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Species richness and diversity of terrestrial molluscs (Mollusca, Gastropoda) in Yapo classified forest, Côte d'Ivoire

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Abstract

The land snail species richness and diversity in Yapo classified forest, Côte d'Ivoire, was studied using a combination of direct search and leaf-litter sieving techniques. In total, 27 species and 1045 individuals in 8 molluscan families were collected from 31 plots of 400 m² each. Species richness varied from 2 to 16 (mean 7.87 ± 3.57) and the number of individuals from 3 to 57 (mean 33.71 ± 16.67) per plot. Species richness and numerical abundance was dominated by the herbivorous Subulinidae (33.33% for species, 72.54% for numerical abandance) and carnivorous Streptaxidae (29.63% for species, 15.69% for numerical abandance). The most abundant species was *Curvella* sp 4, contributing almost 20.29 % of the total number of individuals. If there are no measures of protection this small terrestrial molluscs populations will disappear. Studies on the molluscan diversity in Yapo classified forest will assist in producing an inventory of the molluscan fauna for biodiversity conservation management in Côte d'Ivoire.

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Introduction

In forest ecostystem, land snails are preyed upon by a number of organism including insects (beetles), amphibians, reptiles, birds and mammals. Hence, loss of land species as result of deforestation has more far-reaching consequences on other organisms than can be imagined (Oke, 2013). Molluscs are good indicators of the health of their environment as they are very prone to habitat degradation (Oke and Chokor, 2010).

Habitat fragmentation, habitat loss and transformation of tropical rainforest into plantations of fast growing exotics coupled with the introduction of alien species have resulted most of the current wave of global land molluscan extinction (Raheem *et al.*, 2009). Unfortunately, the forest in Côte d'ivoire has been degraded continuously within the past three decades. The original forest in 1970 was 16.5 million ha., 4 million ha. in 2000 and only 2 million ha. in 2015. That is to say, less than 13% of the country as against 78% in 1960 (Achard *et al.,* 2002 ; MINEF, 2015). In this regard, pretected forests help to conserve biodiversity of land snail. It is therefore very important to know land snails in order to take a mesures of conservation.

Diversity of land molluscs in Côte d'Ivoire has been poorly studied (Daget, 2003 ; Memel *et al.*, 2008). In this article, we studied the species richness and diversity of land snails collected from the classified forest of Yapo and discuss their implication to conservation.

Material and methods

Study area

Yapo classified forest is located in the Departement of Agboville, in Azaguié's sub-prefecture south of Côte d'Ivoire (5" 40'- 5" 47' N, 4° 06'-4° 11' E ; e.g. Fig. 1). The forest covers about 9000 ha and it is to 25 km in the South of Agboville, 8 km to the North of Azagué and to 50 km in the North-East of Abidjan. The relief is less undulating with many low slopes of less than 5%.

