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A Preliminary Survey and distribution of Land snails of Katana region, Southern Kivu, Democratic Republic of Congo

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ABSTRACT: We investigated land snail fauna of Katana region, along the Lake Kivu and the Kahuzi-Biega National Park in Democratic Republic of Congo, using a combination of direct search and leaf litter sieving techniques. Four plots, in different habitats (Forest, wetland, cultivated area and fallow) were studied, covering low altitude (1400 - 1590 m), middle altitude (1600 - 1790 m) and high altitude (1800 - 2000 m). A total of 31 species and 2209 individual land snails belonging to 9 molluscan families and 23 genera were collected from all habitats. Species richness was ranged from 25 to 10 at different habitats and different altitudes. The wetland has high species richness (25) and the fallow has low species richness (10). *Achatina achatina* and *Achatina fulica* (Achatinidae) were recorded in all the habitats in the region (constant species), where *Arion rufus* (Arionidae), *Homorus amputatus* (Achatinidae) and *Subulinuscus ruwenzorensis* (Achatinidae) are found in one habitat (25 %) and are uncommon in Katana region (accidental species).The land snail species inventories will increase our knowledge of the molluscan fauna of the Katana region and assist in conservation management.

KEYWORDS: Land snail, distribution, Katana, Democratic Republic of Congo.

1 INTRODUCTION

In contrast to well-studied groups, such as plants, birds and aquatic snails [1], [2], [3], [4], [5], [6], [7], [8], [9] Congolese's land snails are so poorly known [10] that conservation needs cannot be determined reliably.

Land snails occur in nearly every terrestrial habitat types and play significant ecological roles as prey and nutrient cyclers [11], [12], including as a calcium source for bird eggshells [11]. It is also serving as food items for salamanders, small mammals, birds, humans and some arthropods as well as processing decaying plant material [13], [14] and serves as useful biological indicators of soil quality and chemistry [15], [16].

Land snails include several distinct lineages of terrestrial gastropods and belong to the second largest phylum after arthropods in terms of number of species with more than one laky described species [17]. Land snails constitute about six per cent of the total species on Earth [18].

A large part of molluscan fauna in many tropical regions of the world is still poorly known. Land snails prove to be valuable research subjects for studies in evolutionary biology, biogeography, phylogeography, biodiversity, ecology and conservation biology [19], [20]. With their generally low dispersal powers, land snails tend to exhibit conservative distribution patterns, making them valuable subjects in studying historical biogeography [21], [22], [23]. Highly various and narrowly distributed, land snails are good indicators of areas of conservation importance and endemicity when compared to widely distributed groups such as vertebrates [24].

However, past collectors rarely recorded environmental data, so habitat associations of snails are poorly known. Quantifying land snail richness and density along with other habitat parameters may allow their use as indicator taxa in

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understanding effects of habitat change from acid rain [25], climate change [26], or disturbance [27]. The distribution and activity of land snails depend on several factors including precipitation, soil pH, soil calcium content, canopy density, etc. [11] Documenting species distributions will identify uncommon species having potential conservation needs.

In Democratic Republic of Congo in general and in Katana region in particular, studies related to the land snails don't exist except the studies of [10], [28], [29], [30], [31] and [32], who presented some species collected in other regions of Democratic Republic of Congo, long time ago contrary to other regions in the world where a large number of studies highlighting the need for mollusc conservation globally [33], [34],[35], [36], [37].

It is hypothesized that land snails are largely distributed in the Katana region in the different existing habitats. The objective of this study is to identify the land snails of the Katana region and determine their distribution in different habitats.

2 MATERIAL AND METHODS

2.1 STUDY AREA

Katana region is located on the western flank of Lake Kivu, between latitudes 2°15' and 2°30'S and longitudes 28°45' and 28°85' E.

