LAND SNAIL SPECIES RICHNESS IN A COCOA AGRO-FOREST IN ILE-OLUJI, ONDO STATE, NIGERIA

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Abstract

The need to preserve traditional agro-forestry for bio-diversity conservation in Nigeria has become of utmost importance. The land snail community of an agro-forest in Ile-Oluji, Ondo State, Nigeria, was studied using a combination of direct search and leaf litter sieving techniques. A total of 33 species and 875 individual snails belonging to 10 molluscan families were collected from 9 plots of 400 m^2 each. Sixty-five to 129 individual snails were collected per plot and the species richness varied from 13 to 24. The most abundant snails numerically (74%), were the detrivorous, family Subulidae, while the members of the carnivorous, Streptaxidae, contributed about 60% to species richness. The streptaxid genus *Gulella* was the most speciose while the most abundant species was the *Gulella io,* contributing 13% of the total number of individuals. *Trachycystis* sp. (Charopidae) was recorded for the first time in Nigeria. The land snail species composition in Ile-Oluji agro-forest is similar to that recorded from primary forest reserves and old-growth forests in Nigeria. The land snail species inventory will increase our knowledge of the molluscan fauna of the forest region and assist in conservation management.

Keywords: molluscs, bio-diversity, Ile-Oluji, agro-forestry, Nigeria.

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Introduction

Conservation of bio-diversity, particularly in the tropics, is an issue of increasing importance, as ongoing large scale habitat destruction poses major threats to the survival of many species (Wilson, 1992; Vitousek *et al* 1997; Van Gemerden *et al* 2005). This ongoing rapid habitat modification in many tropical regions now implies that areas of conservation need to be identified quickly. Therefore, conservation planners are urgently challenged to obtain more information on bio-diversity patterns in tropical forests by the use of taxonomic inventories of many groups of organisms (Myers *et al* 2000; Gaston and Rodrigues, 2003; Hotopp *et al* 2008). The bio-diversity and conservation values of traditional agro-forests in West Africa and many other parts of the world have been recognized by several authors (Rice and Greenberg, 2000; Asare, 2005; Harvey *et al* 2006; Vaughan *et al* 2007; Oke and Chokor, 2010). Cocoa (*Theobroma cacao*) agro-forests cover extensive areas in tropical Africa and provide a livelihood for small-scale farmers by providing a diversity of products including cacao beans, timber, fruits, medicinal products, and carbon credits (Ruf and Schroth, 2004; Asare, 2005, 2006). Cocoa agro-forestry is viewed as a sustainable land-use practice that complements the conservation of bio-diversity and meeting other ecological, biological and economic objectives (Rice and Greenberg, 2000). Cocoa agro-forests create forest-like habitats, which habour tropical bio-diversity in rapidly degrading landscapes, while providing an economic crop for small-holder farmers, and serving as faunal refugia for birds, ants and other wildlife species (Rice and Greenberg, 2000).

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Molluscs are good indicators of the health of their environment as they are very prone to habitat degradation and because they have low mobility and short range endemism, they are closely associated to the soil properties and disturbance history of their environment (Strayer *et al* 1986; Winter and Gittenberger, 1998; Fontaine *et al* 2007). They have the highest number of recorded extinctions known in modern times (Lydeard *et al* 2004) and many more species are threatened. Molluscs are easy to sample and their calcareous shell remain relatively intact for some time before they disintegrate and a knowledge of their abundance and diversity will assist in managing biological resources in the region.

Ondo State is one of the leading cocoa-producing states in Nigeria (Asare, 2005, 2006; Oke and Odebeyi, 2007) and very little is known of the land mollusc diversity in the state. The only available published work on land molluscs in Ondo State was by Oke and Chokor (2010) in Idanre Hills. Other studies from the region include those carried out in Ekpoma, Erin Ijesha, and Okomu National Park (Oke and Alohan, 2006; Oke, 2007; Oke *et al* 2007).

The objective of this research is to study the land snail abundance and species richness in a cocoa agro-forest in Ile-Oluji, Ondo State, Nigeria, and compare the results obtained with those from other ecosystems in Nigeria and elsewhere.