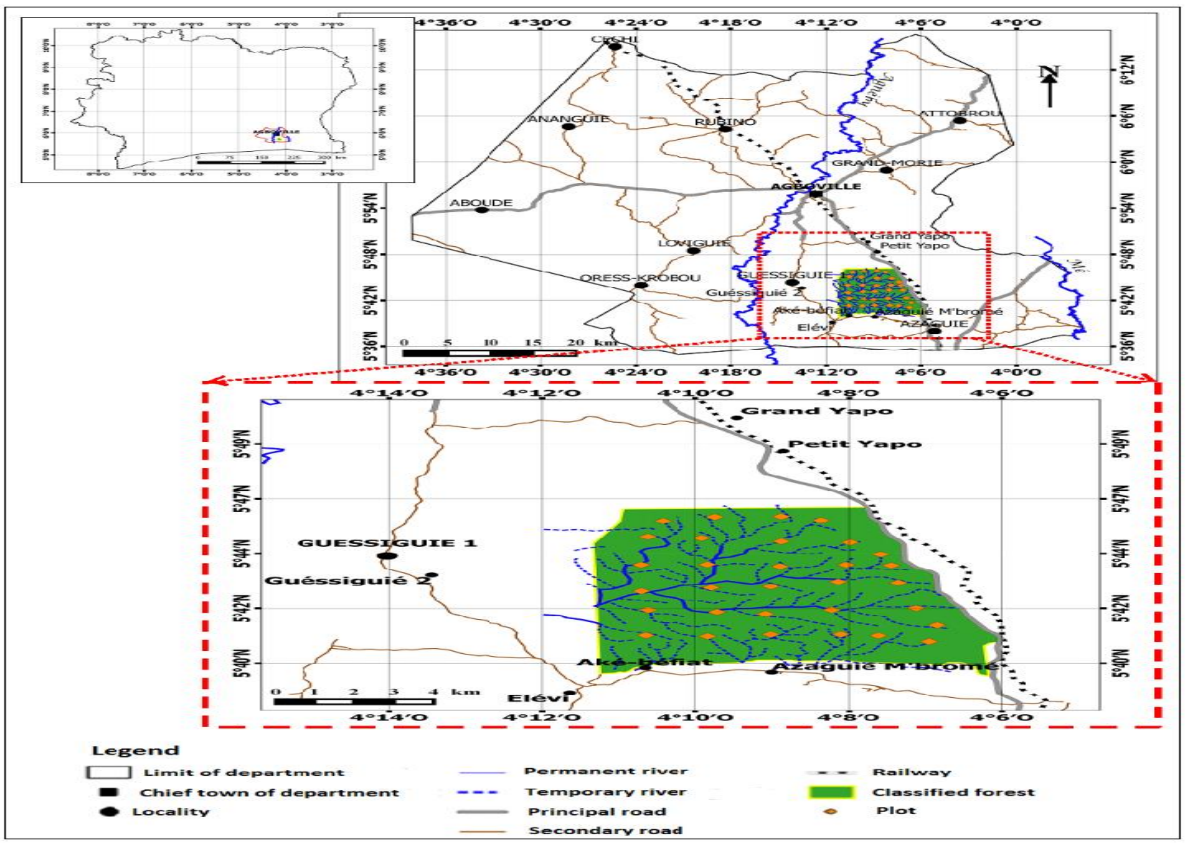

Fig. 1. The location of Yapo classified forest and Sampling site in Côte d'Ivoire.

The average altitude oscillate around 70 m above sea level. Except the hydromorphic soils localised in the dregs, the present soils belong to ferralitic soils characterized by an acid pH 4.5 from 5. At West of the forest there is Agnéby river.

The remainder of the hydrographic network is composed of temporary river. The climate is subequatorial, with four distinct season: great rainy season (March-June), little dry season (July-August), little rainy season (September-November) and great dry season (December-February) (SODEXAM, 2014). The annual average rainfall in the area of Azaguié varies to 1500 mm from 2100 mm, with an annual mean temperature of 27°C (Vroh*et al.*, 2010). The forest is located in a climax of dense forest wet sempervirens characteristic of the ombrophilous sector of guinéen domain.

The vegetation is secondary formation. It is characterized by layers of large trees (*Terminalia ivorensis*, *Khaya ivorensis*, *Dacryodes klaineana*)shrubs (*Garcinia afzelii*, *Coffea afzelii*, *Macaranga beilei*, *Rauwolfia vomitoria*) grass (*Aframomum sceptrum, Halopegia azurea, Nephrolepis biserrata*) and creepers (*Adenia lobata, Cercerstis afzelii, Cnestis ferruginea*) (SODEFOR, 1999 ; Piba, 2016).

Sample collection

Land mollusc samples were collected during little rainy season (September-November 2014) and great rainy season (April-June 2015). Because these period constitutes the period where abundance and species richness of terrestrials molluscs are highest (Oke and Alohan, 2006 ; Oke and Chokor, 2010 ; Patil *et al.*, 2012).

Systematic sampling was retained. This sampling consists in distributing the samples in a more or less regular way. It provides information on all the study area. The place of plots took account of some parameters such as wet places, dense undergrowth, shaded places and accessibility to the site. In total thirty one (31) plots were sampled.

