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## The land snail diversity in a square kilometre of tropical rainforest in Okomu National Park, Edo State, Nigeria

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**ABSTRACT:** The land mollusc fauna in a single square kilometer of undisturbed tropical rainforest in Okomu National Park, Edo State, Nigeria was surveyed by sampling thirty 20-m<sup>2</sup> plots. Sampling methods were similar to those used in the rainforests in Cameroon and Sabah. Samples were collected by sieving leaf litter, topsoil and by hand picking within the forest floor or vegetation. A total of 1442 individual molluscs belonging to 46 species in 11 molluscan families were collected. In number and diversity, the Streptaxidae was the most dominant family constituting 33% of the total number of species collected and 35% of the total number of individuals. Few species were abundant as most species were rare. The diversity of land molluscs in Okomu National Park is much lower than that reported for Cameroon and Sabah. Possible causes may be due to poor knowledge of the molluscan fauna and inability to sample the entire available habitat in the rainforest. Further studies in other parts of the rainforest in West Africa will provide more information on the molluscan diversity.

**Key Words:** Biodiversity, Gastropoda, species diversity, abundance.

### **Introduction**

The land snail species richness in some tropical rainforest has been assessed recently by several authors (Emberton, 1995; Tattersfield, 1996; Gargominy & Ripken, 1998; de Winter & Gittenberger 1998; and Schuilthuizen & Rutjes 2001). These studies revealed high levels of species richness, low densities and considerable heterogeneity in richness and species composition among plots within the study area contrary to the assertions by Solem (1984) that tropical rainforest have impoverished land molluscs fauna.

Cameroon, Mylonas, Triantis, Parmakelis, & Vardinoyannis (2003) in studying the land snail diversity in a square kilometer of Cretan marquis using the protocol designed by de Winter & Gittenberger (1998) stressed the lack of replicates of the kind of study carried out in the rainforest of Cameroon and Sabah.

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This paper aims at studying the composition of land molluscs in the lowland rainforest in Okomu National Park, using protocols similar to those used in the rainforest studies by de Winter and Gittenberger (1998) and Schilthuizen and Rutjes (2001). We also aim at increasing our knowledge of the biodiversity of the land mollusc fauna in Okomu National Park and later to make comparisons with studies carried out in other parts of the world. Interest in the park is due to the fact that it is the only lowland rainforest protected by law in Nigeria and it has the largest surviving population of the white-throated guenons.

## **Materials and Methods**

### *The Study Area*

Okomu National Park (Lat. 6° 18' N, Long. 5° 15'E) is situated in the lowland rainforest belt of southwestern Nigeria in Okomu, Ovia South West Local Government Area, Edo State, Nigeria (Fig. 1). It covers approximately 114 sq. Km. It was established in 1987 as a wildlife sanctuary and it is the largest lowland rainforest area to be protected by law in Nigeria.

The climate is tropical. The vegetation is typical evergreen tropical rainforest type, rich in *Khaya* and *Guarea* spp., with a middle story of dense-crowned, wide-spreading trees and a ground flora that is mainly herbaceous and characterized by an abundance of creepers, mostly *Acacia ataxacantha* and rattan (*Calamus deerratus*).

### *Sampling*

Sampling was carried out in June 10 -11 2003, November 10, 2003, July 7-10, 2004, and 20 -22 April in 2005 by the authors and four field assistants. Thirty plots of 20 x 20m each were randomly selected for qualitative and quantitative analysis of the molluscan fauna in the Okomu National Park sanctuary. Sampling comprised of intense two person-hour hand searches for molluscs in the rainforest and collection of surface litter with some top soil in polythene bags. At every plot we intensively searched for snails and slugs, paying particular attention to habitats favoured by these animals, such as logs, the bark and buttresses of large trees, leaf litter and undersides of leaves. We collected over 200 litres of litter and top soil from a variety of micro-habitats within the forest. Litter samples were carried to the laboratory for sieving and sorting. The litter was searched immediately on arrival for the presence of slugs and then air-dried. After drying, litter samples were then passed through a series of sieves of different mesh sizes. All snails, slugs and shell fragments encountered as well as those collected alive in the field were preserved in 70% ethanol. This provides materials for future anatomical studies.