Materials and methods

Study area

Ile-Oluji cocoa agro-forest lies within Latitudes 7° 22'-7° 24' N and Longitudes 4° 47'-4° 50' E. in Ondo State, Nigeria (Figure 1). The cocoa farms are within the valleys of highlands of crystalline or Quartzite rocks of the Basement Complex, being pophyritic granites and gneisses of either Jurassic or Miocene origin (Reyment, 1965). The original rainforest has been cleared but for some trees of economic importance that provide shade for the cocoa agro-forest, such as *Cola nitida, Citrus sinensis, C. reticula, Milicia excelsa, Irvingia gabonensis, Terminalia superba, Khaya ivorensis*, and *Garcinia kola* (Asare, 2005). The climate is tropical with two distinct seasons – the rainy (March-October) and dry (February-October).

Sampling

Sampling was carried out in one of the cocoa agro-forest in Ile-Oluji, Ondo State, Nigeria. Nine plots of 20m x 20m each were randomly selected within a patch of the cocoa farm. Each plot was marked with pegs and delineated with a rope. At each plot we intensely searched for snails and slugs during two person-hours (i.e. two searchers active for one hour). In addition, we collected an average of 50 litres of litter and top soil sample from ten randomly selected sites (1m x 1m each) within each plot. Litter samples and top soil were sieved with a 0.75 mm mesh width in the field and collected into polythene bags for transportation to the laboratory. The samples were dried in the laboratory and exhaustively searched for land molluscs. All snails, slugs and shell fragments encountered, as well as those collected alive in the field, were preserved in 70% ethanol after drowning. To avoid over-estimation of species richness, juvenile shells and broken shells were excluded from the analysis, so that over-estimation of species richness is not likely. Snails were identified mainly based on conchological characters by the first author (COO) with reference to voucher materials previously identified by specialist in different parts of the world (British Museum, London; Museum of Natural History, Leiden; and Natal Museum, South Africa).

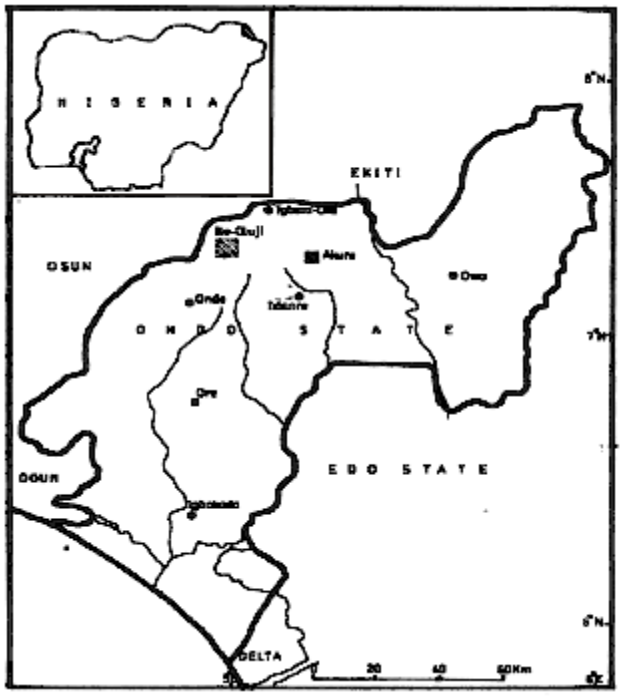

Figure 1: Study area showing where samples were collected.

The measure 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 (á), providing a measure of diversity difference among sites (Magurran, 1988; Schilthuizen and Rutjes, 2001). 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. Estimation of true diversity was carried out by performing 100 randomisations on the data from the 9 plots, and calculating *S* using the Chao 2 and second-order jackknife richness estimators in the program Estimate S7.5 (Colwell, 2006). We used individual-based and sample-based rarefaction curves to produce a smooth curve that estimates the number of species that would be observed for any smaller number of individuals or samples, under the assumption of random mixing of individuals or random sample order (Gotelli and Colwell, 2001). Difference among sites from similar studies in south-west Nigeria (Oke *et al* 2008, Oke and Chokor, 2010) was compared by using species rarefaction curves (Colwell and Coddington, 1994; Gotelli and Colwell, 2001). We define sample intensity as the ratio of individuals to species and inventory completeness as a ratio of the species observed to the estimated number of species obtained using the Chao 2 non-parametric estimator (Colwell and Coddington, 1994; Gotelli and Colwell 2001).

