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Population dynamics of land snails (Mollusca: Gastropoda) in Katana region, west coastline of Lake Kivu, Eastern of Democratic Republic of Congo

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ABSTRACT: Monthly and seasonal fluctuations in densities of land snails were recorded in four different sites (forest, fallow, cultivated area and wetland) in Katana region during the period of January to December 2013. The aim of this survey is to study the population dynamics of the land snails of the Katana region considering some geo-physical factors (rainfall, relative humidity and temperature) in different habitats. The study revealed the occurrence of 31 species of land snails belonging to 9 families of class Gasteropoda. The land snail species and their total catch were: *Limicolaria laeta medjensis* (225 specimens), *Limicolaria distincta* (195 specimens), *Ataxon faradjense* (159 specimens), *Achatina achatina* (147 specimens), *Lehmannia valentiana* (118 specimens), *Achatina tincta* (108 specimens), *Curvella bathytoma* (98 specimens), *Trichotoxon pardus* (78 specimens), *Trichotoxon ruwenzoriense* (75 specimens), *Burtoa nilotica emini* (72 specimens), *Nothapalus paucispira xanthophaes* (69 specimens), *Trichotoxon maculatum perforatum* (68 specimens) ,*Pachnodus rutshuruensis* (66 specimens), *Gymnarion aloysii-sabaudiae* (65 specimens), *Mesafricarion putzeysi* (64 specimens), *Cerastus bequaerti* (60 specimens), *Gullela pupa ituriensis* (58 specimens), *Helixarion insularis* (58 specimens), *Bukobia cockerelli* (56 specimens), *Mesafricarion maculifer pilsbry* (56 specimens), *Perideriopsis fallsensis* (56 specimens), *Achatina fulica* (54 specimens), *Burtoa nilotica obliqua* (52 specimens), *Pleuroprocta silvatica* (52 specimens), *Pseudoglessula walikalensis* (35 specimens), *Achatina osborni*(31 specimens), *Loevicaulis schnitzleri* (17 specimens), *Subulinuscus ruwenzorensis* (6 specimens), *Homorus amputatus* (4 specimens) , *Theba pisana* (4 specimens) and *Arion rufus* (3 specimens) in a descending order. The densities of the recorded land snails varied seasonally and the general seasonal peak was recorded during rainy while the lowest density observed during dry. Ecological factors which may influence the distribution or variation of the recorded land snails were also determined (temperature, relative humidity and rainfall). We remarked that the rainfall and the relative humidity were the two main ecological factors which influence the distribution or variation of the land snails in Katana region.

KEYWORDS: Population dynamics, snails, Katana region, Democratic Republic of Congo.

1 INTRODUCTION

Land snails have been known to play significant ecological roles as prey and nutrient cyclers [1] [2], including as a calcium source for bird eggshells [1]. It is also serving as food items for salamanders, small mammals, birds, humans and some arthropods as well as processing decaying plant material [3], [4] and serves as useful biological indicators of soil quality and chemistry [5] , [6]. Land snails constitute about six per cent of the total species on Earth [7]. Several factors are considered as affecting the ecology of land snails, hence their focal and seasonal distributions. These include geo-physical factors such as rainfall, temperature, light and hygrometry of the atmosphere, chemical factors such as ion concentration in the soil as well as biological factors such as availability of food, competition and predator-prey interactions [8], [9], [10], [11], [12]. Besides, the land macrophytes have been shown to play vital roles in the distribution of land snails in different parts of Africa [11], [13]. However, the importance of different ecological factors vary significantly from one ecological zone to the other and even from one soil body to the other, suggesting local investigations to identify important factors in each zone or soil bodies [14], [15], [16], [17], [18].

Many studies concerned with the ecology and population dynamics of the group of gastropods which play an important role as good indicators of areas of conservation importance and endemicity when compared to widely distributed groups such as vertebrates have been conducted by [19], [20], [21], [22], [23], [24], [2], [25], [11].

These studies have led to general opinion; that the development of an effective strategy of integrated control requires the study of population dynamics and its relation to environmental factors. Population dynamics of these animals depend on the geo-physical of a given region, also land contours; soil composition; hydrography and climate all have effect on snail population dynamics [1], [2], [19], [26], [27], [28], [11], [12].

In Democratic Republic of Congo in general and in Katana region in particular, studies related to the population dynamics of land snail doesn't exist except the studies of [29], [30], [31], [32], [33], [34] which presented some species collected in others region of Democratic Republic of Congo long time ago contrary to others region in the world where a large number of studies highlighting the need for mollusc conservation globally [14], [35], [36], [15], [37], [16], [38], [17], [18] and the study of [39] which presented a preliminary survey and distribution of land snails of katana region. It is hypothesized that population dynamics of land snails depends largely on geo-physical factors such as rainfall, relative humidity and temperature in the Katana region in the different existing habitats. The aim of this survey is to study the population dynamics of the land snails of the Katana region considering some geo-physical factors (rainfall, relative humidity and temperature) in different habitats.

