100 randomizations of sample accumulation order (without replacement) 95% confidence limit.



**Figure 4:** Principal Component Scree Curve (Rank Abundance) of Land Molluscs in Cross River National Park (Akamkpa) Nsam Community, Nkunaya Station, Cross river State, Nigeria.



**Figure 5:** Dendrogram of Similarity of Species using Bray-Curtis Similarity Index in Cross River National Park (Akamkpa) Nsam Community, Nkunaya Station, Cross river State, Nigeria.



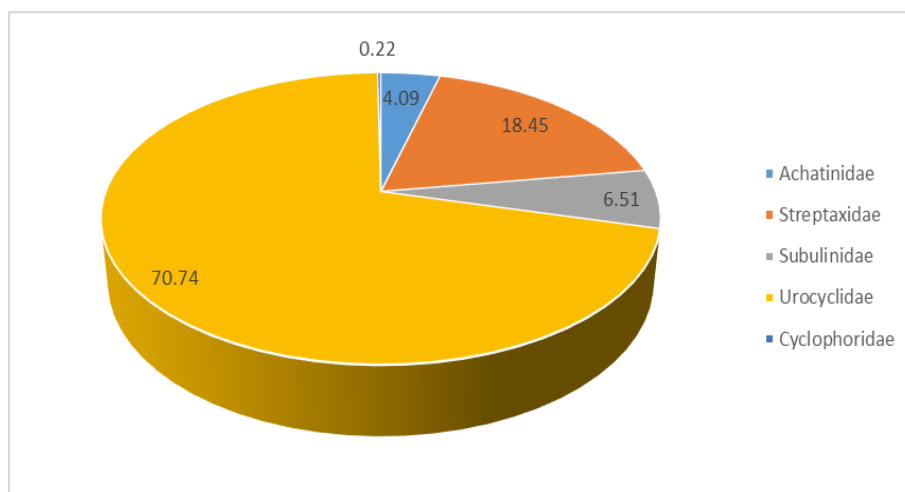
**Table 3:** List of Molluscs collected in Cross River National Park (Akamkpa) Buffer Zone, Erokut Station from the Ten Plots between October, 2021 and December, 2022.

FAMILY AND SPECIES	1	2	3	4	5	6	7	8	9	10	TOTAL
<b>ACHATINIDAE</b>											
<i>Archachatina marginata</i>	6	0	1	4	3	0	7	6	10	4	41
<i>Callistoplepa</i> sp.	0	0	6	0	3	3	3	0	6	3	24
<i>Lignus auaripigmentum</i>	6	0	5	1	0	3	2	3	2	0	22
<i>Limicolaria flammea</i>	0	0	0	3	0	3	0	0	0	0	6
<b>AILLYIDAE</b>											
<i>Allya camerunensis</i>	0	0	0	0	0	0	3	0	0	0	3
<b>STREPTAXIDAE</b>											
<i>Gonaxis camerunensis</i>	1	18	18	4	4	10	11	2	19	4	91
<i>Gulella</i> sp.	0	2	0	0	0	0	1	0	0	1	4
<i>Gulella io</i>	0	0	0	0	0	0	0	0	2	4	6
<i>Ptychotrema</i> sp.	0	1	0	0	0	0	0	1	2	2	6
<i>Ptychotrema anceyi</i>	48	26	12	22	18	2	8	24	6	0	166
<i>Ptychotrema complicatum</i>	1	7	0	0	0	0	0	0	1	2	11
<i>Ptychotrema collumelaris</i>	0	1	0	0	0	0	0	0	0	0	1
<b>SUBULINIDAE</b>											
<i>Curvella</i> sp.	4	3	0	3	0	3	6	5	30	0	54
<i>Curvella ovata</i>	0	0	0	0	0	0	0	0	0	0	0
<i>Subulina striatella</i>	6	0	6	0	0	0	0	0	0	0	12
<i>Subulina pattalus</i>	6	0	3	0	0	0	0	0	0	0	9
<i>Subulina involvita</i>	12	0	0	0	0	0	0	0	0	0	12