We used a combination of direct search and litter-sieving techniques (Tatterfield, 1996; Oke, 2009; 2013, Wronski *et al.*, 2014). Direct searching involved examination in plot of 20 X 20 m of all potential molluscan microhabitats that could be accessed, such as fallen tree trunk, deep litter bed, rock face, etc.

All the plots were sampled at each season. At each plot, we searched intensively for molluscs for two person-hours (i.e. two searchers active for one hour). we collected an average of 5 L of litter and topsoil from 1 x 1 m sites within each plot. Litter samples and top soil were exhaustively searched in the laboratory for land molluscs. All live slugs and snails, and all empty shells were collected. Live specimens were drowned and preserved in 70% ethanol.

Species identification

The identification was made on the basis of morphological criteria and standard keys (Bequaert, 1950;Abbott, 1989 ; Daget, 2003; Rowson, 2009 ; Oke, 2013).

Data 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). 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.

The true diversity was estimated by performing 500 randomisations on the data and calculating *S* using the Chao 2 and second-order jackknife richness estimators in the program Estimate S 7.5.0 (Colwell 2006).

We used sample-based rarefaction curves to produce a smooth curve that estimates the number of species that would be observed for any smaller number of samples, assuming random mixing of sample order

(Colwell and Coddington 1994; Gotelli and Colwell 2001). We defined sample intensity as the ratio of individuals to species (Oke and Chokor, 2009). Pearson correlation, was used to show the relationship between number of individuals and number of species, using STATISTICA 7.1.

Résults

In total, 1045 individuals belonging to 27 species in 16 genera and 8 families of pulmonate molluscs were collected. Each plot yielded between 3 and 57 individuals (mean 33.71 ± 16.67) and between 2 and 16 species (mean de 7.87 ± 3.57).

Table 1. List of terrestrial molluscs recorded in Yapo classified forest, with number of specimens collected. Families, genera and species South Côte d'Ivoire.

	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	25	26	27	28	29	30	31	Total
Achatinidae																																
Achatina achatina	1	0	0	0	0	1	1	0	0	0	0	3	2	0	1	1	3	2	0	1	2	0	0	0	0	2	1	1	0	0	0	22
Archachatina Ventricosa	0	0	0	0	0	0	0	0	1	0		2	4	0	0	2	2	1	0	0	1	3		0	0	0	0	0	0	0	0	16
Lignus sp	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0	0	6
Limicolaria flammea	1	0	0	1	2	0	0	0	0	4	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	5	0	0	0	0	0	16
Ferussaciidae																																
Cecilioides sp	0	2	3	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	4	5	0	0	0	0	3	2	23
Subulinidae																																
Subulona sp 1	7	0	5	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	8	2	1	0	0	4	0	37
subulona sp 2 (juvénile)	0	1	0	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	11
Striosubulina striatella	5		8	3	0	4	0	0	0	2	0	0	0	2	3		0	1	0	1	0	0	0	5	7	0	2	0	0	2	0	45
Curvella sp 1	8	1	5	2	9	0	2	0	4	0	1	2	6	1	0	15	0	0	0	0	0	0	0	4	1	0	0	0	5	9	12	87
Curvella sp 2	4	16	0	1	15	7	1	0	1	0	4	2	4	12	0	0	0	9	0	0	0	0	0	17	9	3	10		9	7	21	152
Curvella sp 3	8		10	1	2	4	0	9	0	4	23	1	1	3	0	1	1	3	0	3	3	0	0	4	2	0	0	0	3	5	0	91
Curvella sp 4	1	5	2		0	0	14	0	15	32	1	20		24	14	9	27	2	0	0	5	2	0	1	1	0	9	21	0	2	5	212
Pseudopeas sp 1	8		5	2	0	1	0	1	0	1	9	4	1	1	0	6		0	0	0	0	9	0	3	2	0	12	8	0	1	0	74
Pseudopeas sp 2	1	1	0	7	0	0	0	7	1	0	0	0	0	4	0	1	2	0	0	1	12	4	0	1	1	0	0	4	1	0	1	49
Streptaxidae																																
Edentoulina sp	2	0	0	0	0	0	0	0	0	0	3	0	12	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	21
Gonaxis sp 1	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2	1	9
Gonaxis sp 2	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	12
Gonaxis sp 3	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	4		2	0	0	4	7	0	3	0	0	0	0	0	0	0	23
Gullela io	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	9	0	0	0	0	12	10	39
Gullela sp 1	0	0	0	0	0	0	0	0	0	1	4	2	7	0	0	2	7	1	0	0	1	4	0	0	0	0	0	0	0	0	0	29
Gullela sp 2	0	0	0	0	2	0	0	0	0	7	0	0	9	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	23
Gullela cf opoboensis	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	1	0	8

