Land Snail Community Structure and Diversity in Unprotected and Protected Forest Areas of Ekiti State, Nigeria

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Abstract

The community structure and diversity of land snail fauna in Ekiti State was investigated in two protected and one unprotected tropical rainforest ecosystems. Twelve (12) plots measuring 20m x 20m each were surveyed in each forest area, using direct search and leaf-litter filtering techniques. A total of 1095 specimens representing 43 species in 9 molluscan families were collected. Each forest area yielded between 190 and 584 individuals. Alpha diversity ranged from 27 to 32 species, with species richness highest in Ogbesse Forest Reserve and least in the unprotected forest area at Ipole Iloro. The herbivorous Subulinidae and carnivorous Streptaxidae were the most represented families as regards species richness, with family Subulinidae (45.20%) being the most abundant numerically. The most abundant species was *Thapsia oscitan* of the family Urocyclidae, contributing almost 15% of the total number of individuals. Six (6) species occurred as singleton while 4 species occurred as doubleton. There was considerable variation in species richness between the three sampled forest areas, Cluster analysis formed two groups, Analysis of similarity (ANOSIM) between clusters using the Bray-Curtis similarity index gave values of R=1, P=0.34, indicating that the study areas were well separated. The high diversity and abundance recorded from this study reveal the study area is rich in land snails, thus, efforts should be made to maintain the ecological integrity of the protected areas as well as improve biodiversity conservation and management in the unprotected areas.

Keywords: Land snails, conservation, forest reserves, Ekiti, Nigeria

Introduction

Tropical rainforests are important for the quantity and diversity of life they support. They cover 7% of the earth's land area and contain about 50 percent of terrestrial species (FAO, 1999). The influences of forests and biodiversity are global, reaching far beyond national borders, in both space and time. They are also known to be diverse in terms of land mollusc diversity and the majority of them are found in the leaf litters and the soil (Emberton, 1996). The greater part of this terrestrial gastropod biodiversity, however, goes unnoticed by people because they are mostly small creatures, seeking out a living as detritivores and carnivores and contributing significantly to nutrient cycling through the facilitation of decomposition and return of plant litter to the soil.

At the moment, forest reserves in Nigeria are exposed to uncontrolled exploitation of timber and wildlife poaching, land conversion to farming, bushfire, grazing, and exploitation of non-timber products together with direct and indirect impacts from extractive industries (Oke and Olisa-Emodoh, 1998; Oke, 2013). The effects of disturbance in the forest are manifested easily at the forest floor and the species community therein. The preservation of biodiversity in tropical rainforest requires high-quality data and efficient methods for prioritizing species and sites for conservation. Most often, land snails are not considered in the establishment and selection of reserves and the checklist or systematics of the invertebrate species present are not accounted for (Ponder, 1997; Oke, 2013). There is an on-going loss of land snail biodiversity without any abatement in preserve or reserve set out to give some level of protection for species in the locality.

The importance of timber resources as major forest products in Ekiti State cannot be overemphasized. They serve as a major source of income to individuals as well as government. Recently there has been a gross increase in the demand for timber and raw product in the state (Falaye et al., 2006). Several molluscan surveys have been conducted in the Southwest region of Nigeria but none has been conducted in Ekiti State, with ten forest reserves. This paper presents the first malacological survey in Ekiti State, thus baseline data to subsequent malacological studies in the area.