2 MATERIALS AND METHODS

2.1 SITES OF INVESTIGATION

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. It is bordered on the east by Lake Kivu and on the west by the Kahuzi-Biega mountain forest (Figure 1).

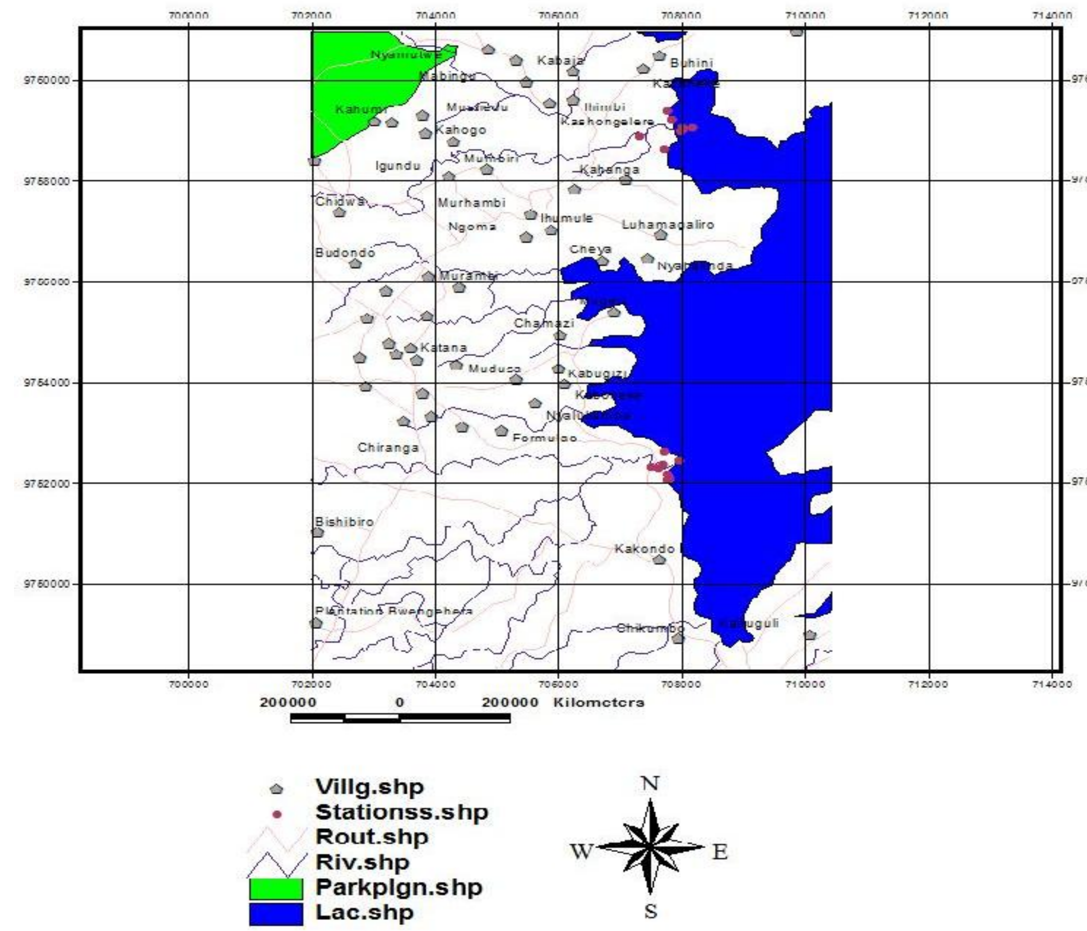


Figure 1. Katana region's Map

It is covered by four localities namely Irhambi/Katana, Bugorhe, Luhihi and Bushumba in the territory of Kabare, province of South-Kivu, Democratic Republic of Congo. Rainfall is about 1500 mm annually [40]. The soil comprises clay and rich volcanic soil, which is easily eroded. The geological composition is of Precambrian metamorphoses sediments (metamorphic rocks) and Preterozoic platform sediments [41]. [42] 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 SAMPLING OF LAND SNAILS

Monthly samples of land snails were collected from the four sites during a period of one year (from January, 2013 till December, 2013). Systematic field collections were conducted in various ecological units were potentially interesting for mollusc 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 [43]. A total of 24 sampling points were made in the four sites. For each point, two transects and five quadrats by transect and hunting sight have been made. This method is to collect the litter on a surface of 2m 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 [44], [45], [46], [47]. Hunting sight is a complementary method to quadrat widely used in entomology. 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 are 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 [29], [48], [47], [50]. Land snail species were sorted, counted, and entered into an Excel spreadsheet and presence and abundance was summarized for each habitat, month, season and plot. The relative density of each species was calculated by using the following relation [51]:

$$\text{Relative density} = \frac{\text{Total number of species individuals in the site}}{\text{The surface of all quadrats in the site}} X100$$

2.3 GEO-PHYSICAL FACTORS

Meteorological data were obtained from a global 0.5×0.5^{o} gridded data set of monthly terrestrial surface climate [52], [53] for the 2013 period, those meteorological data concerned the rainfall, relative humidity and temperature which were measured by digital probe apparatuses[52], [53].

