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Distribution and Diversity Land Snails in Human Inhabited Landscapes of Trans Nzoia County, Kenya

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The study evaluated the distribution and some ecological aspects of land snails in croplands of Trans Nzoia, Kenya from January to December 2016. Snails were collected monthly during the study period and sampled using a combination of indirect litter sample methods and timed direct search. Snails collected were kept in labeled specimen vials and transported to the National Museums of Kenya for identification using keys and reference collection. In order to understand environmental variables that affect soil snail abundance; canopy, soil pH and temperature was measured per plot while humidity and rainfall data was obtained from the nearest weather stations to the study sites. A total of 2881 snail specimens (29 species from 10 families) were recorded. The families Subulinidae, Charopidae and Urocyclidae were found to be dorminant. The most abundant species was *Opeas lamoense* (12% of the sample). Land use significantly ($p< 0.05$) affected snail distribution, where abundance of land snails was highest in the wetlands, natural forest and plantation forests. Snail abundance was significantly positively correlated with temperature, rainfall, relative humidity, campy and litter. The area has high species composition, diversity and richness but agricultural activities may affect the overall species richness. Further studies should be conducted to determine whether some of these snails are vectors for trematodes and possible epidemiology of schistosomiasis in the region.

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1. INTRODUCTION

In terms of diversity, molluscs are the second animal phylum surpassed only by Arthropoda, with an estimated 80,000 species accounting for 25% of the earth's fauna. They inhabit both the aquatic (marine and freshwater) and the terrestrial environments [1]. Land snails are predominantly terrestrial, where they perform several ecological roles such as in the decomposition of soil organic matter, soil mineralization, and food source for vertebrates. Medical attention focus on snails as intermediate hosts for several trematodes that cause diseases in humans and domestic animals. Meanwhile land snails have received relatively little attention, yet, this group of animals has several characteristics that make them useful indicator species [2]. Their distribution may further be affected by human activities within the landscape. Yet there are few studies on the distribution of snails in agricultural landscape of Trans Nzoia in Kenya, which is regarded as the most intensely changing in recent years. The present longitudinal study followed seasonal density fluctuations in populations of snails and determined the prevalence in relation to various environmental factors, in the Trans Nzoia County, Kenya.

2. MATERIALS AND METHODS

2.1 Study Area

This study was carried out in croplands of Trans Nzoia County in Kenya (Latitude 0°24' N, longitude 35°14' E, altitude of 2100 m above sea level). The temperature range from 14.2°C to 26.3°C with an average of 16.6°C. The mean rainfall is just over 1000 mm annually. Wet months occur between the months of March to May while December to February is dry months and September to October is the period of short rains. The area covers 147 km^2 and has a population of approximately 1.2 million people (KNBS, 2010).

2.2 Sampling Techniques

Snails were collected monthly from January 2016 to December 2016. Within the larger plot measuring 100 m × 100 m (used for vegetation survey), two sampling plots of 10 m × I m were selected. In each of the plots, 4 sub-plots of I m × I m were randomly selected using a calculator that generates random numbers and the last number within a range of one to nine selected. Snails were sampled using a combination of indirect litter sample methods and timed direct search [3,4]. In the timed direct search method, live snails and shells were searched and collected within the I m × I m plot for 15 minutes. They were searched in all microhabitats found within the plot that included forest floor litter, under dead fallen wood, under surfaces of leaves, on growing moss on tree trunks among others. Snails collected were kept in labeled specimen vials. Live snails and dead shells were separated at the end of each day. Live snails were preserved in 70% ethanol while shells were kept in dry labeled vials. All the materials were transported to the National Museums of Kenya for identification using keys and reference collection. In the litter sample method, 4 litres of leaf litter was put in a polythene bag, air-dried and then sieved using a stacked sieve (top = 2 mm, bottom = 0.5 mm). The amount of litter collected varied, with the forest, scrub and ecotones having a relative constant amount while in the grasslands, a lower volume of litter was collected. The litter retained on the top sieve was briefly inspected for any live snail or dead shells and discarded. The litter retained on the bottom sieve was transferred to another polythene bag or container and later small macro-snails that may have been overlooked during the direct search sampling were sorted using a strong illumination at the laboratory at the National Museum of Kenya (NMK). The retrieved snails were stored and identified.