<i>Pseudopeas</i> sp.	0	3	3	0	0	0	0	0	0	0	6
<b>UROCYCLIDAE</b>											
<i>Thapsia</i> sp.	0	12	0	0	6	0	0	11	3	0	32
<i>Trochozonites hystrix</i>	2	6	0	0	0	0	1	0	0	2	11
<i>Trochozonites</i> sp.	2	14	3	6	20	12	15	0	3	2	77
<b>CYCLOPHORIDAE</b>											
<i>Cyclophorus</i> sp.	0	0	0	0	0	0	0	0	0	3	3
<b>Total No. of Individual Plots</b>	<b>94</b>	<b>93</b>	<b>57</b>	<b>43</b>	<b>54</b>	<b>36</b>	<b>57</b>	<b>52</b>	<b>84</b>	<b>27</b>	<b>597</b>
<b>Total No. of Species per Plot</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>7</b>	<b>6</b>	<b>7</b>	<b>10</b>	<b>7</b>	<b>11</b>	<b>10</b>	<b>88</b>

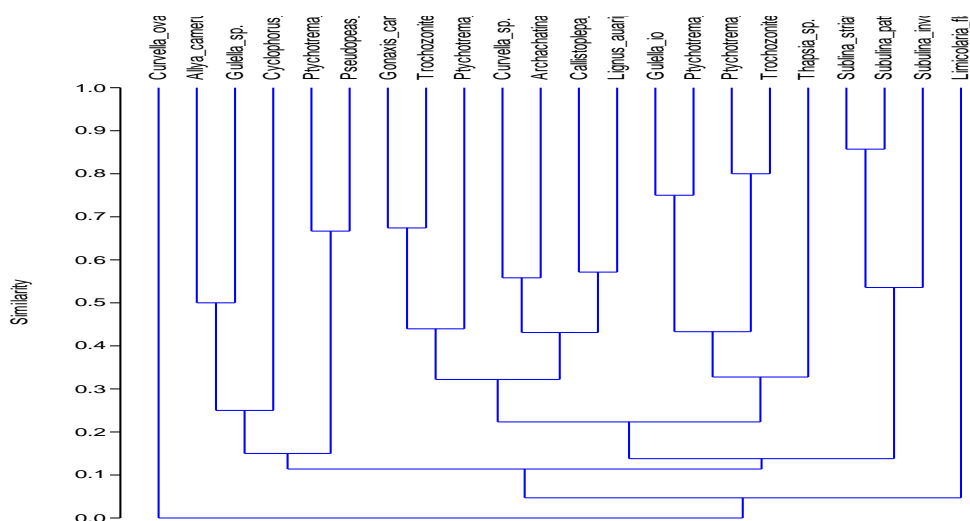
**Table 4:** List of Molluscs collected in Cross River National Park (Akamkpa) Buffer Zone, Erokut Station from the Ten Plots between June, 2021 and March, 2022.

<b>Family</b>	<b>Number of Species</b>	<b>% Species</b>	<b>Number of Individual</b>	<b>% Individuals</b>
Archatinidae	4	18.18	44	14.81
Aillyidae	1	4.55	1	0.34
Streptaxidae	7	31.82	150	50.51
Subulinidae	6	27.27	35	11.78
Urocyclidae	3	13.64	66	22.22
Cyclophoridae	1	4.55	1	0.34
<b>Total</b>	<b>22</b>	<b>100</b>	<b>297</b>	<b>100</b>