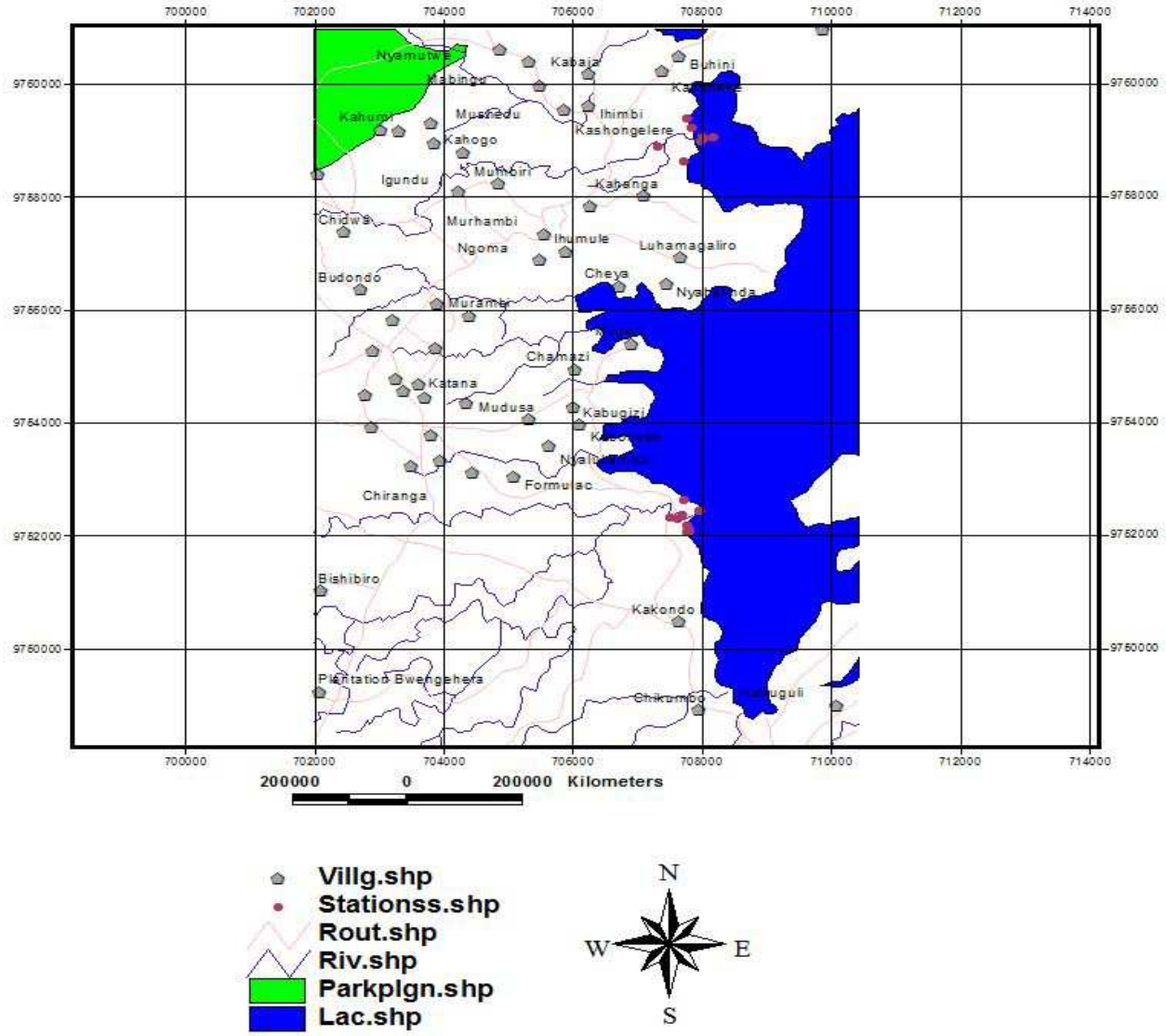

Figure 1: Katana region's Map

It is covered by 4 localities, namely Irhambi/Katana, Bugorhe, Luhihi and Bushumba in the territory of Kabare, province of South-Kivu, Democratic Republic of Congo. Its rainfall is about 1500 mm annually [6]. The soil comprises clay and rich volcanic soil, which is easily eroded. The geological composition is of Precambrian metamorphose sediments (metamorphic rocks) and Preterozoic platform sediments [38].

Ref [39] describes metamorphic limestone and numerous travertines along Lake Kivu and Lake Edward: carbonates for the production of cement are also found at the north and north-west of Lake Kivu. The sampling sites include forest, fallow, cultivated area and wetland.