Table 1 (continued)

Taxas	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	25	26	27	28	29	30	31	Total
Urocyclidae																																
Trochozonites talcosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Verucarion sp1	0	0	0	0	0	0	0	0	0	0	2	4	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	11
Verucarion sp 2	0	0	0	0	0	0	0	0	0	0	0	5	0	1	3	0	5	0	0	0	0	1	0	0	0	0	0	0	0	2	0	17
Maizaniidae																																
Spirulozania sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	2	2	0	0	0	0	0	0	7
Veronicellidae																																
Pseudoveronicella sp	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3
Total individuals	47	29	45	19	34	21	18	17	24	51	50	46	50	50	23	44	47	27	3	7	29	38	4	62	50	12	35	34	18	54	57	1045
Total species	12	7	9	8	7	8	4	3	6	7	10	11	12	9	5	10	7	12	2	5	8	10	3	15	12	4	6	4	4	16	8	27

The relation between numerical abundance and the specific richness is illustrated by Fig. 2. There was a positive (r= 0.77) and significant relationship between total number of terrestrial molluscs collected at a site and the number of species recorded at that site ($P < 0.05$).

The species collected from all the sample plots are listed in Table 1. Two families are most species-rich and abundant: Subulinidae, represented by 9 (33.33%) species and 758 (72.54%) individuals and Streptaxidae, 8 (29.63%) species and 164 (15.69%) individuals.

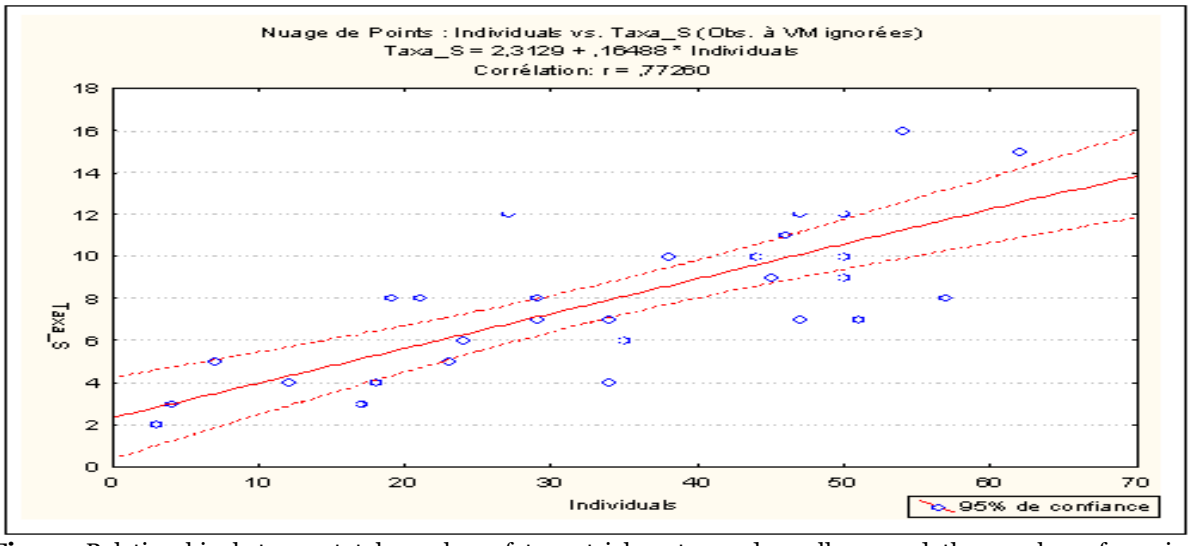

Fig. 2. Relationship between total number of terrestrial gasteropods molluscs and the number of species recorded in Yapo classified forest, South Côte d'Ivoire.