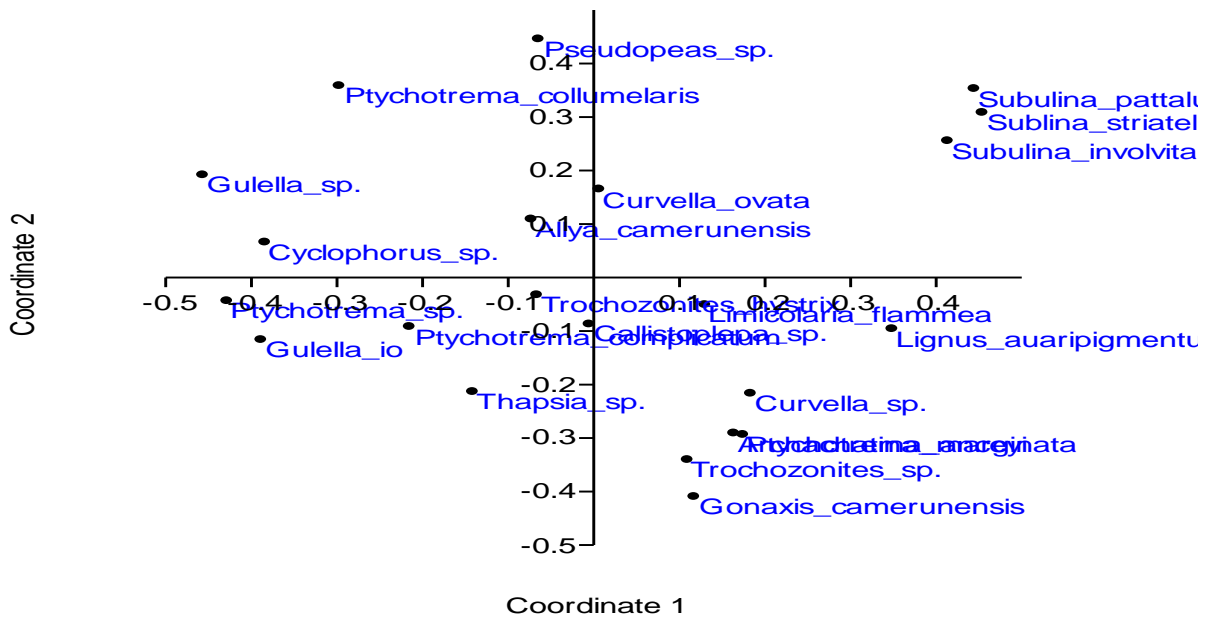


**Figure 6:** Percentage Abundance of Individual Mollusc collected from Cross River National Park (Akamkpa) Nsam Community, Nkunaya Station between October, 2021 to December, 2022.

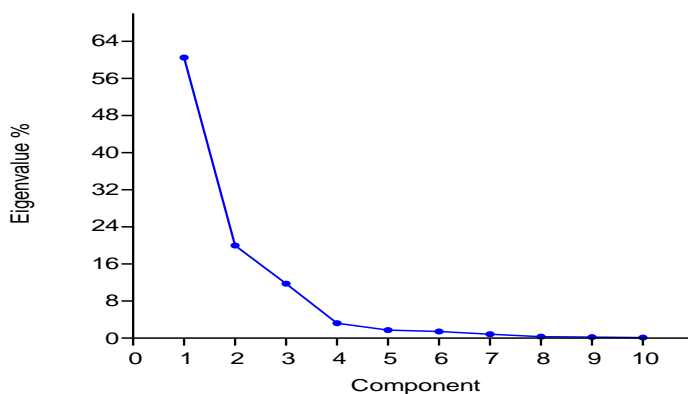
Figure 7 showed the dendrogram of similarity, dividing the species collected into 2 distinct groups at 50% similarity. *Gulella opoboensis* made up the first group, while all the remaining species made up the second group. Two species occurred with more than 50 individuals, four species with more than 15 individuals, two species with more than 10 individuals and 11 species with less than 10 individuals.



**Figure 7:** Dendrogram of Similarity of Species using Bray-Curtis Similarity Index in Cross River National Park (Akamkpa) Buffer Zone, Erokut Station, Cross River State, Nigeria.



**Figure 8:** Relationship between the Geographical Position and Species Richness of Land Molluscs in Cross River National Park (Akamkpa) Buffer Zone, Erokut Station, Cross River State, Nigeria



**Figure 9:** Principal Component Analysis Scree plot (Rank Abundance Curve) of Land Molluscs in Cross River National Park (Akamkpa) Buffer Zone, Erokut Station, Cross River State, Nigeria.