2.2 DATA COLLECTION AND ANALYSIS

Systematic field collections were conducted in various ecological units which were potentially interesting for molluscs habitats ranging from forest, wetland, and fallow to cultivated area. Collection techniques varied widely depending upon the habitat but included visual searches and leaf litter sieving [40]. A total of 24 sampling points were made from the 3 gradients of altitude [low altitude (1400 - 1590 m), middle altitude (1600 - 1790 m) and high altitude (1800 - 2000 m)]. For each point, two quadrats and hunting sight have been made. This method is to collect the litter on a surface of 1m ^{2} using a small shovel

gardening. The quadrat method used stratified random sampling, which differs in that it will sample chosen microhabitat areas most likely to support snails, because at no site are gastropods completely homogeneous in distribution. The litter collected is then screened so most gastropods in this litter are collected [41], [42], [43], [44]. Hunting sight is a complementary method to quadrat widely used in entomology [24]. It involves directly observe individuals in their habitat, tree trunks, under windfalls, under stones, on the old walls, etc. This method is very interesting and is complementary to quickly draw up an initial list; it is less accurate, especially for smaller species which are often ignored. The duration of the hunting sight was set at 10 minutes per habitat sampling. For identification, the shells of individuals were first sorted by morphological resemblance and studied most often using a binocular microscope. The identification was carried out mainly by using the key of identification ([10], [45], [46].

Snail species were sorted, counted and entered into an Excel spreadsheet and their presence and abundance were summarized for each habitat, altitude and plot. ANOVA analysis was conducted to compare Habitats and altitudes, and the Shannon Diversity (H') was calculated for each habitat. Shannon's index accounts for both abundance and evenness of the species present. The proportion of species relative to the total number of species is calculated, and then multiplied by the natural logarithm of this proportion. The resulting product is summed across species, and multiplied by –1.

To classify the snail species presence/absence data into representative associations, a hierarchical agglomerative cluster analysis was performed on the most common species data using Ward's linkage method and Euclidian distance measure. Cluster analysis creates groups by sequentially merging sample units into larger groups [47].

3 RESULTS

Land snails collected in different habitats and altitudes in the Katana region are presented in the table 1.

Table 1. Checklist and classification of land snail of Katana region, DRCongo

Class	*Order*	*Family*	*Genus*	*Species*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Achatina*	*tincta*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Achatina*	*fulica*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Achatina*	*achatina*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Achatina*	*osborni*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Burtoa*	*nilotica emini*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Burtoa*	*nilotica obliqua*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Curvella*	*bathytoma*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Homorus*	*Ampuctatus*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Limicolaria*	*distincta*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Limicolaria*	*laeta medjensis*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Nothapalus*	*paucispira xanthophaes*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Perideriopsis*	*fallsensis*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Pseudoglessula*	*walikalensis*
Gasteropoda	*Pulmonata*	*Achatinidae*	*Subulinuscus*	*ruwenzoriensis*
Gasteropoda	*Pulmonata*	*Arionidae*	*Arion*	*rufus*
Gasteropoda	*Pulmonata*	*Enidae*	*Cerastus*	*bequaerti*
Gasteropoda	*Pulmonata*	*Enidae*	*Pachnodus*	*rutshuruensis*
Gasteropoda	*Pulmonata*	*Helicidae*	*Theba*	*pisana*
Gasteropoda	*Pulmonata*	*Limacidae*	*Lehmannia*	*valentiana*
Gasteropoda	*Pulmonata*	*Streptaxidae*	*Gullela (Pupigullela)*	*pupa ituriensis*
Gasteropoda	*Pulmonata*	*Urocyclidae*	*Ataxon*	*faradjense*
Gasteropoda	*Pulmonata*	*Urocyclidae*	*Trichotoxon*	*pardus*
Gasteropoda	*Pulmonata*	*Urocyclidae*	*Trichotoxon*	*maculatum perforatum*
Gasteropoda	*Pulmonata*	*Urocyclidae*	*Bukobia*	*cockerelli*
Gasteropoda	*Pulmonata*	*Urocyclidae*	*Trichotoxon*	*ruwenzoriense*
Gasteropoda	*Pulmonata*	*Vaginulidae*	*Pleuroprocta*	*silvatica*
Gasteropoda	*Pulmonata*	*Vaginulidae*	*Loevicaulis (Arion)*	*schnitzleri (distinctus)*
Gasteropoda	*Pulmonata*	*Zonitidae*	*Mesafricarion*	*putzeysi*
Gasteropoda	*Pulmonata*	*Zonitidae*	*Helixarion*	*insularis*
Gasteropoda	*Pulmonata*	*Zonitidae*	*Gymnarion*	*aloysiisabaudiae*
Gasteropoda	*Pulmonata*	*Zonitidae*	*Mesafricarion*	*maculifer pilsbry*