The measures of diversity used in this study are 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 ( $\alpha$ ), providing a measure of diversity difference among sites. If  $I$  equals 1, sites have identical faunas and higher values indicate increasing differentiation. High values of  $I$  can result from geographical or ecological replacement of taxa, or from chance effects due to sampling error. These patterns can be distinguished by comparing the variance of sites per species to the maximum variance possible for the same values of S and  $\alpha$ , as explained in Cameron (1992). If the achieved variance is low, replacement effects will be more important than chance effect and vice versa. Estimation of true diversity was carried out by performing 100 randomisation on the data and calculating S using the estimators Chao2 and second-order jackknife in the program EstimateS6.0b (Colwell, 2000)

The vast majority of the species were classified according to shell character only. This means that the estimates of the number of species might be conservative; additional cryptic species may be present, especially among the shelled Urocyclidae. To avoid overestimation of species richness, juvenile and broken shells were excluded from the analysis, so that underestimation is more likely.

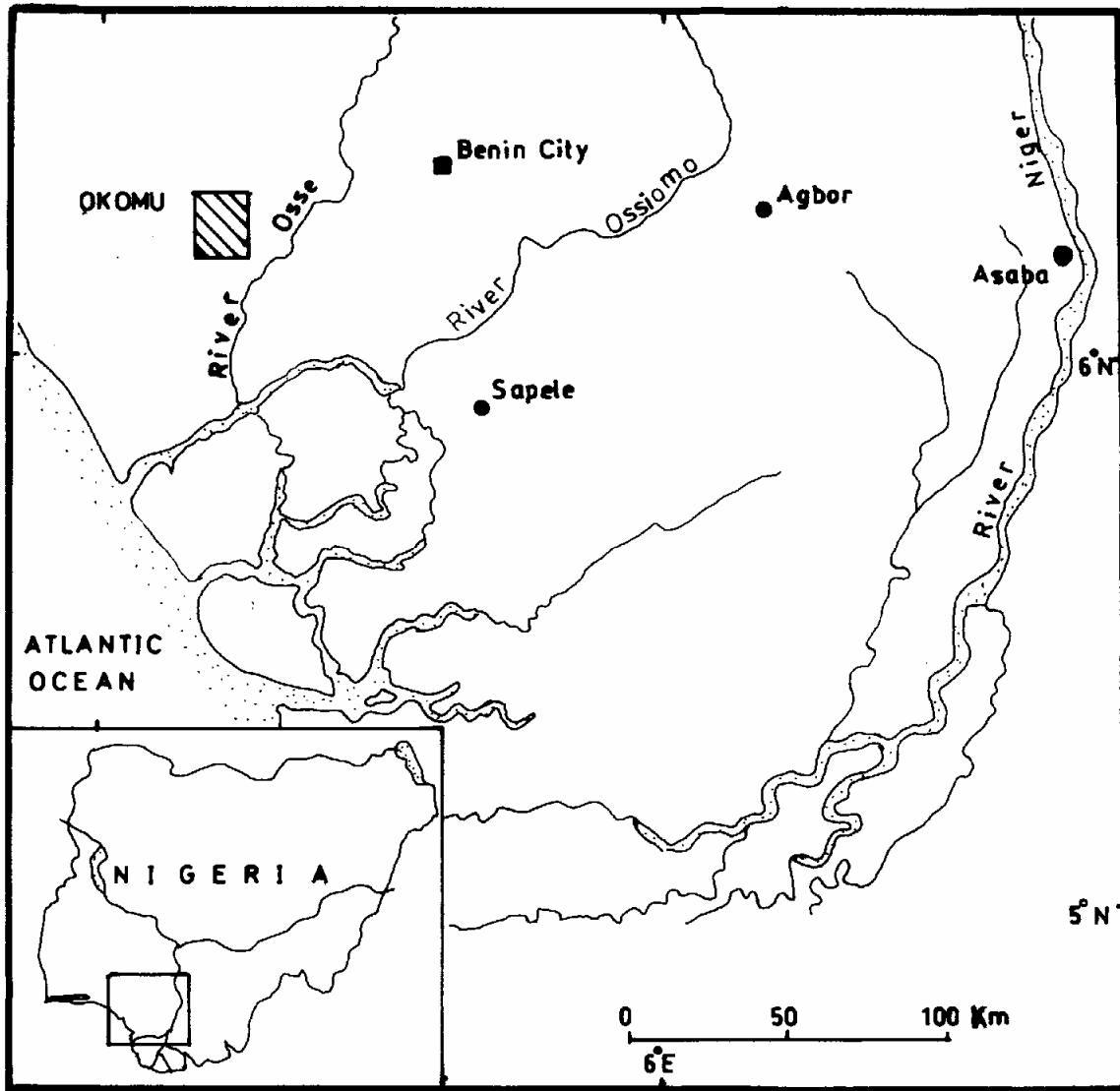


Fig. 1. Map Midwestern Nigeria showing the location of Okomu National Park where samples were collected, with inset showing its position in Nigeria.