## Species Diversity, Richness and Evenness of Cross River National Park (Nkunaya Station and Buffer Zone

Species diversity includes species richness (the number of species) and species evenness (how individuals are distributed among species). Table 5 shows the

richness, diversity, and evenness of molluscs across various plots. Margalef's species richness index (d) for the Buffer Zone of Cross River National Park was 3.18. Shannon-Weiner's diversity index (H1) revealed the highest diversity (2.26) in plot 10 of the Buffer Zone and the lowest (1.11) in plot 10 of the Nkunaya Station Zone. Evenness (€) was highest in plot 10 of the Buffer Zone (0.96) and lowest in plot 5 of the Nkunaya Station Zone (0.26).

#### **Total Number of Species Counts from Cross River National Park (Nkunaya Station and Buffer Zone) from the 10 Plots**

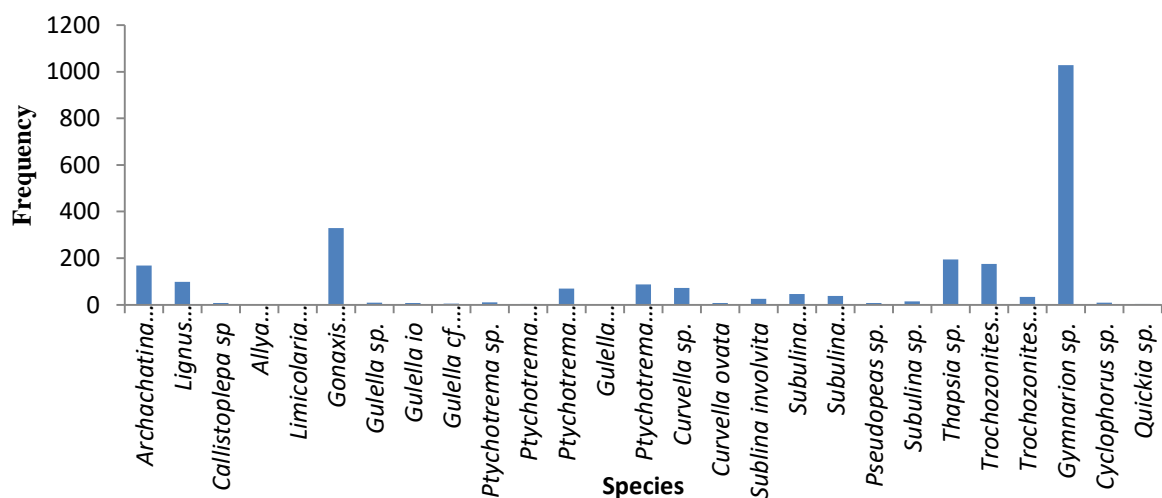
Table 5 shows the percentage abundance of species and individuals across the study

sites. A total of 2456 land molluscs from 22 species in 6 families were recorded from 20 plots. The three most abundant families, in descending order, were *Urocyclidae*, *Streptaxidae*, and *Archatinidae*, which together accounted for 90.82% of the total molluscs collected. Figure 10 illustrates the species count across sites, with *Streptaxidae* having the highest percentage of species in the Nkunaya Station Zone, followed by *Subulinidae* and *Urocyclidae* from the same zone, and *Archatinidae* from the Buffer Zone. Families with the fewest species were *Aillyidae*, *Cyclophoridae*, and *Succineidae*. *Gymnarion sp.* (*Subulinidae*) had the highest number of individuals (997), followed by *Gonaxis camerunensis*.