A few species were very abundant, few very rare, while most were intermediate in abundance (Fig. 3). Five species occurred with more than 50 individuals among them two species surpass 150 individuals. Six species occurred with fewer than 10 individuals, with one species represented by two individuals. The most abundant species contributed about 58.96% (616) of the total number of individuals: *Curvella sp* 4 (20.29%), *Curvella sp* 2 (15.55%), *Curvella sp* 3 (8.71%), *Curvella sp* 1 (8.33%) et *Pseudopeas sp* 1 (7.08%). Three families presented each by one specie with a low number of individuals : Ferussaciidae (*Cecilioides* sp, 23 individuals), Maizaniidae (*Spirulozania* sp, 7 individuals) and Veronicellidae (*Pseudoveronicella* sp, 3 individuals). The edible species *Achatina achatina* and *Archachatinaventricosa* account respectively for 2.10% (22 individuals) and 1.53% (16 individuals) of

total number of collected individuals. The rarefaction curve increases up to twenty-ninth sampling before stabilized reaching the asymptote (Fig. 4). The number of species recorded was not different from that obtained by the nonparametric estimators. Estimated species richness based on Chao 2 and Jack 2 gave values of 26.85 and 26.94 species respectively. 'Sample intensity' (ratio of individuals to species) was 38.70:1. Whittaker's index was 2.43, indicating high differentiation among plots.

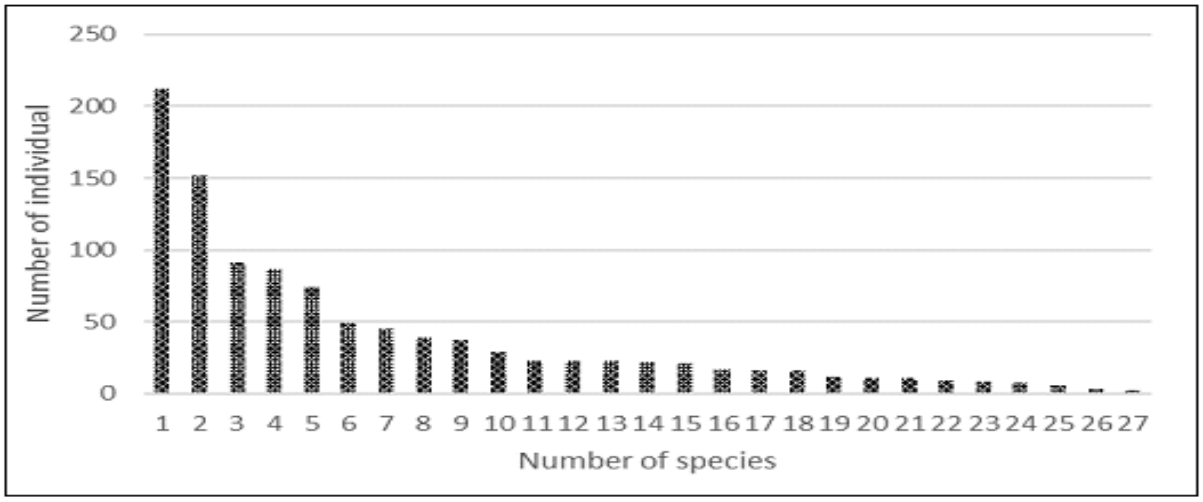

Fig. 3. Rank-abundance curves for land snails from the classified forest of Yapo, South Côte d'Ivoire.