Statistical analyses were carried out with the *PAST* Software Package (Version 2.15, Hammer *et al* 2001). Hierarchical clustering (Bray-Curtis similarity measure) was used to identify natural groupings among the sampled points according to similarities in their species composition. Cluster analysis is the arrangement of samples into groups (cluster), so that samples within the same cluster are more similar to each other than to samples from different clusters (Gauch and Whittaker, 1981). The non-parametric one-way Analysis of Similarity (ANOSIM, Clarke, 1993) was used to test for significant differences 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

Results

Table 1 lists the species and abundances of land molluscs recorded from the study-area. A total of 875 individual snails belonging to 33 taxa in 22 genera and 11 families of land molluscs were collected from 9 plots in Ile-Oluji. Each plot yielded between 65 and 129 individuals (97.22±24.55) and between 13 and 26 species (18.78 ± 3.99). Species richness and abundance was dominated by 3 families: Streptaxidae, represented by 12 (36%) species and 312 (36%) individuals, followed by the Subulinidae with 7 (21%) species and 339 (39%) individuals, and Urocyclidae with 4 (12%) species and 113 (13%) individuals.

Figure 2 shows the rank-abundance plot for land molluscs from Ile-Oluji. The long tail of the rank abundance plot is clearly evident indicating the dominance of a few species and many rare species. The five most abundant species contributing over 50% of the total number of individuals in order of dominance were: *Striosubulina striatella* (14.63%), *Gulella io (13%), Pseudopeas* sp.1 (11.3%), *Thapsia oscitans* (8.9%) and *G. opoboensis* (6%). These species were also widespread occurring in almost all the plots. Fifteen species (45.46%) occurred with less than 10 individuals, of which two species (*Archachatina marginata* and *Gulella reesi)* occurred as singletons and five species (*Limicolaria flammea, Afropunctum seminium, Kempioconcha* sp*., Pseudoveronicella liberiana* and *Trochozonites* sp.) as doubletons.

Other widespread species with intermediate abundances include *Aillya camerunensis, Rachistia* sp*., Cecilioides* sp*., Gonaxis camerunensis, Gulella monodon, G. pupa, Ptychotrema okei, P. shagamuense, Tomostele musaecola, Curvella* sp*., Pseudopeas* sp., and *Trochozonites talcosus*. With regards to the distribution of land molluscs, that is, the number of stations at which a species occurred, rarity was not a major feature of the fauna in that many species had wide ranges: 4 species (12%) were found in one plot, 8 species (24%) in two plots and 17 species (52%) in almost all the plots. The helicoid micro-snail, *Trachycystis* sp. (Charopidae), to the best of our knowledge,was recorded for the first time in Nigeria. Plates 1-32 show some of the species collected in the cocoa agro-forest.

The sample-based species accumulation curves for land molluscs in Ile-Oluji was far from reaching an asymptote when sampling stopped. Also the curve lay higher than those reported for land molluscs from Idanre Hills, Gelegele Forest and Egbeta Oil Palm Plantation (Figure 3). Estimate of true species richness using the non-parametric Chao 2 and Jackknife 2 gave values of 33.59 and 34.22 respectively. Inventory completeness was 98% and 96% using the Chao 2 and Jack 2 estimators respectively. Whittaker's index amounted to 1.76 indicating a moderate level of faunal hetero-geneity amongst the plots.

The dendrogram of similarity divided the plots into two distinct groups at 60% similarity (Figure 4). Plot 1-7 formed one cluster, and Plots 8-9 formed the second group. Analysis of Similarity (ANOSIM), using Bray-Curtis similarity index, revealed a significant difference in species composition between the Plots 1-7 and Plots 8-9 clusters (R=0.9026, p=0.029). Similarity Percentage (SIMPER) analysis revealed that the taxa primarily responsible for the observed difference between the

Table 1: List of land-snails recorded in Ile-Oluji, with number of specimens collected. Families and species within family are ordered alphabetically.