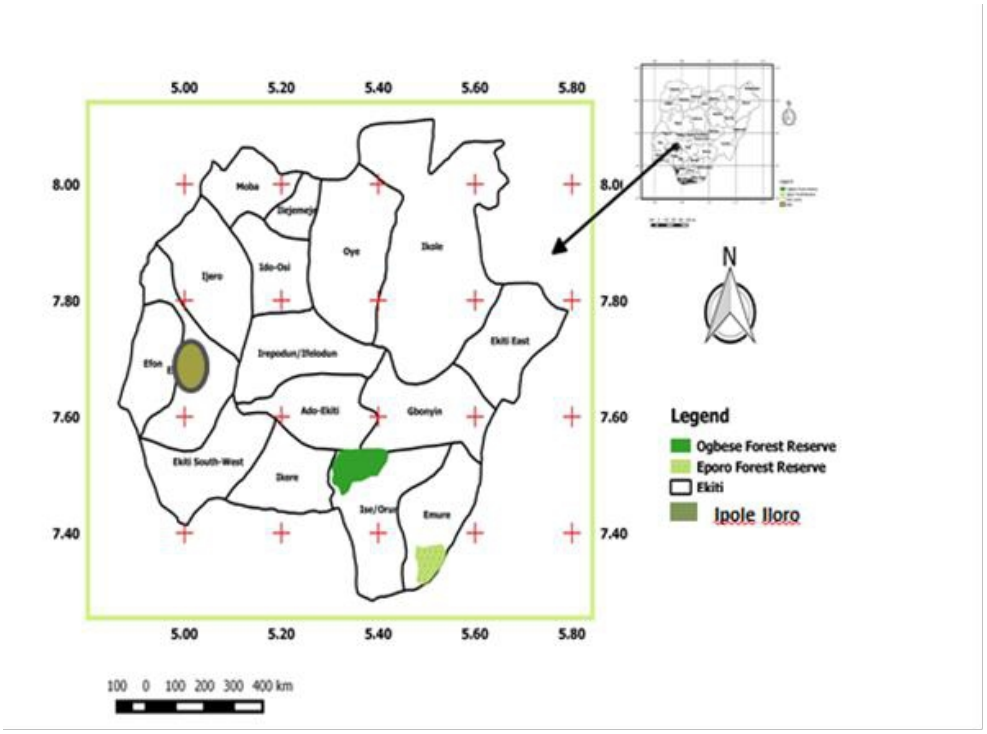
Materials and Methods

Study Area

Ekiti State is located in Southwest of Nigeria and lies between 7°49'N and 5°27'E. The State is mainly an upland zone, rising over 250m above sea level. The vegetation consisting of lowland rainforest in the south and savannah vegetation in the north, with about 297.2km^2 of the state vegetation under reservation as government reserve area, while the unreserved areas known as free areas measure about 3969km^2 (Falaye et al., 2006). The three

sampled sites Ogbesse Forest Reserve, Eporo Forest Reserve, and Ipole Iloro forest area are represented in Figure 1.

The Ogbesse Forest Reserve is about 73km^2, close to Ado-Ekiti the Ekiti State capital and lies on Latitude 7°31'N and Longitude.5°27'E. The area lies entirely within the pre-Cambrian Basement Complex rock group which underlies much of Nigeria. The elevation reaches 350 m above the sea level and is situated entirely within the upper Ogbese basin. The area experiences a tropical climate with distinct wet and dry seasons. The rainy season lasts for 9 months annually between March and November while the dry season lasts for 3 months between December and February. The reserve has been completely logged and cleared for farms, *Gmelina arborea*, *Tectona grandis* and *Terminalia superba* plantations. Widespread burning and clearing of the land are apparent while illegal logging continues. The reserve's size, its location close to the state capital and the fact that a road runs through it to Ise Town are probably all factors that have contributed to the over-exploitation of its natural resources in a relatively short period of time. Eporo Forest Reserve is about 62km^2 (6°06′N and 5°26′E) and located in Emure Local Government Area of Ekiti State.



(Adopted from Alo et al., 2014)

Fig. 1: Map of Ekiti State, Nigeria showing the location of Ogbese Forest Reserve, Eporo Forest Reserve and Ipole Iloro forest area where samples were collected.

In contrast to Ogbese, Eporo has a rugged topography of old granite rocks but similar in climate and vegetation. Eporo Forest Reserve has been cleared and invaded upon by farmers. However, previous research conducted over a 33 month period, by Ogunjemite et al. (2005), revealed that logging pressure on the forest is intense and increasing. Ipole Iloro forest area is an unprotected ecosystem located in Ipole Ekiti Local Government Area of Ekiti State. It lies on Latitude 7°31′N and longitude 5° 00″E as shown in Fig 1. The site is characterized by highly undulating ridges with granite crop and has an attitude of 250m above sea level. Located within the sampling site is the Arinta water fall. Vegetation in Ipole Ekiti has been so strongly modified during centuries of cultivation, grazing, and burning that there are now few areas of untouched secondary rainforest. Many of the forest trees are commercially useful e.g., Mahoganies, Guarea, African walnut, Iroko, and Obeche.

Sampling Method

We collected land snail from the study areas using a combination of direct search method and litter sieving technique (Tattersfield, 1996). The direct search method involves examining all potential molluscan microhabitats that can be accessed and handpicked, in a while the litter sieving technique involves the collection of litters and topsoil. The litter sieving technique was designed to detect both large-sized taxa that often occur at low density and micro-species that are often cryptic and litter-dwelling (Winter and Gittenberger, 1998).