**Table 5: Species Diversity, Species Richness and Evenness of the 10 Plots in Buffer Zone (Cross river National Park) and Nkunaya Station Zone (Cross river National Park) Respectively.**

		Margalef's species (d)	Shannon-Weiner's Index (H)	Evenness €
Plot 1	Buffer Zone	2.63	1.73	0.51
	Nkunaya Station	1.97	1.65	0.43

<b>Plot 2</b>	<b>Buffer Zone</b>	2.57	2.03	0.69
	<b>Nkunaya Station</b>	2.25	1.35	0.29
<b>Plot 3</b>	<b>Buffer Zone</b>	2.55	1.94	0.77
	<b>Nkunaya Station</b>	1.77	1.73	0.56
<b>Plot 4</b>	<b>Buffer Zone</b>	2.00	1.47	0.62
	<b>Nkunaya Station</b>	2.69	1.78	0.39
<b>Plot 5</b>	<b>Buffer Zone</b>	1.55	1.40	0.67
	<b>Nkunaya Station</b>	2.20	1.20	0.26
<b>Plot 6</b>	<b>Buffer Zone</b>	2.12	1.57	0.69
	<b>Nkunaya Station</b>	2.31	1.61	0.42
<b>Plot 7</b>	<b>Buffer Zone</b>	2.51	1.94	0.70
	<b>Nkunaya Station</b>	2.05	1.78	0.54
<b>Plot 8</b>	<b>Buffer Zone</b>	1.91	1.43	0.60
	<b>Nkunaya Station</b>	1.82	1.18	0.30
<b>Plot 9</b>	<b>Buffer Zone</b>	2.68	1.91	0.61
	<b>Nkunaya St</b>	2.19	1.63	0.42
<b>Plot 10</b>	<b>Buffer Zone</b>	3.18	2.26	0.96
	<b>Nkunaya Station</b>	1.75	1.11	0.30



**Figure 10:** Species count from Buffer Zone (Cross river National Park) and Nkunaya Station (Cross river National Park).

## Discussion.

This study describes the seasonal species composition and richness of land snail's species. A total of 2456 land molluscs individual representing 22 species belonging to 6 families were recorded from 20 plots in the study sites as compared to Osiele et al., (2022) reported a total of 593 individuals that belong to 26 species in Odukpani and Mfamosing low forest and limestone hills in Nigeria, which is lower than that recorded from this study. The study showed that the terrestrial molluscs fauna of Mfamosing Limestone Hill was moderately diverse and low as compared to this study. Species richness was dominated by the *Streptaxidae*, while numerical abundance was dominated by the *Subulinidae*, *Streptaxidae* and *Urocyclidae*, contributing to more than 95% of the total number of individuals which is higher as compared to this study three most abundant families, declining in rank order were *Urocyclidae*, *Streptaxidae* and *Archatinidae*, together representing

90.82% of the total number of molluscs collected from the sites which indicates a decline in the species richness and high abundance of land snails make Cross river a unique site for molluscan conservation in Nigeria. Oke (2013) reported a total of 28 species and 639 individuals in 7 molluscan families were collected from 17 plots. Species richness was dominated by the *Streptaxidae* (36%) and *Subulinidae* (32%), and numerical abundance by the *Subulinidae* (56%) and *Streptaxidae* (32%). The most abundant species was *subulinid*, *Subulona pattalus*, contributing almost 25% of the total number of individuals which is lower than the abundance observed in this study. Gazama (2012) recorded 12 species of terrestrial molluscs from six families, with the family *Achatinidae* occurring throughout the study area. Only one family of slugs (*Veronicellidae*) was recorded, and five of the six families were represented by a single species each in northern Nigeria, indicating lower species richness compared to this

study. Ogbeide *et al.* (2018) reported 1,095 individuals representing 43 species across 9 molluscan families, with the highest species richness in the Ogbesse Forest Reserve and the least in the unprotected forest area at Ipole Iloro. The *Subulinidae* and *Streptaxidae* were the most represented families in terms of species richness, with the *Subulinidae* being the most abundant numerically (45.20%), which is moderately higher than the numbers of species in this study. Seasonal changes in habitat conditions promote species turnover rather than nestedness diversity patterns, because it produces mass migration or species emergence (Lange *et al.*, 2016). Interestingly, we found that trophic levels are related to beta diversity components. For instance, producers had high turnover and total beta diversity, whereas decomposers had low nestedness. One possible explanation for high turnover for producers (except that higher plants had generally low beta diversity) is that they rely on the local environment (such as,

nutrient supply), whereas herbivores and carnivores tend to be controlled by food availability. If the local nutrient supply shows high spatial heterogeneity in the field, for example, this would also be likely to lead to high patchiness in community composition.