	Land mollusc species Plots	1	2	3	4	5	6	7	8	9	Total
	Achatinidae										
1	*Archachatina marginata* (Swainson, 1821)								1		1
2	*Archachatina papyracea* (Pfeiffer, 1845)								3		3
3	*Limicolaria flammea* (Müller, 1774)								2		2
	Aillyidae										
4	*Aillya camerunensis* (Odhner, 1927)	2	1			2	2	2		5	14
	Cerastidae										
5	*Rachistia* sp.	2			1		5	2		4	14
	Charopidae										
6	*Trachycystis* sp.	1	1	2	7	1	3	5		7	27
	Euconulidae										
7	*Afropunctum seminium* (Morelet, 1873)						1		1		2
	Ferussaciidae										
8	*Cecilioides* sp.	4	6	4	6	4	8	6	3		41
	Streptaxidae										
9	*Edentulina* sp.								5	1	6
10	*Gonaxis camerunensis* (d'Ailly, 1896)	3	4	4	1	4	2	2	8	8	36
11	*Gullela io* (Verdcourt, 1974)	12	17	7	14	13	25	17	1	8	114
12	*Gullela monodon* (Morelet, 1873)	8	1	4	2	5	8	4	2	8	42
13	*Gullela opoboensis* (Preston, 1914)	4	3	6	6	4	5	11	4	8	51
14	*Gulella pupa* (Thiele, 1911)	2	2		6	1	1			5	17
15	*Gullela reesi*(Preston, 1914)					1					1
16	*Gulella gemma* (d'Ailly, 1896)								2	1	3
17	*Ptychrotrema okei* (Winter, 1996)	1		1				1	2	4	9
18	*Pty. shagamuense* (Oke & Odiete, 1996)		1			1			5	3	10
19	*Streptostele* sp.		3			1					4
20	*Tomostele musaecola* (Morelet, 1860)	2	1		5		3	1	1	6	19
	Subulinidae										
21	*Curvella* sp.	5		6	6	4	2	8	7	7	45
22	*Kempioconcha* sp.								1	1	2
23	*Pseudopeas* sp.1	14	5	10	14	9	11	14	14	8	99
24	*Psedopeas* sp.2	1			1	1	2	2	7	6	20
25	*Pseudopeas* sp.3				2					1	3
26	*Striosubulina striatella* (Rang, 1860)	5	5	19	17	7	31	17	17	10	128
27	*Subulona* sp.	1	3	4	6	3	3		15	7	42
	Succineidae										
28	*Quickia* sp.	1							2	2	5
	Urocyclidae										
29	*Thapsia oscitans* (Connolly, 1925)	7	10	7	8	11	11	13	3	8	78
30	*Trochozonites talcosus* (Gould, 1850)		1	1	4	2	1	2	10	7	28
31	*Trochozonites* sp.1						1			1	2
	Trochozonites adansoniae (Morelet, 1848)		1			2				2	5
32	Veronicellidae										
33	*Pseudoveronicella liberiana* (Gould, 1850)								1	1	2
	Total no. of individuals	75	65	75	106	76	125	107	117	129	875
	No. of species per plot	18	17	13	17	19	19	16	24	26	33

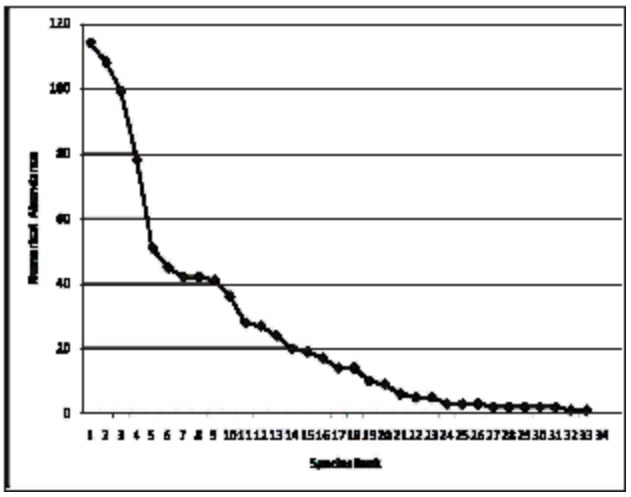

Figure 2: Rank abundance plot for land snails in Ile-Oluji, Ondo State, Nigeria.