Twenty four sites were sampling in this study included *forest, wetland, and fallow to cultivated area*. Thirty one species of land snails were recorded in Katana region during the study. These species were subdivided into 23 genera, 9 families, 1 order and 1 class. The genera Achatina and Trichotoxon are largely represented in the samples with respectively 4 and 3 species each fallowed by the genera Limicolaria and Mesafricarion represented by two species each. Others genera are less represented with one species. Achatinidae family is the most representative with 13 species divided in 7 genera, followed by Urocyclidae family with 5 species divided in 3 genera and the Zonitidae family with 4 species and 3 genera. The families Enidae and Vaginulidae are represented by 2 species each divided in 2 genera each. The less representative families are Streptaxidae, Arionidae, Limacidae and Helicidae with one species each.

All these species was recorded in different habitats in the Katana region (Table 2)

Table 2. Survey of species collected in different habitats

Species	Wetland	Forest	Cultivated area	Fallow	Total	Frequency (%)
Achatina achatina	X	X	X	X	4	100
Achatina fulica	X	X	X	X	4	100
Achatina osborni		X		X	2	50
Achatina tincta	X	X	X		3	75
Arion rufus	X				1	25
Ataxon faradjense	X		X	X	3	75
Bukobia cockerelli	X	X	X		3	75
Burtoa nilotica emini		X	X	X	3	75
Burtoa nilotica obliqua	X	X	X		3	75
Cerastus bequaerti	X		X		2	50
Curvella bathytoma	X	X	X		3	75
Gullela pupa ituriensis	X	X	X		3	75
Gymnarion aloysiisabaudiae	X		X		2	50
Helixarion insularis	X		X		2	50
Homorus amputatus		X			1	25
Lehmannia valentiana	X		X		2	50
Limicolaria distincta	X		X		2	50
Limicolaria laeta medjensis	X	X	X		3	75
Loevicaulis schnitzleri		X		X	2	50
Mesafricarion maculifer pilsbry	X		X		2	50
Mesafricarion putzeysi	X		X		2	50
Nothapalus paucispira xanthophaes	X		X	X	3	75
Pachnodus rutshuruensis	X		X		2	50
Perideriopsis fallsensis	X		X		2	50
Pleuroprocta silvatica	X			X	2	50
Pseudoglessula walikalensis	X			X	2	50
Subulinuscus ruwenzorensis		X			1	25
Theba pisana	X				1	25
Trichotoxon ruwenzoriense	X		X	X	3	75
Trichotoxon maculatum perforatum	X		X		2	50
Trichotoxon pardus	X		X	X	3	75
Species richness	25	13	22	10		

* Constance species (F ≥ 50 %), secondary species (25 < F < 50 %), accidental species (F ≤ 25 %) [47]

The wetland has high species richness (25) and the fallow has low species richness (10). *Achatina achatina* and *Achatina fulica* (Achatinidae) was recorded in all the habitats in the region (constant species), where *Arion rufus* (Arionidae), *Homorus amputatus* (Achatinidae) and *Subulinuscus ruwenzorensis* (Achatinidae) are found in one habitat (25 %) and are uncommon in Katana region (accidental species). The first one was collected in the wetland and the two last were recorded in the forest only ; the Shannon index shows a variation between the habitats, as observed in the figure 2.

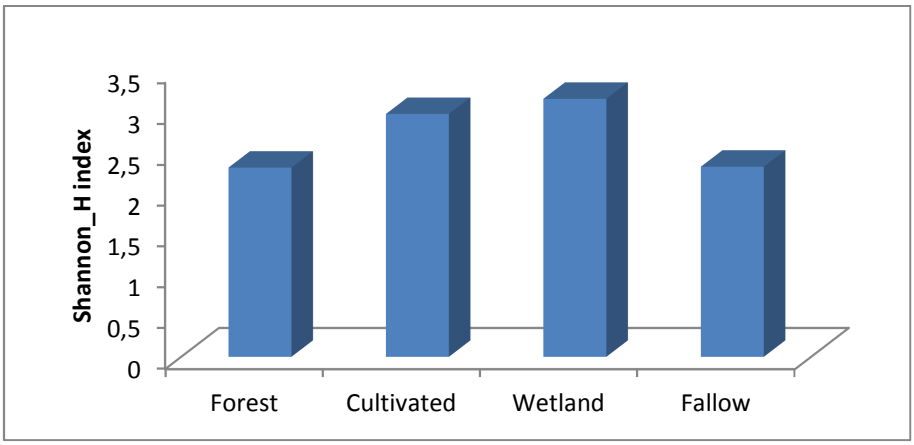

Figure 2. Shannon index for the different habitats of land snails in the Katana region

Shannon index varied between the different habitats in the Katana region. It is high in the wetland and cultivated area than in forest and fallow. The total number of land snails collected in the different habitats is presented in table 3.