### **Conclusion.**

In conclusion, Cross River National Park exhibits moderate richness in land snail species, though there is a decline in species families due to anthropogenic activities such as land use changes, habitat destruction, and pollution. This study provides essential data on species diversity and abundance, aiding reserve managers in monitoring threatened populations and emphasizing the importance of including invertebrates in conservation planning.

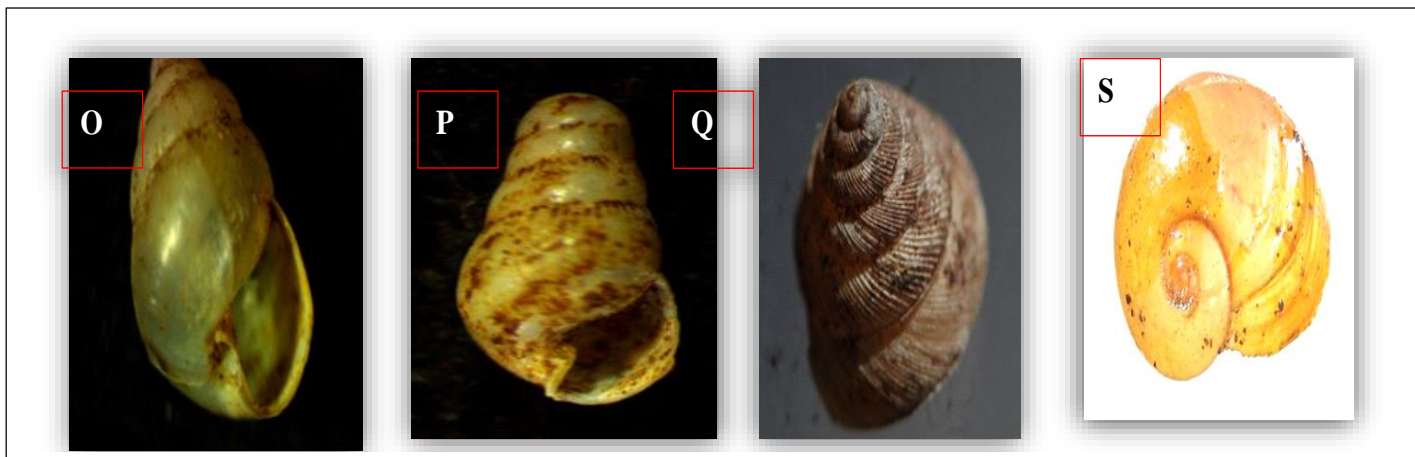
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their kind assistance in planning and logistics.





**Plate:** (A) *Alliia camerunensis* H 4.5mm;(B) *lignus* sp. H 46mm; (C) *Ptychotrema collumelaris* H 9.8mm; (D) *Cyclophorus* sp.H 5.5mm;(E) *Subulina* sp. H 10mm, (F) *Ptychotrema cf anceyi* H 9.5mm; (G) *Callistoplepa* sp. H 10 mm (H) *Curvella* sp. H 3.5mm. (I) *Thapsia* sp. H 5.5mm (J) *Subulina striatella* H 2.1mm (K)*Gulella monodon* H 3.5mm (L) *Limicolaria flammea* H 5mm (M-M2) *Quickia* sp. H 4mm (N-N2) *Trochozonites lysterix* H 6.1mm (O) *Achatinidae marginata* H 155mm (P) *Pseudopeas* sp. H 11.3mm (Q) *Trochozonites* sp. H 1mm (R) *Gymnarion* sp. H 5mm

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