2.3 Environmental and Physical Characteristics

A number of environmental parameters were recorded during the study. Canopy was scored visually and recorded as percentages of the area covered in the sampling sites. Temperature was measured using a mercury thermometer graduated from 0° to 50° centigrade graduation. Humidity and rainfall data were obtained from weather station.

2.4 Data Analysis

Snail counts based on simple descriptive statistics were compared. To test associations between ecological factors (some of which were recoded) and densities of the most abundant snail species correlation were conducted. One way ANOVA was used to test for the differences in the abundance of the land snails among the different vegetation types. Association between snail abundance and environmental variables was done using Pearson correlation analysis. A Chi-square test (χ^2) was performed to check if abundance of snails was uniformly distributed across families. A value of $p< 0.05$ was considered statistically significant.

3. RESULTS

A total of 2881 freshwater snails, belonging to ten families and 29 species were collected from the study area (Table 1). Family Subulinidae had the highest number of specues (6), followed by Charopidae and Urocyclidae families with 4 each while families Achatinidae, Euconulidae and Streptaxidae was represented by 3 species each. The five most abundant species were *Opeas lamoense*, constituting 12% of the entire sample, followed by *Trachonanima mozambicensis* (10%), *Achatina fulica* (9.6%), *Curvella calorphaphe* (6.7%) and *Melanoides tuberculata* (6.2%). A Chi-square test was performed to check if abundance of snails was uniformly distributed across families. Results revealed significant difference in the abundance of land snails in the families (χ^2 = 1126.03, P < 0.05).

Total abundance of snail specimens in the different landscape types are shown in Fig. 1. Abundance of land snails was highest in the wetlands (N = 1187, 41.2%), followed by natural forest (N = 899, 31.2%) and then plantation forest (N = 475, 16.5%) but were least in grazing landscapes (N = 186, 6.5%) and croplands (N = 134, 4.7%). Results of the ANOVA showed a significant difference in the abundance of land snails in the human affected landscapes (F = 34.898, p < 0.05).

Correlation analysis between environmental variables and snail abundance is shown in Table 2. Snail abundance was significantly positively correlated with temperature, rainfall, relative humidity, canopy and litter but was not affected by pH of the soils. In terms of environmental variables, temperature was negatively associated with rainfall and canopy while rainfall influenced positively changes in relative humidity, canopy and litter.

4. DISCUSSION

This study found a generally high abundance of snails in the areas studied confirming Trans Nzoia County in Western Kenya indeed has rich snail's biodiversity. A large proportion of species recorded were members of the family Subulinidae, Charopidae and Urocyclidae which does not compares with other molluscan studies in forested areas of East Africa [1,5] where Streptaxidae dominates that East African terrestrial mollusc fauna. Despite somewhat a high diversity of snails in croplands in Trans Nzoia County, comparing the current number with studies done in other areas indicate a lower snail diversity. For instance, a study in were observed on different sites of the forest. Kakamega by Lange [6] yielded 47 species; in Mount Kenya region [4] where 53, 49, 46 and 34 Other studies have found 29 species in Amboni caves in Tanzania, 46 species in Usambara Mountains, 45 species from the metamorphic