Table 3. Number of land snails collected in different habitats in Katana region

Taxa	Wetland	Forest	Cultivated area	Fallow	Total
Achatina achatina	14	30	80	23	147
Achatina fulica	5	10	27	12	54
Achatina osborni	0	11	0	20	31
Achatina tincta	7	9	92	0	108
Arion rufus	3	0	0	0	3
Ataxon faradjense	20	0	107	32	159
Bukobia cockerelli	2	5	49	0	56
Burtoa nilotica emini	0	10	46	16	72
Burtoa nilotica obliqua	7	16	29	0	52
Cerastus bequaerti	19	0	41	0	60
Curvella bathytoma	46	4	48	0	98
Gullela pupa ituriensis	15	3	40	0	58
Gymnarion aloysiisabaudiae	7	0	58	0	65
Helixarion insularis	25	0	33	0	58
Homorus ampuctatus	0	4	0	0	4
Lehmannia valentiana	20	0	98	0	118
Limicolaria distincta	79	0	116	0	195
Limicolaria laeta medjensis	67	17	141	0	225
Loevicaulis schnitzleri	0	4	0	13	17
Mesafricarion maculifer pilsbry	12	0	44	0	56
Mesafricarion putzeysi	30	0	34	0	64
Nothapalus paucispira xanthophaes	10	0	44	15	69
Pachnodus rutshuruensis	13	0	53	0	66
Perideriopsis fallsensis	17	0	39	0	56
Pleuroprocta silvatica	13	0	0	39	52
Pseudoglessula walikalensis	20	0	0	15	35
Subulinuscus ruwenzorensis	0	6	0	0	6
Theba pisana	4	0	0	0	4
Trichotoxon ruwenzoriense	5	0	54	16	75
Trihotoxon maculatum perforatum	10	0	58	0	68
Trichotoxon pardus	26	0	37	15	78
Total	496	129	1368	216	2209
Per cent (%)	22.45	5.84	61.93	9.78	

Limicolaria laeta medjensis, Limicolaria distincta, Achatina achatina, Lehmannia valentiana and *Ataxon faradjense* are the most land snails collected with high number of individuals during the sampling period (abundant species). Some species are uncommon (rare species) such as *Theba pisana, Homorus ampuctatus, Loevicaulis schnitzleri* and *Arion rufus* with one individual collected during the sampling [47]. Cultivated area contribute with 61.93 % of the total land snail collected; wetland with 22.45 %, forest with 5.84 % and fallow with 9.78 %. The cluster analysis of the different habitats (Figure 3) shows that there are similarity between fallow and forest and cultivated area and wetland following the number of land snails recorded in the different habitats.