## Results

Table 1 lists the 46 taxa recorded from Okomu National Park, south western Nigeria, of which 23 could be identified to species level and the other 23 taxa seem to be of unclear status or may be new species. Eleven land molluscan families were represented in the collection, one Prosobranchia Mesogastropoda and the remaining Pulmonata.

The molluscan fauna is dominated by two families, the Streptaxidae (15 species) and the Subulinidae (12 species) constituting over 50% of the total number of species. The Streptaxidae was the most dominant family constituting 33% of the total number of species collected and 35% of the total number of individuals. The diversity per plot ranged from 5 to 31 species (mean 12.43; standard deviation 5.62). Whittaker's index  $I$  of species diversity was 3.70. This figure indicates a relative substantial degree of beta diversity, i.e., differentiation among the plots. The richest site (plot 1) was fifteen species short of the total for the site.

Fig. 2. gives the absolute abundance of all the forty-six species found in the area of study. In total, we collected 1442 individuals from all the plots. Each plot yielded between 6 and 117 specimens (mean 48.06; standard deviation 31.79). The abundant species include *Pseudopeas* sp.1 (260 individuals), *Subulina* sp. (119 individuals), *Gulella opoboensis* Preston, 1914 (118 individuals), *Subulona* sp. (118 individuals), *Curvella* sp.1 (95 individuals), and *Gonaxis camerunensis* d'Ailly, 1896 (72 individuals). Most species are rare and occurred as single individual or in a single plot. Fifteen species (33%) were represented by five individuals or less, 11 (23%) species occurred only in one plot of which 8 species (17%) were found as single individual. The most widely distributed species (*Subulina* sp.) occurred in 25 (83%) of the plots. 11 (23%) species occurred in more than half the plots while the remaining 35 (77%) species occurred in less. Land snail abundance was significantly higher in the rainy season than in the dry (Two-tailed Mann-Whitney test,  $0.01 < P(u \geq 610) < 0.02$ ). Eighty percent of the total number of species was collected during the first sampling period and ninety in the second. Subsequent sampling added two species each to the collection.

## Discussion

Our studies on the land mollusc of Okomu National Park reveal a moderately high diversity given the poor knowledge of the malacofauna of this West African region. Forty-six species were recorded in a single square kilometer. The species diversity of a patch of rainforest in Okomu National Park is about half the number of species reported by de Winter and Gittenberger (1998) in Cameroon and lower than that reported by Schilthuizen and Rutjes (2001) in Sabah. However, we collected more species than that reported from a square kilometer of forest in French Guyana (Gargominy & Ripken, 1998), Cretan maquis (Cameron et. al, 2003), Arabuko Sokoke forest, Kenya (Lange & Mwinzi, 2003) and from any other part of western Nigeria (Oke & Olisa-Emodoh, 1998; Oke, Alohan & Ejiofor, 2001).

The molluscan diversity in Okomu National Park is comparable to that found in a patch of lowland rainforest in Madagascar (Emberton, 1995) where 52 species was recorded, and Kakamega Forest in Western Kenya (Tattersfield, 1996) with 50 species. Moreover, our findings also corroborates other works carried out in the Afrotropical region with respect to the preponderance of carnivorous Streptaxidae (Tattersfield, 1996; Emberton et. al., 1997, Winter & Gittenberger, 1998). Some of these carnivorous snails depend on molluscan prey and other soft-bodied invertebrates.

The low abundance found in Okomu National Park is similar to that reported for other tropical rainforests. We collected about half the number of individuals recorded by Winter & Gittenberger (1998) in Cameroon and three times the number recorded by Schilthuizen and Rutjes (2001) in Sabah. This is not unexpected probably because of the variety of habitats available in the rainforest, high predation rate and high rates of litter of decomposition. Land molluscs live in the various strata provided by tropical rainforest and some are known to live in the soil, on litter, shrubs, epiphytes, trees and tree-trunks. This habitat stratification coupled with the high rate of predation make estimation of land molluscs difficult.

Table 1: Checklist of land molluscs in a single square kilometer of rainforest in Okomu National Park in June 2003, November 2003, July 2004 and April 2005.