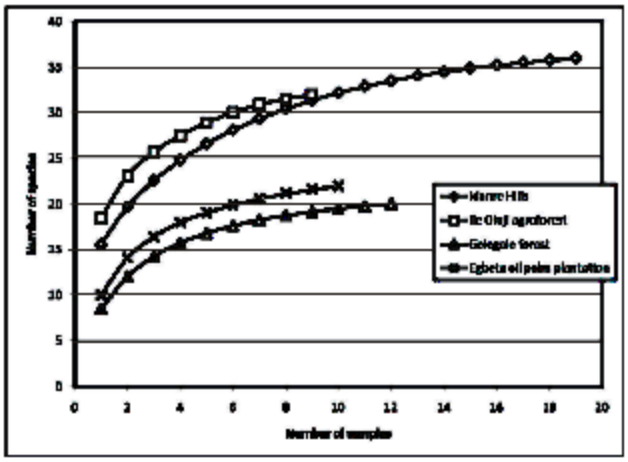

Figure 3: Sample-based species accumulation curves for land molluscs in Ile-Oluji cocoa agro-forest, Idanre Hills, (Ondo State), Gelegele Forest, Egbeta Oil Palm Plantation (Edo State), Nigeria. Plotted values are means based on 100 randomisation of sample accumulation order (without replacement). See Oke *et al*. (2008) and Oke andChokor (2010) for data on other sites compared.

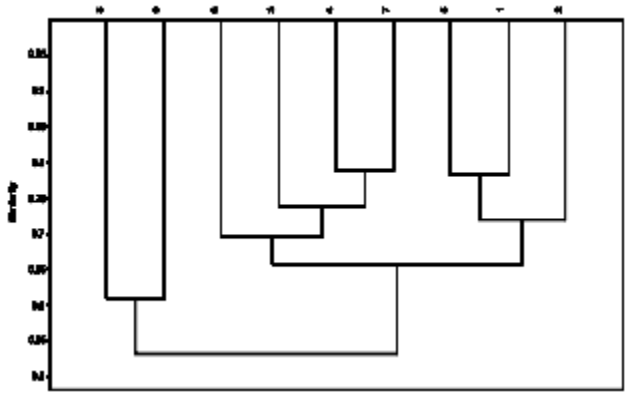

Figure 4: Dendrogram of similarity by plots using Bray-Curtis similarity index.

groups include *Gulella io* (10.58%), *Subulona* sp. (8.38%), *Striosubulina striatella* (7.63%) and *Trochozonites talcosus* (7.12%) amongst others.

Discussion

The total number of species supported by a habitat is one of the most fundamental ecological characteristics of any system. This study describes the land mollusc species richness observed in the cocoa agro-forest in Ondo State, Nigeria. A total of 33 species and 875 individuals in 11 molluscan families were collected. This represents a considerable amount of molluscan diversity for the region given the small sample size. Although, estimates of true species richness based on Chao 2 and Jackknife 2 (Colwell 2006) gave values of 33.59 and 34.22 respectively, the species accumulation curve was very far from reaching an asymptote when sampling stopped. Therefore, it is not impossible that a few more species might be recorded from the area if sampling intensity is increased even though the calculation of inventory completeness (98%) showed that the methods used were adequate. Also, the considerable heterogeneity between some of the plots, as shown by the analysis of similarity (ANOSIM) and Whittaker's index, demonstrates that cocoa agro-forestry has great capacity of providing several microhabitats for diverse populations of molluscan species to thrive.