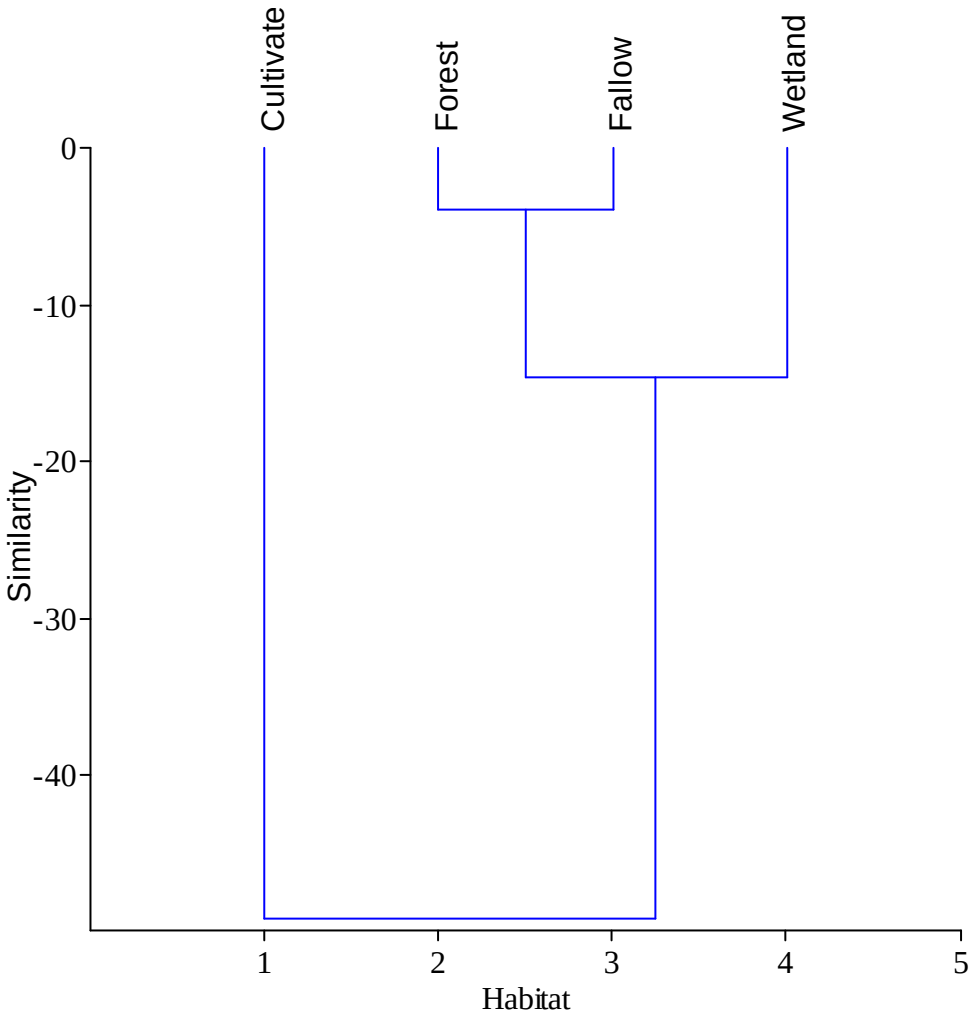

Figure 3. Cluster analysis of number of land snails recorded in different habitats in Katana region

The number of land snails collected at different habitats and altitudes range is presented in the Figure 4.

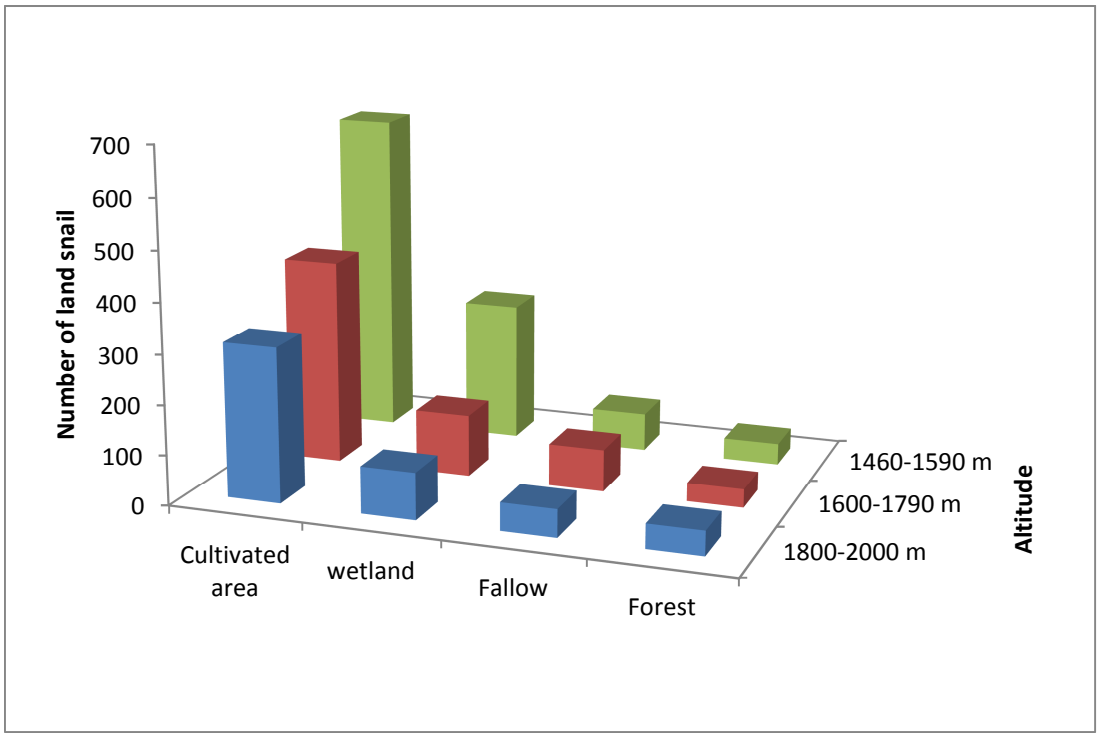

Figure 4. Number of land snails collected in different habitats and at different altitudes in Katana region