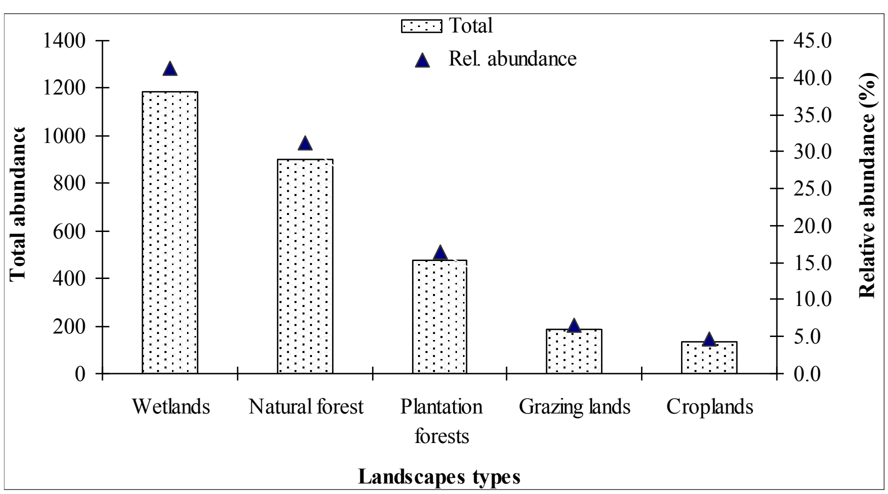

Fig. 1. Total abundance of snail specimens in the different landscape types

limestone forest at Kimboza, Uluguru Mountains, 34 from the submontane forest at Uluguru North Forest Reserve and 36 from Mazumbai Forest in the West Usambara [7]. This low diversity could possibly be as a result of human impact on the landscapes.

Abundance of land snails was highest in the wetlands, natural forest and plantation forest. The high diversity level in the wetlands and forests agrees with work done by Emberton [1] and Tattersfield [3]. The trees are favoured by the adult snail probably because their foliage is food to the snails or they are refuge sites for the snails while their young ones occurred in soil litter. This probably means that the snails lay their eggs on the ground, the eggs hatch and live on the ground until they mature. On the other hand, most snail species were litter dwelling which could be the reason why they were mostly seen alive in soil litter. This observation agrees with work done by Schilthuizens and Rutjes [2] where they observed ecological specialization of snails. Therefore more studies are required

Table 1. A list of the 29 species/morphospecies and their respective families in croplands of Trans Nzoia County in Kenya, from January 2016 to December 2016

Family	Species	Abundance
Achatinidae	*Achatina fulica* (Dunker, 1852)	276
	Achatina albopicta (E.A. Sm., 1878)	154
	Limicolaria martensiana (E. A. Smith, 1880)	123
	Total	**553**
Cerastidae	*Conulinus ugandae costatus* (Verdcourt, 1985)	117
	Rhachidina braunsi (Martens, 1869)	24
	Total	**141**
Charopidae	*Afrodonta kempi* (Connolly, 1925)	56
	Prositala butumbiana (Martens, 1895)	34
	Trachycystis iredalei Preston, 1912	22
	Trachycystis lamellifera (E. A. Smith, 1903)	11
	Total	**123**
Cyclophoridae	*Elgonocyclus koptaweliensis* (Germain, 1934)	19
	Total	19
Euconulidae	*Afroconulus iredalei* (Preston, 1912)	44
	Afroguppya rumrutiensis (Preston, 1911	42
	Afropunctum seminium (Morelet, 1873)	10
	Total	**96**
Streptaxidae	*Gulella* (*Molarella*) *ugandensis* (E. A. Smith, 1901)	86
	Gulella (*Silvigulella*) *osborni* Pilsbry, 1919)	64
	Gonaxis enneoides (von Mts., 1878)	37
	Total	**187**
Subulinidae	*Opeas lamoense* (Mel. & Ponson., 1892)	345
	Curvella calorphaphe (Preston, 1910)	221
	Pseudoglessula ingloria (Connoly, 1923)	112
	Ischnoglessula elegans (Martens, 1895)	102
	Oreohomorus nitidus (Martens, 1897)	34
	Pseudopeas elgonense Connolly, 1923	13
	Total	**827**
Maizaniidae	*Maizania elatior* (Martens, 1892)	68
	Micromaizania volkensi (Martens, 1895)	56
	Total	**124**
Thiaridae	*Melanoides tuberculata* (O.F. Müller, 1774)	178
	Total	178
Urocyclidae	*Trachonanima mozambicensis* (Prf., 1855)	**287**
	Thapsia curvatula (von Mts., 1897)	123
	Trochonanina spp.	33
	Trochozonites sp.	12
	Total	811
	Grand Total	**2881**