Twelve plots were sampled from each location and a total of 36 plots were sampled during the course of this study. At each plot (20m x 20m), we searched intensively for land snails, in addition, we randomly collected leaf litters and topsoil in 10 bags within each plot with a total of 120 bags collected per sampled site. The sample bags were taken to the laboratory, with the leaf litters and topsoil passed through sieves of various mesh sizes, and land snails shell were sorted out of the samples. All live specimens were preserved in 70% alcohol. Fieldwork was not undertaken at night because of the difficulties this would have entailed, including adequate access and searching of sites, and safety issues related to the habitat types sampled. Slugs were not considered and the sampling methods would not be suitable to determine slug abundance. All specimens were identified and lodged in the Egborge's Museum in the Department of Animal and Environmental Biology, University of Benin.

Statistical 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 Chao 2 and second-order jackknife richness estimators in the program Estimate S 7.5 (Colwell, 2006). We defined sample intensity as the ratio of individuals to species number, and inventory completeness as the percentage of the observed number of species over the expected number of species as estimated by Chao2 or Jack2 (Coddington et al., 1996; Soberon et al., 2007). Statistical analyses were performed using the PAST software (Hammer et al., 2001). Hierarchical clustering (Bray-Curtis similarity measure) was used to identify natural groupings among the sampled sites according to similarities in their species composition. The non-parametric one-way Analysis of Similarity (ANOSIM; Clarke, 1993) was used to test for statistical differences in species composition between clusters. From ANOSIM, if $R > 0.75$ groups are well separated, if $R > 0.5$ groups are overlapping but clearly different, and if $R > 0.25$ groups are barely separable (Lovell et al., 2010).

Results

A total of 1095 individuals, 43 species in 24 genera and 9 molluscan families were recorded from 36 plots in all the forest areas, and each sampled forest area yield between 27 to 32 species and 190 to 584 individuals (Table 1). The families Subulinidae and Streptaxidae were the most abundant and dominant families in each forest area. They represent between 80% and 90% of the mollusc individuals. The Subulinidae was outstanding in terms of abundance within each forest area and in all the forest combined. They contributed between 31 % and 48% of the fauna in each forest area and over 60% of the entire population.

Table 1: List of land molluscs collected from an unprotected forest area (Ipole Iloro) and two protected forest areas (Ogbese and Eporo Forest Reserves) in Ekiti State.

FAMILY/SPECIES	IPOLE ILORO	OGBESE	EPORO	TOTAL
ACHATINIDAE				
Archachatina achatina	0	0	12	12
Archachatina marginata	4	2	1	7
Archachatina papyracea	0	2	0	2
Lignus sp.	2	4	2	8
Limicolaria flammea	4	1	1	6
AILLYDAE				
Aillya camerunensis	1	2	6	9
CHIROPIDAE				
Trachcycytis sp.	0	0	21	21
EUCONULIDAE				
Afropunctium seminium	0	14	45	59
Kaliella sp.	0	13	0	13
FERRUSSACIIDAE				
Cecilioides sp.	1	8	0	9

Cecilioides sp.2	0	2	0	2
STREPTAXIDAE				
Edentulina liberiana	0	1	0	1
Gonaxis camerunensis	5	0	3	8
Gullela io	2	0	0	2
Gulella monodon	13	18	20	51
Gulella opoboensis	10	40	103	153
Gulella pupa	2	0	0	2
Gulella reesi	0	1	0	1
Gullela sp.	1	0	0	1
Ptychotrema aequatoriale	1	0	0	1
Ptychotrema okei	1	0	0	1
Ptychotrema shagamuense	1	3	0	4
Tomostele musaecola	0	13	30	43
SUBULINIDAE				
Curvella feai	4	27	38	69
Curvella ovata	10	14	20	44
Curvella sp.2	1	16	10	27
Curvella sp.3	0	17	32	49
kempiochoncha sp.	10	12	19	41
Pseudoglessula sp	2	0	0	2
Pseudopeas sp.1	34	10	11	55
Pseudopeas sp.2	0	17	12	29
Pseudopeas sp.3	0	15	6	21
Subulona sp	14	0	23	37
Subulona patalus	1	8	1	10
Subulina striatella	16	4	11	31
Subulina involunta	0	4	0	4
SUCCINIDAE				
Quickia sp.1	0	6	7	13
Quickia sp.2	0	6	4	10
UROCYCLIDAE				
Gymnarion sp	15	0	0	15
Thapsia oscitans	10	29	119	158
Trochozonites talcosus	17	10	19	46
Trochozonites sp.1	8	1	3	12
Trochozonites oblique striae	0	1	5	6
Total Number Of Individuals	**190**	**321**	**584**	**1095**
Total Number Of Species	**27**	**32**	**28**	**43**