Most of the species recorded in this study had wide geographic range and had been recorded elsewhere within the region (Oke and Alohan, 2006; Oke and Chokor, 2010). However, there are a few narrow range endemics that, malacologically, may be of conservation interest. The collection contains an unidentifiable helicoid, charopid micro-snail here referred to as the genus *Trachycystis* sp. (Charopidae). The shell is small and measures 1.29 x 2.32 mm, and has 7 whorls. There are no comparable nominal taxa in West Africa. A search through the literature on land molluscs from West Africa and DR Congo has not led to any result. It is not unlikely that this shell represents an as yet unknown taxon endemic to the region.

Comparatively, the number of species recorded in the cocoa agro-frorest in Ile-Oluji was similar to that obtained at Idanre Hills (36 species) but higher than those recorded from an oil palm plantation and secondary forests within the region (Oke and Ugiagbe 2007; Oke *et al* 2008; Oke and Chokor, 2010). Both individual and sample-based species accumulation curves for Ile-Oluji were higher than those obtained for Idanre Hills, Gelegele Forest and the oil palm plantation in Egbeta (see Figure 3; data for comparison

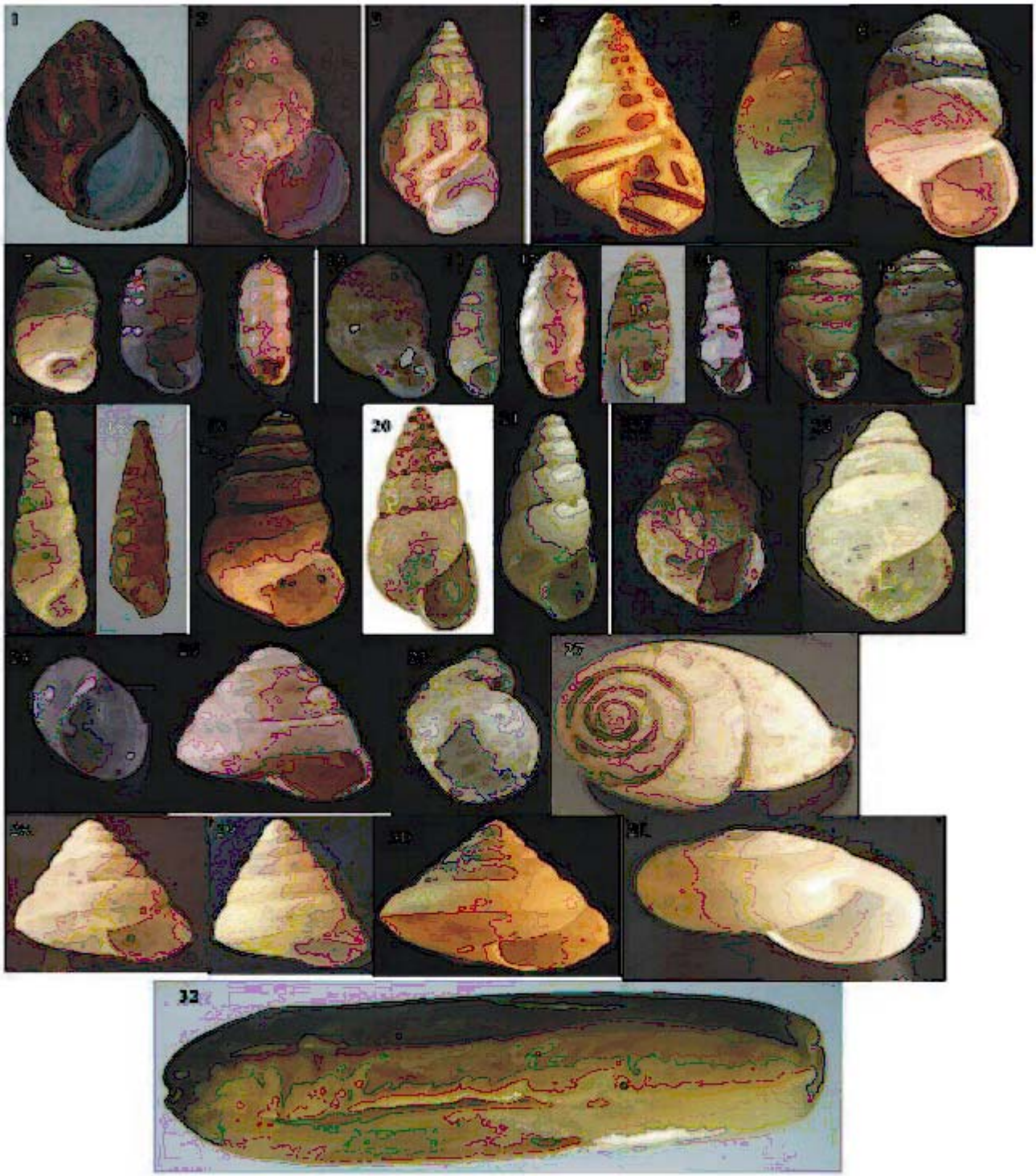

Plate 1-32. Some of the species of land molluscs collected from Ile-Oluji agro-forest, shell height in bracket. **1.** *Archachatina marginata* (155 mm), **2.** *Archachatina papyracea* (60 mm), **3.** *Limicolaria flammea* (51 mm), **4.** *Rachistia* sp. (15 mm) **5.** *Cecilioides* sp. (4.3 mm) 6. *Edentulina* sp. **7.** *Gulella monodon* (7.8 mm), **8.** *Gulella gemma* (4 mm), **9.** *Gulella io* (3.5 mm) **10.** *Gulella opoboensis* (4.7 mm), **11.** *Stretostele* sp. **12.** *Ptychotrema okei* (10.9 mm), **13.** *Ptychotrema shaganuense* (17 mm), **14.** *Tomostele museacola* (4 mm), **15.** *Gulella reesi* (5mm), **16.** *Gulella pupa* (4 mm) **17.** *Striosubulina striatella* (15.5 mm), **18.** *Subulona* sp.1 (23 mm), **19.** *Kempioconcha* sp. (12 mm), **20.** *Pseudopeas* sp1. (11.3 mm), **21.