2.4 STATISTICAL ANALYSIS

Analysis of one-way ANOVA on past software was used to test the present data. Linear correlation coefficients were calculated between the densities of the recorded species and environmental factors using the past software.

3 RESULTS

3.1 THE RELATIVE DENSITIES OF THE SNAIL SPECIES RECORDED FROM THE STUDIED SITES DURING THE PERIOD OF INVESTIGATION.

Table 1. Relative densities of the land snail species recorded from the studied sites during the period of investigation

		Sites				
No	Species	Forest	Wetland	Cultivated area	Fallow	Total
1	*Perideriopsis fallsensis*	0	7.1	16.25	0	23.35
2	*Limicolaria distincta*	0	32.9	48.3	0	81.2
3	*Nothapalu spaucispira xanthophaes*	0	4.2	18.3	6.25	28.75
4	*Curvella bathytoma*	1.7	19.2	20	0	40.9
5	*Cerastus bequaerti*	0	7.9	17.1	0	25
6	*Burtoa nilotica emini*	4.2	0	19.2	6.7	30.1
7	*Achatina tincta*	3.8	2.9	38.3	0	45
8	*Pachnodus rutshuruensis*	0	5.4	22.1	0	27.5
9	*Mesafricarion putzeysi*	0	12.5	14.2	0	26.7
10	*Helixarion insularis*	0	10.4	13.75	0	24.15
11	*Gymnarion aloysii-sabaudiae*	0	2.9	24.2	0	27.1
12	*Arion rufus*	0	8.3	44.6	13.3	66.2
13	*Trichotoxon pardus*	0	10.8	15.4	6.25	32.45
14	*Trichotoxon maculatum perforatum*	0	4.2	24.2	0	28.4
15	*Pleuroprocta silvatica*	0	5.4	0	16.25	21.65
16	*Loevicaulis schnitzleri*	1.7	0	0	5.4	7.1
17	*Burtoa nilotica obliqua*	6.7	2.9	12.1	0	21.7
18	*Achatina osborni*	4.8	0	0	8.3	13.1
19	*Mesafricarion maculifer pilsbry*	0	5	18.3	0	23.3
20	*Ataxon faradjense*	0	1.25	0	0	1.25
21	*Lehmannia valentiana*	0	8.3	40.8	0	49.1
22	*Bukobia cockerelli*	2.1	0.8	20.4	0	23.3
23	*Theba pisana*	0	1.7	0	0	1.7
24	*Trichotoxon ruwenzoriense*	0	2.1	22.5	6.7	31.3
25	*Achatina achatina*	12.5	5.8	33.3	9.6	61.2
26	*Limicolaria laeta medjensis*	7.1	27.9	58.75	0	93.75
27	*Pseudoglessula walikalensis*	0	8.3	0	6.25	14.55
28	*Achatina fulica*	4.2	2.1	11.25	5	22.55

29	*Subulinuscus ruwenzorensis*	2.5	0	0	0	2.5
30	*Homorus amputatus*	1.7	0	0	0	1.7
31	*Gullela pupa ituriensis*	1.25	6.25	16.7	0	7.5
	Total	54.25	206.5	553.3	90	904.05

A total of 31 land snail species (*Gullela pupa ituriensis, Perideriopsis fallsensis, Achatina achatina, Achatina fulica, Achatina osborni, Achatina tincta, Arion rufus, Ataxon faradjense, Bukobia cockerelli*, *Pleuroprocta silvatica*, *Burtoa nilotica emini*, *Cerastus bequaerti*, *Burtoa nilotica obliqua Curvella bathytoma*, *Gymnarion aloysii-sabaudiae*, *Helixarion insularis*, *Lehmannia valentiana*, *Limicolaria distincta*, *Trichotoxon maculatum perforatum*, *Limicolaria laeta medjensis*, *Loevicaulis schnitzleri*, *Mesafricarion maculifer pilsbry*, *Trichotoxon pardus*, *Mesafricarion putzeysi*, *Nothapalus paucispira xanthophaes*, *Pachnodus rutshuruensis*, *Pseudoglessula walikalensis*, *Subulinuscus ruwenzorensis*, *Theba pisana*, *Trichotoxon ruwenzoriense*, *Homorus amputatus*) belonging to 9 families under class Gastropoda were collected from the sites of investigation during the study period.

As shown in table (1), the total relative density of the collected land snails was 904.05 specimens, from which 54.25, 206.5, 553.3 and 90 individuals were recorded at the different sites: forest, wetland, cultivated area and fallow respectively. By regarding these results, one can conclude that cultivated area site and wetland site were rich in land snails. It was observed that these two sites are characterized by a lot of plants on which land snails feed, a penetrate substrate with organic matter in which land snails can be hided during dry season, can penetrate for laying and clay-sandy substratum with decaying matter and a lot of vegetation and in Katana region, wetland is cultivated by human being.