Species richness was also dominated by Subulinidae and Streptaxidae in declining order. They contributed 81% of the total number of species in all the area. The most speciose genus was the carnivorous snail (*Gullela*) with 6 species representing 32% of all the genera. The most frequently encountered

species were: *Gulella monodon* (51), *Pseudopeas* sp.1 (55), *Afropunctium seminium* (59), *Curvella feai* (69), *Gulella opoboensis* (153), and *Thapsia oscitans* (158), all with more than 50 numbers of individuals. Fourteen species were common to all forest while 12 species occurred in only one forest area which includes: *Trachycytis* sp., *Cecilioides* sp.2, *Gullela io*, *Edentulina liberiana*, *Kaliella* sp., *Gulella pupa*, *Gulella reesi*, *Gullela* sp., *Ptychotrema aequatoriale*, *Ptychotrema okei*, *Pseudoglessula* sp., and *Gymnarion* sp. The minimum and maximum numbers of species per plot were 4 and 25 (mean = 12.62). Species richness and mean number of species were higher in Ogbese Forest Reserve than in Eporo Forest Reserve and Ipole Iloro. There was also variation in the land snail abundance across all the plots within the forest areas, the number of specimens per plots ranged from 8 to 62 (mean = 30.41). There was a significant difference in land snail abundance between the reserves and the unconserved area (Kruskal-Wallis, H=37.77, P>0.0001).

Inventory completeness showed that specimen collected was between 77% and 96% of the potential species in the forest areas in Ekiti State while the ratio of individuals to species (sample intensity) was between 7.04 and 20.14. Beta diversity as revealed by Whittaker's index stood at 1.63 in Ipole Iloro, 2.67 in Ogbese Forest Reserve and 2.87 in Eporo Forest Reserve. Alpha diversity (Shannon-Weiner) was higher in Ogbese Forest Reserve followed by Eporo Forest Reserve and lastly Ipole Iloro. Expected species using nonparametric species estimators such as Chao2 and Jacknife2 gave the values 35 and 41 for Ipole Iloro, 35 and 36 for Ogbese and 28 and 31 for Eporo respectively.

The rank abundance curve for the Eporo Forest Reserve plots laid above the others reflecting most the rare species and therefore displaying the longest tail followed Ogbese Forest Reserve and Ipole Iloro. The species on the first ranks have the highest abundance (common species) and the tail of the curve consists of species with few individuals (rare species, <10 individuals). Data from 36 plots fitted the geometric or log series species abundance models as shown in Fig 2.

Cluster analysis (Bray-Curtis similarity index) divided the forest areas into two distinct groups at 56% similarity (Fig 3). The two reserves Ogbese Forest Reserve and Eporo Forest Reserve formed one cluster while the unconserved area, Ipole Iloro formed another cluster. Analysis of Similarity (ANOSIM) between the clusters gave values of R=1 and P=0.34 indicating the study areas were well separated in terms of species composition, although not significantly different.

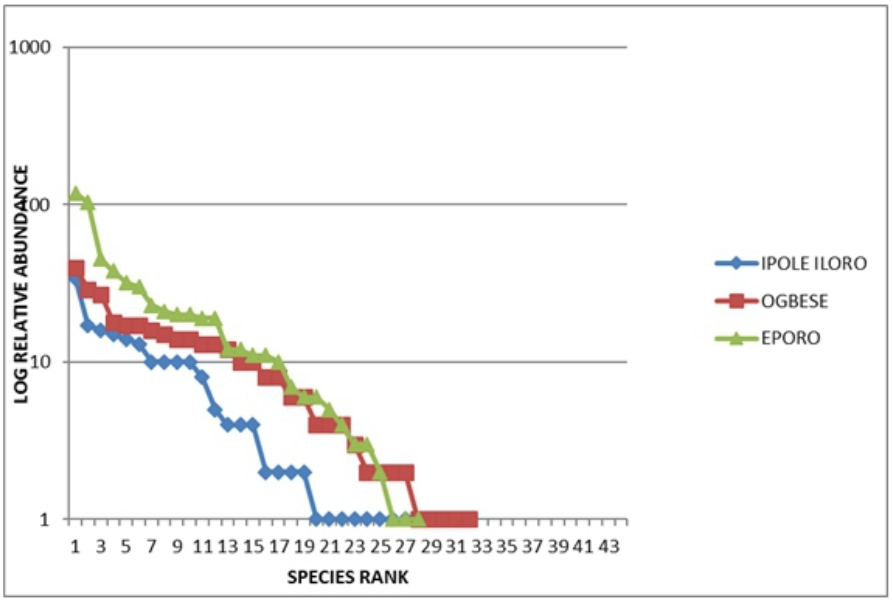


Figure 2: Species rank abundance distribution for land molluscs in Ipole Iloro forest area, Ogbese Forest reserve and Eporo Forest Reserve.