It is observed that the number of land snails is high in cultivated area at different altitudes in the Katana region. Snail abundance declined with increasing altitude. Low numbers are recorded in fallow at different altitudes except in the range of 1460 – 1590 m where it was recorded in forest area. This range of altitude contains high number of land snails in all habitats. The Person's r correlation between the different habitats is present in the table 4.

Table 4. Person's r correlation between the different habitats of land snails in Katana region

	Cultivated area	Wetland	Fallow	Forest
Cultivated area	0			
Wetland	0.99	0		
Fallow	0.51	0.38	0	
Forest	-0.29	-0.15	-0.97	0

The cultivated area is very positively correlated with wetland, positive correlated with fallow but weak negative correlated with forest. Wetland is weak positive correlated with fallow and weak negative correlated with forest. The fallow land is strong negatively correlated with forest. The cluster similarity of the different habitats and different altitudes range shown two major classes (Figure 5). The land snails collected to the altitude 2 (1600 – 1790 m) and altitude 3 (1800 – 2000 m) are similar as shown by the cluster and the altitude (1460 – 1590 m) has its own class.

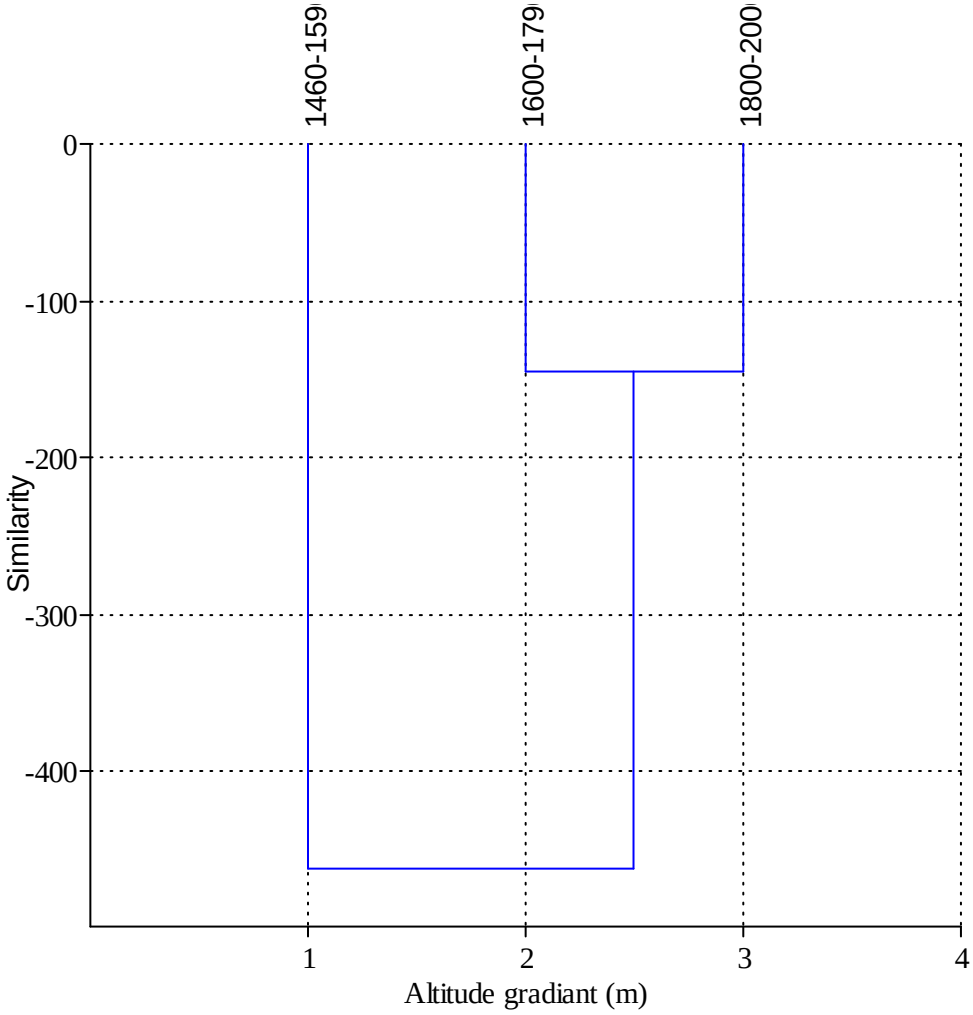

Figure 5. Cluster analysis of land snails collected at different altitudes range in the Katana region

For quantitative data, the results obtained in the several quadrats in different habitats are presented in the table 5.