Discussion

This first study on terrestrial molluscs diversity in Yapo classified forest revealed 27 species. This number of species is lower than those recorded by Daget (2003) (45 species) at Mount Nimba (Côte d'ivoire), Fontaine *et al.* (2007) (74 species) in Gabon, Oke and Chokor (2009) (60 species) in Nigeria. It is also lower comparatively than that recorded by Tattersfield *et al.*(2001) (68 species) in Kenya, Oke (2013) (28 species) in Nigeria and Wronski *et al.* (2014) (68 species) in Equatorial Guinea. The low number of species in Yapo could be explained by the low number of sampling plots in our study area (31) and perhaps the low altitude (around of 70 m). In most these previous studies, the number of sampling plots vary between 37 and 120 plots and species richness increases with the altitude. Wronski *et al.* (2014) and Tattersfield *et al.* (2001) showed that species richness was highest between 400 and 600 m altitude. Also, the level of disturbance and the soil acidity in Yapo (pH 4.5-5) could also have contributed to the low number of species and individuals recorded (SODEFOR, 1999). Tattersfield *et al.* (2001) and Chokor and Oke (2011) observed that species richness was low in the acid sites. Nevertheless, the land mollusc species richness in Yapo is similar to that recorded in Omo Forest Reserve (28 species). This species richness recorded here is higher than those reported by Dayasiri *et al.* (2014) (2 terrestrial species) in South of Sri Lanka and Memel *et al.* (2009) (8 species) in the Parc National du Banco.

The species richness correlates positively (0.77) and significantly ($P < 0.05$) with the number of individuals. Similar result was reported by Oke and Chokor (2009) in Nigeria. Species richness and numerical abundance were dominated by the family Subulinidae (herbivorous) and Streptaxidae (carnivorous). These results are in agreement with those of Tattersfield *et al.* (2001), Oke and Chokor (2009), and Wronski *et al.* (2014). According to Winter and Gittenberger (1998), Streptaxidae occupy a good part of the malacofauna of Afrotropical region and represent between 18% and 46% of the species recorded (Tattersfield, 1996 ; Emberton *et al.*, 1997). Three families (Ferussaciidae, Maizaniidae and Veronicellidae) were represented by one species each and with low numbers of individuals.

The low abundance of the edible snails *Achatina achatina* (22 individuals, 2.10%) and *Archachatina ventricosa* (16 individuals,1.53%) could be the consequence of intense poaching by the local human populations which regard these species as delicacy. The poaching of edible snail is related to the large scale commercialisation of snail 'meat'. An estimated 1700 tons of *Achatinaachatina* and *Archachatina ventricosa* is removed annually from the forest and this has contributed to the reduced natural stock (Kouassi *et al.*, 2008). These low numbers make this forest an important site for the conservation.