3.2 THE VALUES RANGE OF GEO-PHYSICAL PARAMETERS RECORDED IN THE INVESTIGATED SITES

The values range of geo-physical parameters recorded in the investigated region are shown in the figure (2), and it was observed that the differences between monthly rainfall and relative humidity were highly significant except for temperature. The rainfall reached his summit in December and the relative humidity reached his summit in the same month; but it rained highly in December and March and the relative humidity was almost the same during the year, except in June, July and August during which it was low. Temperature was almost the same along the year and varied between 20.2 and 18.9.

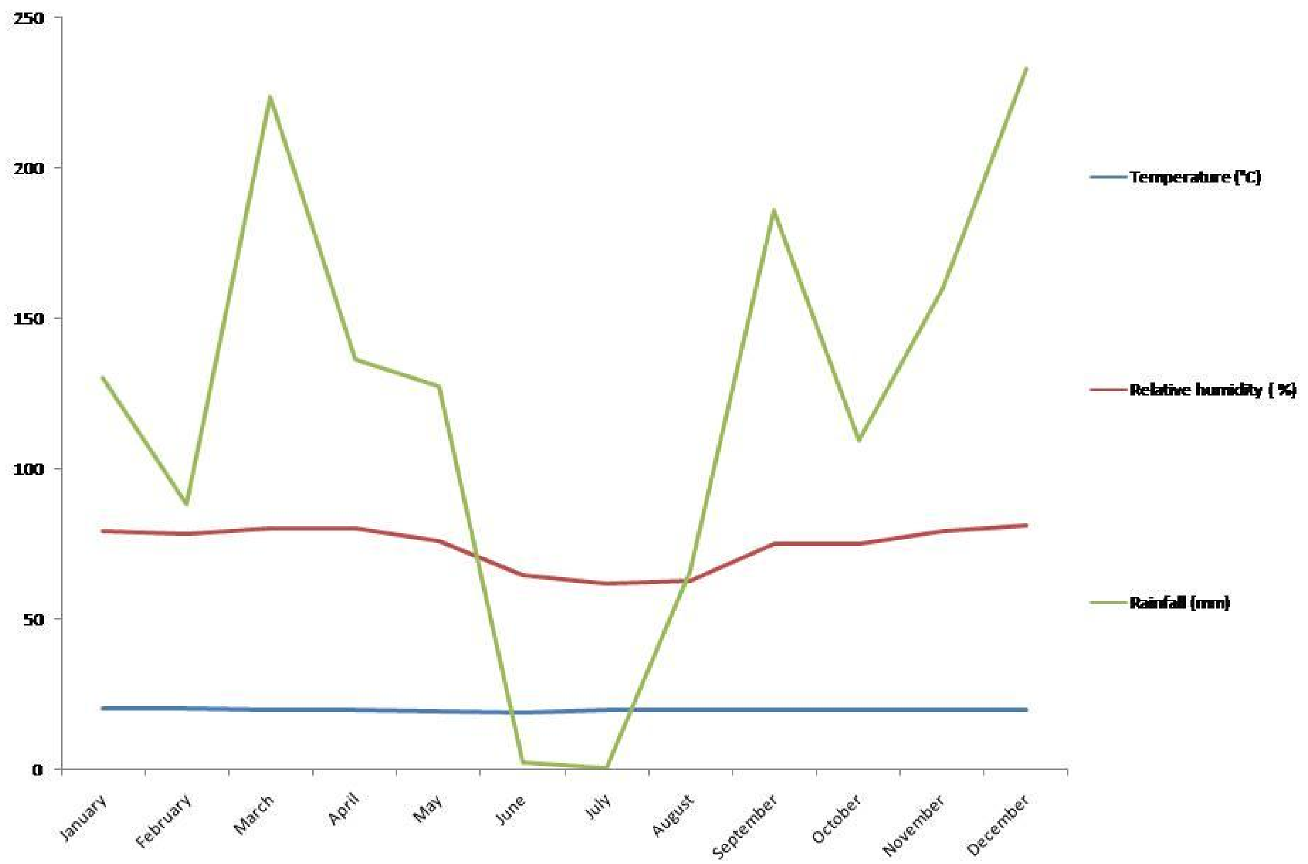


Figure 2.The values range of geo-physical parameters recorded in the investigated sites

3.3 MONTHLY, SEASONAL AND ANNUAL VARIATIONS OF THE RECORDED LAND SNAIL SPECIES

3.3.1 MONTHLY VARIATIONS OF THE RECORDED LAND SNAIL SPECIES

3.3.1.1 PER SITE IN TOTAL ANNUAL

Table 2. Land snails collected during the period of investigation per site.