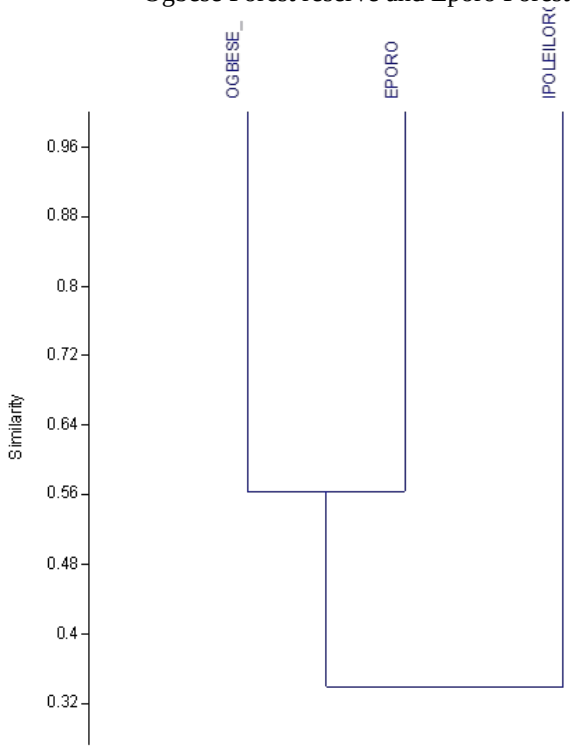


Figure 3: Dendogram of similarities between sampled locations in Ekiti state

Discussion

This study recorded a moderately high land snails abundance and diversity with 1095 individuals, 43 species in 24 genera and 9 molluscan families from 36 plots in the three forest areas. This study concocts to the general notion that land snail biodiversity in the tropical rainforest is relatively diverse. Comparatively with other molluscan surveys in Nigeria, the 43 species recorded in this study is higher than those recorded from cocoa plantation in Usen (Oke and Alohan, 2004), Oil plantation in Egbeta (Oke et al., 2008) and Omo Forest Reserve (Oke, 2013) but lower than that recorded form Okomu National Park(Oke and Alohan, 2006). The dominance of *Thapsia oscitan* has been the most abundant species and occurring in all forest areas suggests that it is has a wide geographical distribution and not threatened. The land snail composition in Ekiti State is the same with other forests in Nigeria and Africa which is not surprising given the presence of common families like the Subulinidae, Streptaxidae, Acharchatinidae, and Urocyclidae in all the sampled forest areas. Although the detritivorous snails (family Subulinidae) dominated in terms of abundance as against those reported from parts of Africa and Nigeria (Emberton, 1996; Emberton et al., 1997; Winter and Gittenberger, 1998, Oke and Alohan 2002, 2004 and Tatterfield et al., 2006). Changes in the species abundance have been ascribed to species response to environmental alteration (Hill et al., 1999, Oke and Chokor, 2011) and different organisms respond differently to environmental changes within the communities (Gomzalez-megias et al., 2008).

Beta diversity (Whittaker index) reflects considerable heterogeneity in molluscan fauna in each sampled forest area. Species richness (Shannon Weiner) was higher in Ogbese Forest Reserve than the other two forest area. The estimated species richness (Chao2 and Jacknife2) as compared to observed species richness showed that about 67% to 74%, 88% to 96% and 88% to 97% of the possible species were collected from Ipole Iloro, Ogbese Forest Reserve, and Eporo Forest Reserve respectively.

Species rank abundance for land snails from the sampled sites shows the presence of some rare species. Five (5) species occurred as a singleton, four (4) species as doubleton while 12 species were unique (occurring in one forest area). Those rare species are often at great risk of local and regional extinction. The forest reserves are closely related in term of species (Bray-Curtis) and the most species-rich habitat in our study was Ogbese Forest Reserve followed by the Eporo Forest Reserve and least in the Ipole Iloro forest area. The cluster analysis of data from the study area form two distinct groups, the protected areas (Ogbese and Eporo Forest Reserve) and the unprotected area (Ipole Iloro).

Conclusion

This study has succeeded in highlighting information on the state of abundance of the identified land snail's species in the three sampled forest areas and it can be stated that the two forest reserves are rich in land snail species. Despite the states of the two forest reserves, the effects of protected area on biodiversity cannot be overemphasized.

Disclosure of interests

The authors declare that they have no competing interests. All applicable Nigerian Forest Reserve Service guidelines for the care and use of protected areas were followed. The authors wish to thank all field guide in the Ogbese Forest Reserve and Eporo Forest Reserve for their support during the field work.

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