Species of land snails	Jun-03	Nov-03	Jul-04	Apr-05
<b>Achatinidae</b>				
1 <i>Archachatina marginata</i> (Swainson, 1821)	2	0	0	0
2 <i>Archachatina papyracea</i> (Pfeiffer, 1845)	3	0	0	0
3 <i>Lignus</i> sp.	13	0	1	0
4 <i>Limicolaria aurora</i> (Jay, 1839)	0	1	0	0
5 <i>Limicolaria flammea</i> (Müller, 1774)	4	0	0	0
<b>Enidae</b>				
6 <i>Rahistia</i> sp.	1	0	1	0
<b>Ferussaciidae</b>				
7 <i>Ceciliooides</i> sp	4	0	0	8
<b>Streptaxidae</b>				
8 <i>Gonaxis camerunensis</i> (d'Ailly, 1896)	26	15	23	8
9 <i>Gulella bolocoensis</i> (Ortiz de Zarate & Ortiz de Zarate, 1955)	4	0	0	0
10 <i>Gulella io</i> (Verdcourt, 1974)	25	9	21	3
11 <i>Gulella monodon</i> (Morelet, 1873)	20	0	22	6
12 <i>Gulella opoboensis</i> (Preston, 1914)	37	0	16	65
13 <i>Gulella peilei</i> (Preston, 1914)	4	0	0	0
14 <i>Gulella pupa</i> (Thiele, 1911)	9	0	9	1
15 <i>Gulella germaini</i> (Connolly, 1929)	12	9	15	14
16 <i>Gulella</i> sp.	2	1	7	0
17 <i>Ptychotrema aequatoriale</i> (Pilsbry, 1919)	14	0	6	7
18 <i>Ptychotrema gelegelei</i> (Oke & Alohan, 2004)	2	0	0	0
19 <i>Ptychotrema okei</i> (Winter, 1996)	22	0	23	3
20 <i>Ptychotrema shagamuense</i> (Oke & Odiete, 1996)	29	1	20	0
21 <i>Streptostele</i> sp.	0	0	1	0
22 <i>Tomostele musaecola</i> (Morelet, 1860)	6	0	2	0
<b>Subulinidae</b>				
23 <i>Curvella feai</i> (Germain, 1915)	7	0	19	0
24 <i>Curvella</i> sp.1	38	2	33	22
25 <i>Curvella</i> sp.2	0	1	0	0
26 <i>Homorus</i> sp.	7	0	18	0
27 <i>kempiochoncha</i> sp.	12	13	26	0
28 <i>Pseudoglessula</i> sp.2	7	2	6	0
29 <i>Pseudopeas</i> sp.1	27	2	36	195
30 <i>Pseudopeas</i> sp.2	0	1	0	0
31 <i>Pseudopeas</i> sp.3	0	1	0	0
32 <i>Subulina</i> sp.	32	13	55	19
33 <i>Subulona</i> sp.	33	1	52	32
34 <i>Pseudoglessulla</i> sp.1	0	0	0	1
<b>Urocyclidae</b>				
35 <i>Thapsia oscitans</i> (Connolly, 1925)	10	0	9	0
36 <i>Trochozonites talcosus</i> (Gould, 1850)	14	0	14	14
37 <i>Trochozonites</i> sp.1	12	1	7	2
38 <i>Trochozonites</i> sp.2	0	0	0	1

Table 1 (Contd.)

39	<i>Trochozonites (Teleozonites) sp.3</i>	15	1	16	11
40	<i>Gymnarion sp.</i>	2	0	7	6
	<b>Succineidae</b>				
41	<i>Quickia sp.</i>	6	1	0	0
	<b>Euconulidae</b>				
42	<i>Afropunctum seminium (Morelet, 1873)</i>	2	2	3	0
43	<i>Kaliella sp.</i>	0	1	0	0
	<b>Aillyidae</b>				
44	<i>Aillya camerunensis (Odhner, 1927)</i>	5	0	0	0
	<b>Veronicellidae</b>				
45	<i>Pseudoveronicella liberiana (Gould, 1950)</i>	3	0	3	0
	<b>Maizaniidae</b>				
46	<i>Maizaniella sp.</i>	0	0	4	0
Total no. of individuals		471	78	475	418
Total no. of species		37	20	30	19