Table 5. Mean density of land snails collected in the different habitats and altitudes in the Katana region

	1460-1590 m	1600-1790 m	1800-2000 m
Forest (Nber/m^2)	1.3	0.9	0.75
Cultivated area (Nber/m^2)	2.9	1.4	1.16
Wetland (Nber/m^2)	1.58	1.08	0.66
Fallow (Nber/m^2)	1.4	0.75	0.58

Cultivated area has relatively a high mean density of land snails (2.9 individuals / m^2) by repeat at the other habitats in the Katana region. For the altitude of 1460 – 1590 m, the forest area has a low mean density of land snails (1.9 individual / m^2) collected but when altitude increased the fallow become less populated by the land snails.

4 DISCUSSION

Katana region contains different habitats in different altitudes range comprising relic forests, wetlands, fallows and cultivated areas. A big area is constituted by cultivated areas and built-up areas. Due to poverty of detailed malacological

surveys involving the Katana region, DR Congo, only fragmentary information on land snail fauna exists in the literature [30], [31] and [32].

Despite the relative diversity of habitats and inaccessibility of some locations, as displayed in our results, the malacological diversity of the Katana area should be much higher than is presently known. *Limicolaria laeta medjensis*, *Limicolaria distincta and Ataxon faradjense* were the most dominant taxa. On the other hand, *Arion rufus, Homorus ampuctatus*, *Subulinuscus ruwenzorensis* and *Theba pisana* were determined from single habitat.

Overall, species richness and Shannon diversity index varied in different habitats, as observed in other studies [48].

The sampling effort is thought to be adequate, but increasing the collection sites to cover all habitat types present, resampling in different periods of the year, and applying soil/litter sampling methods would improve sampling efficiency.

Achatina fulica and Achatina achatina are herbivorous species, and therefore, may be considered as crop pest and others, are hosts for the rat-lung worm, which can transmit meningitis to humans [49], [37].

Accordingly, variation of species assemblages along the altitudinal data was analyzed by Anova and cluster analysis using 3 altitudinal groups (1460 – 1590 m, 1600-1790 m, and 1800 - 2000 m). There is a trend towards differences among habitats, and these were significant ($p < 0.05$). The altitude of 1460 – 1590 m contained high number of land snails in all the habitats because, probably of the calcium contain in the soil [39]. In these areas, thermal water is a principal source of calcium in soil [39].

A linear relationship between altitude and species richness, that decreases slightly with altitude, was observed contrary to the observation in Mut District in Turkey [50] and in Italy forest [51].

[49] found that Africa may provide tentative evidence for a maximum level of land-snail richness at intermediate elevations of about 1000–1500 m.

During the field study, it was observed that habitat quality (rock structure, vegetation cover, and exposure) was effective in species richness. However, the altitude factor was observed to be effective in species composition as observed by [50].

Given the large number of species recorded only once and the small sample size, and considering the lower sampling efficiency and extensive habitat variability, it is evident that there are other species awaiting discovery. Nevertheless, our findings enable us to draw a number of biogeographical and ecological conclusions.

Research on land snails in DRCongo should focus on their distribution patterns, taxonomy and ecology. Taxonomic expertise is a basic foundation for estimation of global biodiversity and formulation of policy on conservation of biological diversity [52]. Thus, research should also focus on the biogeographical patterns, phylogeny and evolution of DRCongo land snail fauna in general and Katana region in particularly. Further, studies to resolve the taxonomically problematic groups through molecular phylogenetic applications or through DNA barcoding should be initiated.

5 CONCLUSION

For informed conservation measures that will be implemented, detailed studies on land snail systematics, on threats to survival and on identifying “hot-spots” for narrow range endemics are urgently needed. Serious attention will be paid towards protecting remaining forested areas and wetlands. Priority should be given to conserve critical habitat for conservation of land snails.

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