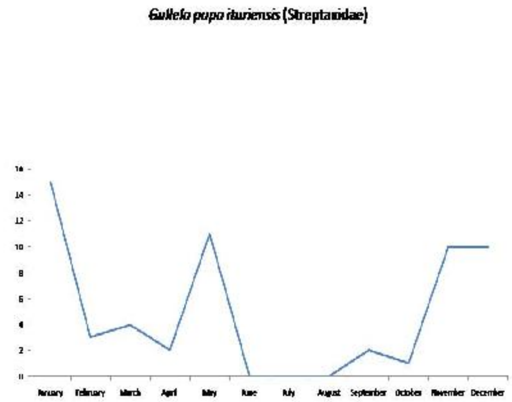
Sites	Forest	Wetland	Cultivated area	Fallow	Total
Gullela pupa ituriensis	3	15	40	0	58
Perideriopsis fallsensis	0	17	39	0	56
Limicolaria distincta	0	79	116	0	195
Nothapalus paucispira xanthophaes	0	10	44	15	69
Curvella bathytoma	4	46	48	0	98
Cerastus bequaerti	0	19	41	0	60
Burtoa nilotica emini	10	0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

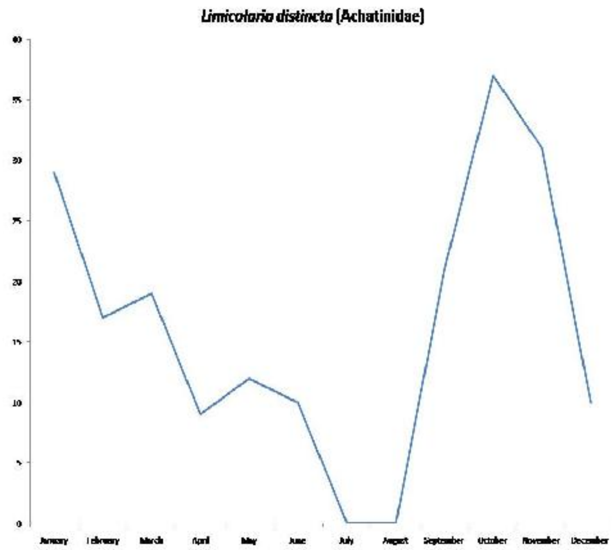
According to the numbers of collected snails in the different sites, the species were arranged in a descending order as: *Limicolaria laeta medjensis* (225 specimens), *Limicolaria distincta* (195 specimens), *Ataxon faradjense* (159 specimens), *Achatina achatina* (147 specimens), *Lehmannia valentiana* (118 specimens), *Achatina tincta* (108 specimens), *Curvella bathytoma* (98 specimens), *Trichotoxon pardus* (78 specimens), *Trichotoxon ruwenzoriense* (75 specimens), *Burtoa nilotica emini* (72 specimens), *Nothapalus paucispira xanthophaes* (69 specimens), *Trichotoxon maculatum perforatum* (68 specimens), *Pachnodus rutshuruensis* (66 specimens), *Gymnarion aloysii-sabaudiae* (65 specimens), *Mesafricarion putzeysi* (64 specimens), *Cerastus bequaerti* (60 specimens), *Gullela pupa ituriensis* (58 specimens), *Helixarion insularis* (58 specimens), *Bukobia cockerelli* (56 specimens), *Mesafricarion maculifer pilsbry* (56 specimens), *Perideriopsis fallsensis* (56 specimens), *Achatina fulica* (54 specimens), *Burtoa nilotica obliqua* (52 specimens), *Pleuroprocta silvatica* (52 specimens), *Pseudoglessula walikalensis* (35 specimens), *Achatina osborni* (31 specimens), *Loevicaulis schnitzleri* (17 specimens), *Subulinuscus ruwenzorensis* (6 specimens), *Homorus amputatus* (4 specimens) , *Theba pisana* (4 specimens) and *Arion rufus*

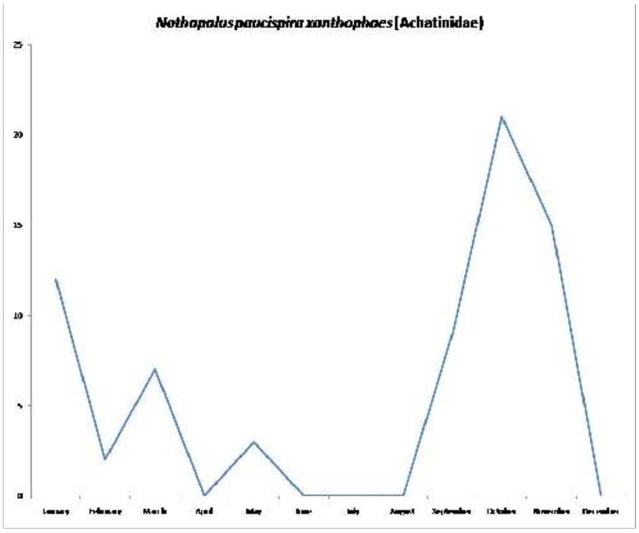
(3 specimens) that formed a total of 2209 specimens land snails among which 129 specimens of land snails have been recorded in the forest, 129 specimens of land snails have been recorded in the wetland, 1368 specimens of land snails have been recorded in the cultivated areas and 216 specimens of land snails have been recorded in the fallow as shown in table 3 bellow.