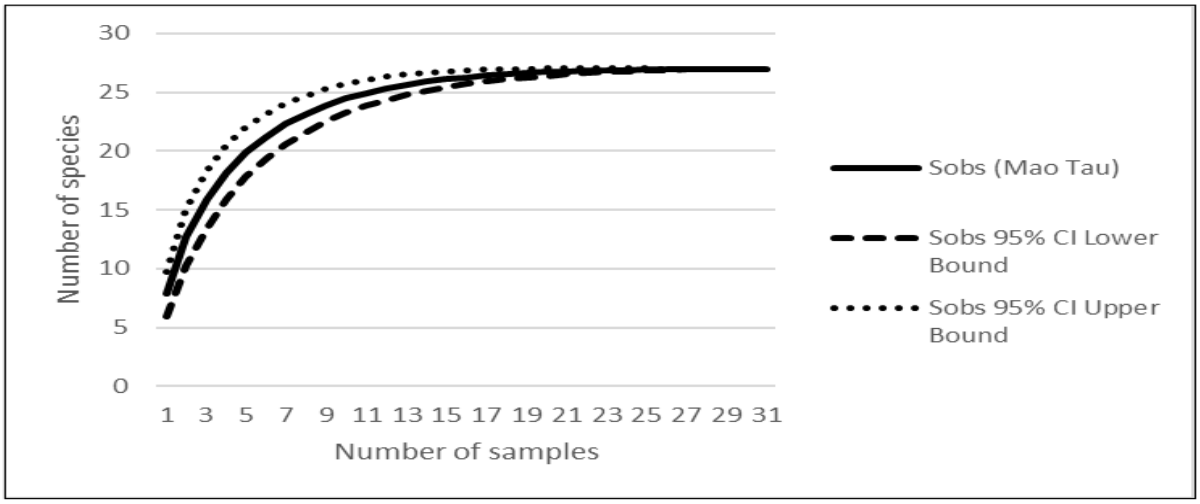

Fig. 4. Sample-based species accumulation curves for land molluscs in classified forest of Yapo, South Côte d'Ivoire. Plotted values are means based on 500 randomization of sample accumulation order (without replacement).

There are few abundant species, few rare species and a high number of intermediate species. These results are the sign that special attention must be put to this forest because the destruction of a small space could lead to the extinction of many species.

The sample-based species accumulation curve for land snails in Yapo classified forest reached the asymptote, which wants to say that sampling was maximum. Whitteker's index obtained (2.43) is low compared to those recorded by Oke and Chokor (2009, 2010) in cocoa plantations (3.1 and 2.72) and in Idanre hills (3.03), Nigeria. However, this value indicates that there is considerable heterogeneity between plots.

Giving the fact that the Ivorian rainforest is under enourmous anthropogenic pressure such as bush fire, commercial logging and deforestation for plantation agriculture, the high number of species in this pioneering study and high heterogeneity observed between the plots are amongst some of factors in favour of protection of this forest.

This is corroborated by the fact that the forest cover declined from 16.5 million ha in 1970 to about 4 million in 2000 and only 2 million ha in 2015 (Achard *et al.*,2002 ; MINEF, 2015). The government, populations, nongovernmental organizations (NGO) and the scientists must federate their efforts in order to preserve and avoid possible loss of species.

Conclusion

This first study on terrestrial diversity of the gastropod molluscs in the classified forest of Yapo showed that this forest has rich malacofauna and appropriate measures to protect it in order to conserve the unique biodiversity.

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Références

Abbott RT. 1989. Compendium of land shells. *American Malacologists*, Melbourne, 240 p.

Achard F, Eva HD, Stibig HJ, Mayaux P, Gallego J, Richards T, Malingreau JP. 2002. Determination of deforestation rates of the world's humid tropical forests. Science **297**, 999-1002.

Bequaert JC. 1950. Studies on the Achatinidae, a group of african land snails. Bulletin of the Museum of Comparative Zoology **105**, 12-16.

Chokor JU, Oke CO. 2011. Effect of soil properties on the abundance and diversity of landmolluscs in South Western Nigeria.International Journal of Tropical Medicine and Public Health **1(1)**, 36-44.

Daget J. 2003. Les Mollusques terrestres et fluviatiles du mont Nimba. In :Lamotte M, and Roy R, Ed. Le peuplement animal du mont Nimba (Guinée, Côte d'Ivoire, Liberia). Mémoires du Muséum national d'Histoire naturelle**190,** 183-209 p.

Colwell RK. 2006. EstimateS: Statistical estimation of species richness and shared species from samples. Version 7.5.

Colwell RK, Coddington JA. 1994. Estimating terrestrial biodiversity through extrapolation. PhilosophicalTransactions of the Royal Society(Series B) **345,** 101-118.

Dayasiri PBIAK, Chandana EPS, Amarasinghe NJDS. 2014. A note on snail diversity in selected areas of 'Kirala Kele' eco-touring in southern Sri Lanka. International Journal of Science, Environment and Technology **3(1),** 1-9.

Dewinter AJ, Gittenberger E. 1998. The land-snail fauna of a square kilometerpatchof rainforest in southwestern Cameroen:high species richness, low abundance and seasonal fluctuations. Malacologia **40(1-2),** 231-250.

Emberton KC, Pierce TA, Kasigwa PF, Tattersfield P, Habibu Z.1997. High diversity and regional endemismin land snails of easternTanzania. Biodiversiiyand Conservation**6,** 1123-1136.