** *Pseudopeas* sp.2 (8 mm), **22.** *Pseudopeas* sp.3 (4 mm) **23.** *Curvella* sp. (3.51 mm), **24.** *Aillya camerunensis* (4.5 mm), **25.** *Afropunctium seminium* (3.5 mm) **26.** *Quickia* sp. (4 mm), **27.** *Gonaxis camerunensis* (18 mm), **28.** *Trochozonites adansonae* (5.5 mm), **29.** *Trochozonites talcosus* (7.7 mm), **30.** *Trochozonites* sp. (6.1 mm), **31.** *Thapsia* sp. **32.** *Pseudoveronicella liberiana* (50 mm, total length).

obtained from Oke and Ugiagbe 2007; Oke *et al* 2008; Oke and Chokor, 2010). The species richness in Ile-Oluji was lower than that recorded from an old-growth forest reserve in Okomu (Nigeria), Gabon and Cameroon where 46, 71and 97 species were recorded respectively (Winter and Gittenberger, 1998; Oke and Alohan, 2006; Fontaine *et al* 2007). However, the mean number of species per site, sympatric diversity (*sensu* Solem, 1984), was higher in Ile-Oluji (18.78 species) than in other previously studied sites in south-western Nigeria (Oke and Alohan, 2006; Oke and Ugiagbe 2007, Oke *et al* 2008; Oke and Chokor, 2010).

The species composition of the molluscan fauna in Ile-Oluji is similar to that reported for primary forest reserves and old-growth forests in southern Nigeria and Gabon (Oke and Alohan, 2006; Oke 2007; Fontaine *et al* 2007) and suggests that traditional cocoa agro-forest provides similar niches to these habitats with respect of molluscan diversity. The carnivorous streptaxids were the most speciose molluscan family in the Ile-Oluji, followed by the detritivorous subulinids and urocyclids. The dominance of the streptaxids is a common feature in Afro-tropical land mollusc community structure as documented by several authors (Tattersfield *et al* 2001; Seddon, *et al* 2005; Oke and Chokor 2010). In conclusion, the land mollusc community structure, high species richness and abundance in Ile-Oluji cocoa agro-forest is comparable to that in old-growth forests in southern Nigeria and stresses the need to preserve traditional agro-forestry for bio-diversity conservation.

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