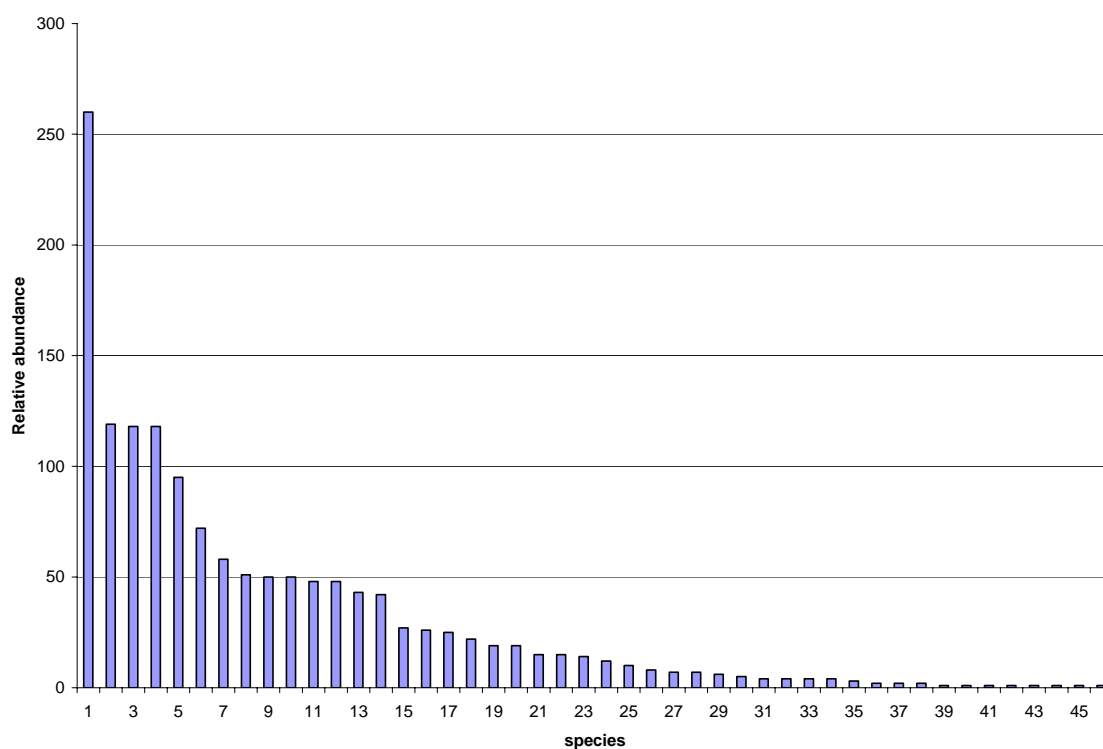


Fig. 2. Relative abundance of 46 species of land molluscs, ordered according to decreasing abundance.

In view of the relatively small area sampled in Okomu, our study revealed a relatively rich malacofauna despite the low abundance and poor knowledge of the West African fauna. Forty-six species were recorded in thirty 20m x 20m plots some of which may be new to science. *Pt. bolocoensis* Ortiz de Zarate & Ortiz de Zarate was recorded for the first time in Nigeria from this forest. Previous records were from Fernando Po and Cameroon (Ortiz de Zarate & Ortiz de Zarate, 1955). *Teleozonites*, a subgenus of *Trochozonites* was also recorded in Okomu, the first time outside East-Central Africa. This may probably be a new species or a new record when comparisons are made with the other species described by Pilsbry (1919). The description of a new species of *Ptychotrema* was recently published by the authors (Oke & Alohan, 2004). Moreover, we found many species of Subulinidae and Urocyclidae that could not be readily identified with diagrams from previous workers. Further malacological studies may reveal the presence of more new species especially in the urocyclid- and subulinid-snails where the taxonomy is highly impoverished by the absence of collectors and researchers. The national park is one of the few biodiversity hotspots in south western Nigeria and is actually the only lowland rainforest reserve in the country. About a third of the species of land molluscs collected in this study are rare and this makes them more vulnerable to extinction. It will be interesting to know the conservation status or legal status of these rare species so as to devise strategies for their protection.

We have reason to suspect that the true diversity in Okomu National Park will be higher than the 46 species recorded. However, this is because there are no less than 11 species with one or two individuals, which suggests that more rare species remain to be discovered. This is borne out by the estimation of true species richness using the Chao 2 and second-order jackknife suitable for small sample size. Chao 2 richness estimator and second-order jackknife using "EstimateS" (Colwell, 2000) with 100 randomization gave values of 57 and 63 species, respectively, which is considerably higher than the actual number of species found in Okomu. Using the program LOGNORM.BAS (Ludwig & Reynolds, 1988) the total number of observed species was 46 while the theoretical number available for observation is about 66 ( $\alpha=0.20$ ,  $S_o=7.50$ , and the lowest chi-square 16.74) and that there are probably 20 species unobserved in the community.

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