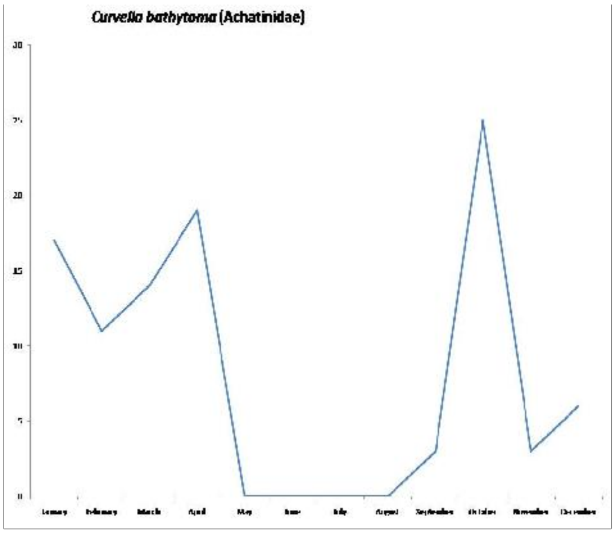
3.3.1.2 PER INDIVIDUAL MONTHLY

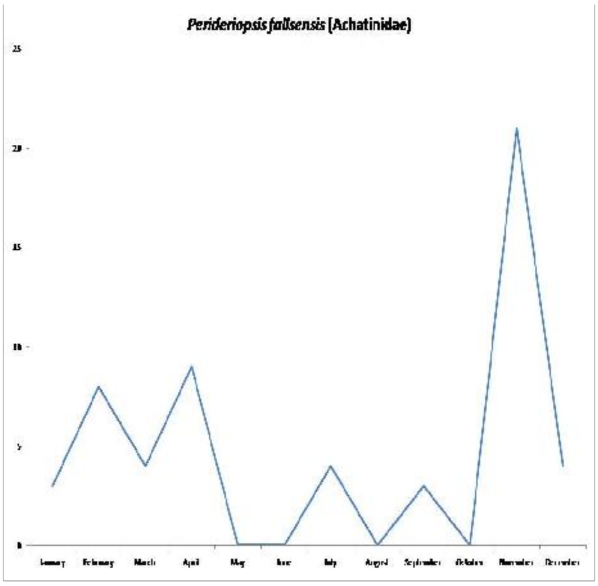
Gullela pupa ituriensis showed the highest peak in January, *Limicolaria distincta*s howed the highest peak in October*, Nothapalus paucispira xanthophaes* showed the highest peak in October*, Curvella bathytoma* showed the highest peak in october*, Perideriopsis fallsensis* showed the highest peak in November*, Cerastus bequaerti* showed the highest peak in October*, Burtoa nilotica emini* showed the highest peak in October*, Achatina tincta* showed the highest peak in January*, Pachnodus rutshuruensis* showed the highest peak in March*, Mesafricarion putzeysi* showed the highest peak in October*, Helixarion insularis* showed the highest peak in October*, Gymnarion aloysii-sabaudiae* showed the highest peak in November*, Ataxon faradjense* showed the highest peak in October*, Trichotoxon pardus* showed the highest peak in November*, Trichotoxon maculatum perforatum* showed the highest peak in March*, Pleuroprocta silvatica* showed the highest peak in October *,Loevicaulis schnitzleri* showed the highest peak in November*, Burtoa nilotica obliqua* showed the highest peak in October*, Achatina osborni* showed the highest peak in October*, Mesafricarion maculifer pilsbry* showed the highest peak in October*, Arion rufus* showed the highest peak in January*, Lehmannia valentiana* showed the highest peak in October*, Bukobia cockerelli* showed the highest peak in October*, Trichotoxon ruwenzoriense* showed the highest peak in October*, Theba pisana* showed two peaks in October and November*, Achatina achatina* showed the highest peak in March, *Limicolaria laeta medjensis* showed the highest peak in March*, Pseudoglessula walikalensis* showed the highest peak in November*, Achatina fulica* showed the highest peak in October*, Subulinuscus ruwenzorensis* showed the highest peak in March and *Homorus amputatus* showed the highest peak in April, figures 3 beneath.