Table 2. Correlation coefficients of land snail metrics on environmental variables in croplands of Trans Nzoia County in Kenya, from January 2016 to December 2016

Temperature	Snail abundance	Temperature	Rainfall	Relative humidity	% canopy	% litter
	0.84*					
Rainfall	0.56*	-0.54*				
Relative humidity	0.46*	0.12	0.44*			
% canopy	0.48*	-0.31*	0.34*	0.07		
% litter	0.55*	0.21	0.45*	0.15	0.47*	
Soil pH	0.21^{NS}	0.11	-0.33*	0.03	0.18	0.06

** Correlation is significant at the 0.05 level (1-tailed), NS no significant correlation*

to have an understanding of the ecological niches and the degree of overlap of snails. Meanwhile, these human affected landscapes have different characteristics that make them distinct in terms of rainfall infiltration, moisture content, complexity of the vegetation structure, amount of litter, canopy cover and soil fertility among other parameters. This could be explained by the wetlands and forests having the highest rainfall and complex vegetation structure with respect to their heterogeneity in plant species. This results in more microhabitats, a wide range of microclimate and an expanded resource spectrum. Most land snails occur in forest litter which provides aestivation, egg-laying and refuge sites for them. Other factors that account for the observed distribution patterns of snails in indigenous forests are that forests are characterized by stability of community through time, environmental heterogeneity and less severe induced perturbations [8]. Forests have higher humidity levels relative to other human affected landscape thus an important recipe for the survival of the malacofauna. Grasslands and croplands had the least abundance and diversity which might be explained by high soil compaction and diverse use of agricultural inputs that are limiting the survival of snails. This could also be due to grasslands having little or no ground litter therefore offering few microhabitats. They had dry, compacted soils and were more open compared to other habitats that had canopy.

The presence of snail species is influenced by the interaction of several environmental factors that include temperature, rainfall, relative humidity, canopy and litter but was not affected by pH of the soils. Temperature significantly influences land snail ecology so much so that any increase affects their survival [9]. These terrestrial snails face limitations of temperature regulation and water balance when their moist bodies are exposed during activity hence they have developed behavioural adaptation of burrowing and the subsequent inactivity as a strategy to overcome them. This could have provided suitable conditions for these sensitive range-restricted snails [8,10]. Mollusc species may prefer habitats with calcium but little moisture and in turn develop ways of coping with moisture stress [11]. Therefore molluscs can be found in a range of moisture levels with some species inhabiting dry environments by confining themselves to more sheltered, moist habitats beneath logs and in deep leaf litter while others are known td-obtain sufficient water from food [12]. Snails are sensitive to changes in moisture levels and any reduction in the atmosphere may cause dehydration and subsequent mortality. These findings agree with studies done by Cejka and others [13] who found that humidity influenced the variation of snail species composition among different Danubian floodplain forest types. Litter has a significant influence on snail abundance too where the more abundant the litter, the more food for the litter-dwelling snails, the more refuge sites to avoid predation and desiccation, and the more substrate for egg laying. In contrast, temperature and canopy cover have a negative influence on snail abundance. These results deviated from the expected results in which a high canopy cover and the more stratified the canopy is, the higher the snail abundance. Soil is important since most important nutrients are obtained from it and determines the kind of plants that the ecosystem will support, hence the type of animals.

5. CONCLUSION

The results of this study clearly demonstrate that majority of snail species were found in the wetlands and natural forest thus emphasizing the role these habitats play in determining land snail distribution and diversities. The land snails depend on the existence of the wetlands and forest, therefore, proper management plan should be drawn to protect the forest and at the same time encourage the local community to be participants in wetland management. There need to understand the impacts of various management practices on the survival of land snails.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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