Fontaine B, Gargominy O, Neubert E. 2007. Snail diversity of the savanna/forest mosaic in Lope National Park, Gabon. Malacologia **49(2),** 313-338.

Gotelli N, Colwell RK. 2001. Quantifying biodiversity: Procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters**4,** 379-391.

Kouassi KD, Otchoumou A, Gnakri D. 2008. Le commerce des escargots (*Achatinaachatina*), une activité lucrative en Côte d'Ivoire. Livestock Research for Rural Development **20(4)**.

Memel JD, Otchoumou A, Kouassi KD, Dosso H. 2008. Inventaire, potentiel et répartition des escargots terrestres d'une forêt tropicale humide de Côte d'Ivoire : le Parc National du Banco (PNB). NOVAPEX **9(2-3),** 119-127.

MINEF. 2015. Ministère des Eaux et Forêt; Gestion durable des ressources forestières, Rapport pour les Etats généraux de la forêt, de la faune et des ressources en eau, Côte d'Ivoire, p 1-5.

Oke OC.2013. Terrestrial mollusc species richness and diversityin Omo Forest Reserve, Ogun State, Nigeria. African Invertebrates **54(1),** 93–104.

Oke OC, Alohan FI. 2006.The land snail diversity in a square kilometre of tropical rainforest in Okomu Natioal Park, Edo State, Nigeria.African Scientist **7(3),** 135-142.

Oke CO, Chokor JU.2009. The effect of land use on snail species richness and diversity in the tropical rainforest of south-western Nigeria. African Scientist **10(2)**, 95-108.

Oke CO, Chokor JU.2010. Land snail species richness and diversity in Idanre Hills, Ondo State, Nigeria. African Journal of Ecology **48,** 1004-1008.

Patil JV, Ekhande AP, Padate GS. 2012. A study of terrestrial molluscs with respect to their species richness, relative abundance and density in Toranmal Reserve Forest, North Maharashtra, India. Europian Journal of Zoological Research **1(2),** 26-30.

Piba SC. 2016. Diversité floristique et potentiel en espèces sources de produits forestiers non ligneux de la forêt classée de Yapo-Abbé : contribution pour un aménagement durable. Thèse unique de Doctorat, Université Nangui Abrogoua, Côte d'Ivoire, 60-135.

Raheem DC, Naggs F, James CPD, Richard CP, Eggleton P. 2009. Fragmentation and pre-existing species turnover determine land-snail assemblages of tropical rain forest. Journal of Biogeography **36(10),** 1923-1938.

Rowson B. 2009.Systématics and diversity of Streptaxidae (Gastropoda : Stylomatophora). PhD Thesis, Cardiff University, UK, 4-62.

Schilthuizen M, Rutjes HA. 2001. Land snail diversity in a square kilometre of tropical rainforest in Sabah, Malaysian Borneo. Journal of Molluscan Studies **67**, 417–423.

SODEFOR. 1999. Plan d'aménagement de la forêt classée de Yap-Abbé : 1999-2023. SODEFOR, Ed. p. 8-9.

SODEXAM. 2014. Données météorologiques de la région de l'Agnéby-Tiassa.

Tattersfield P, Warui CM, Seddon MB, Kiringe JW. 2001. Land-snail faunas of afromontane forests of Mount Kenya, Kenya: Ecology, diversity and distribution patterns. Journal of Biogeography **28,** 843-861.

Tattersfjel P. 1996. Local patterns of land snail diversity in a Kenyan rain forest.Malacologia**38(1-2),** 161-180.

Vroh BTA, Adou YCY, Kouame D,N'da DH, N'guessan KE. 2010. Diversités Floristique et Structurale sur le Site d'une RéserveNaturelle Volontaire à Azaguié, Sud-est de la Côte d'Ivoire.European Journal of Scientific Research **45(3),** 411-421.

Wronski T, Gilbert K, Long E, Micha B, Quinn R, Hausdorf B. 2014. Species richness and meta-community structure of land snails along an altitudinal gradient on Bioko island, Equatorial Guinea. Journal of Molluscan Studies **80,** 161–168.