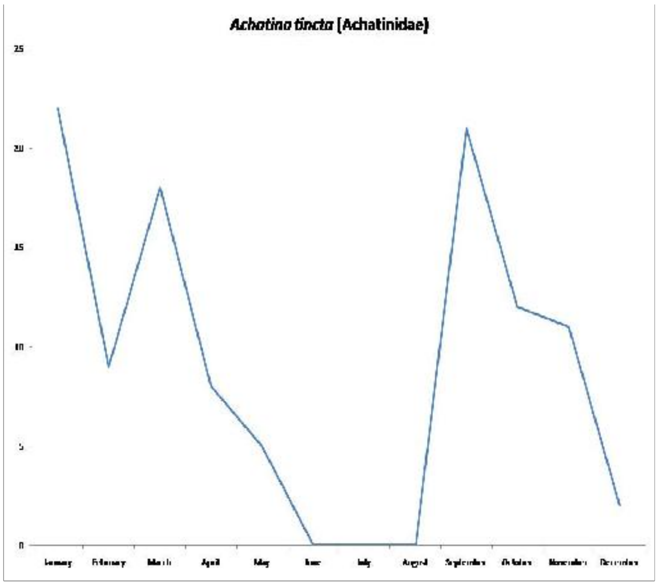


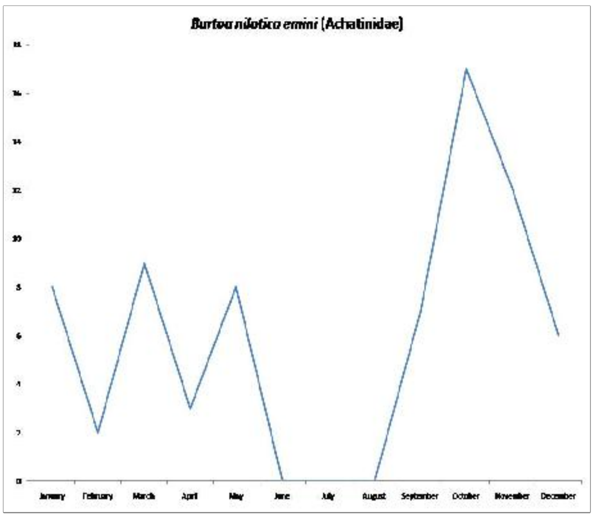


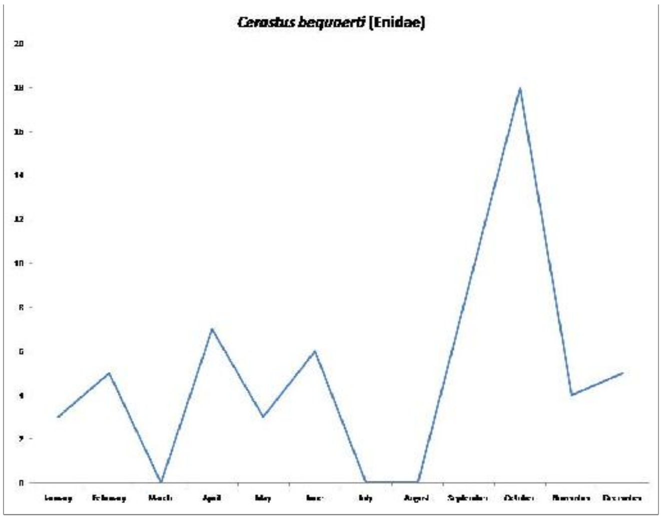

Nothapalus paucispira xanthophaes (Achatinidae)

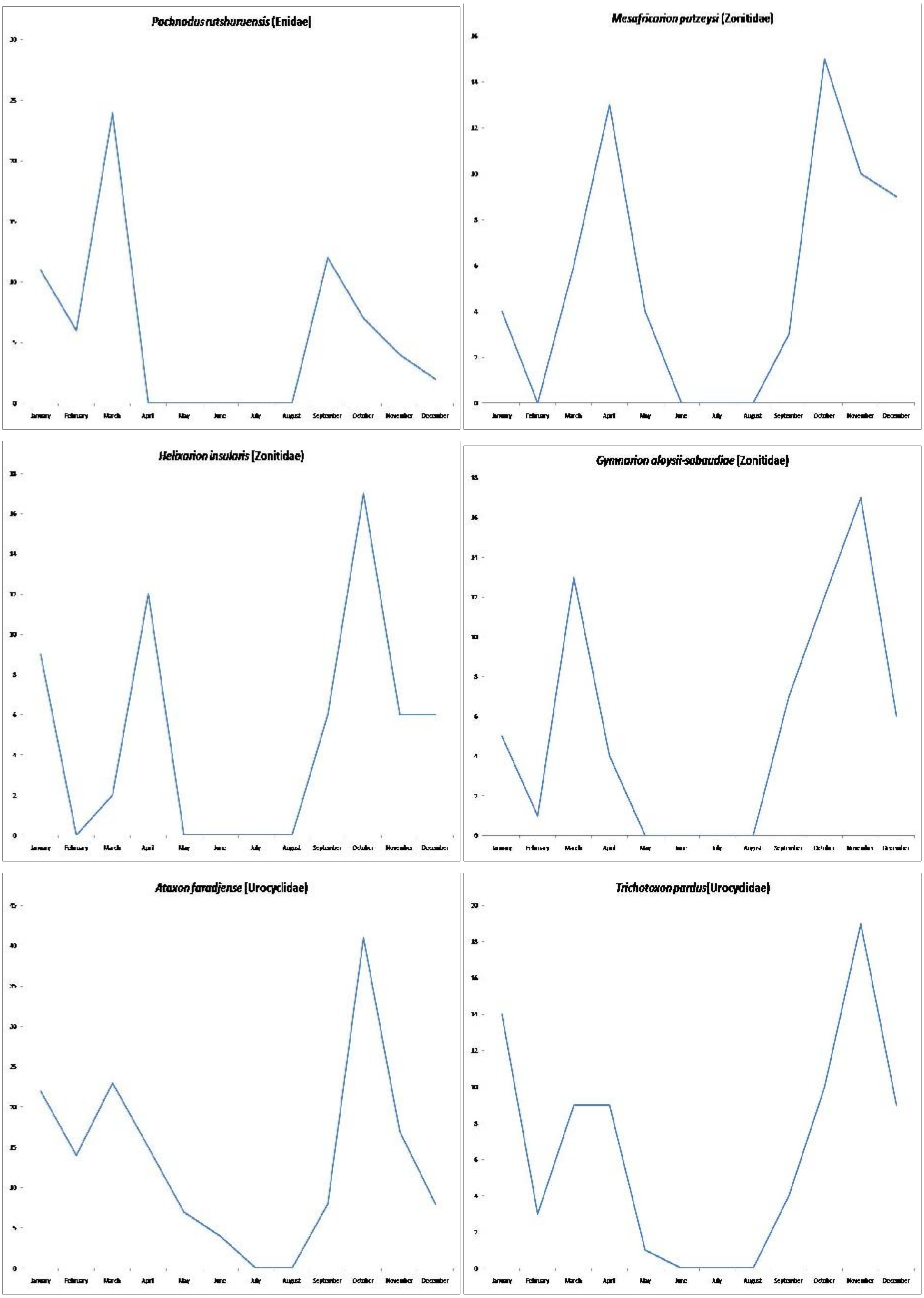

Curvella bathytoma (Achatinidae)


Perideriopsis fallsensis (Achatinidae)


Achatina tincta (Achatinidae)


Burtoa nilotica emini (Achatinidae)
January
February
March
April
May
June
July
August
September
October
November
December


Cerastus bequaerti (Enidae)


Pachnodus rutshuruensis (Enidae)
Mesafricarion putzeysi (Zonitidae)
Helixarion insularis (Zonitidae)
Gymnarion aloysii-sabaudiae (Zonitidae)
Ataxon faradjense (Urocyclidae)
Trichotoxon pardus (Urocyclidae)
January
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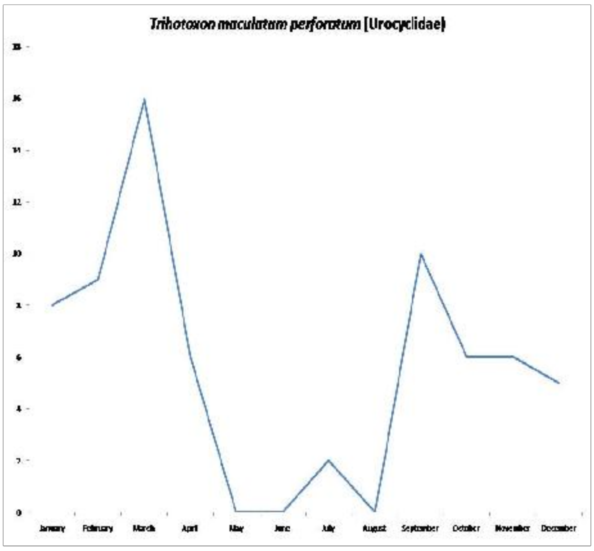
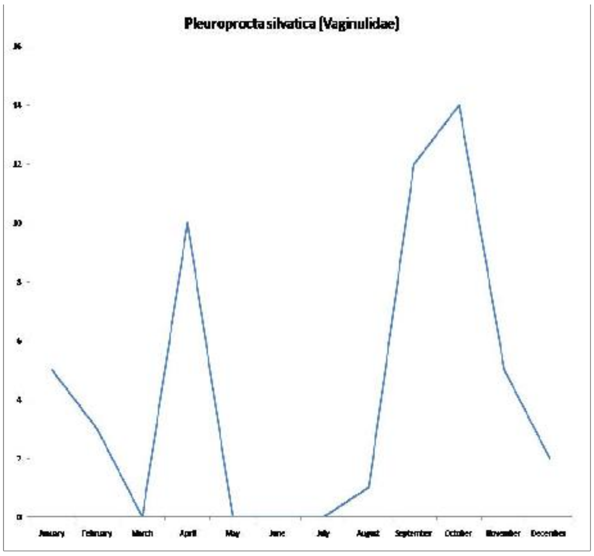
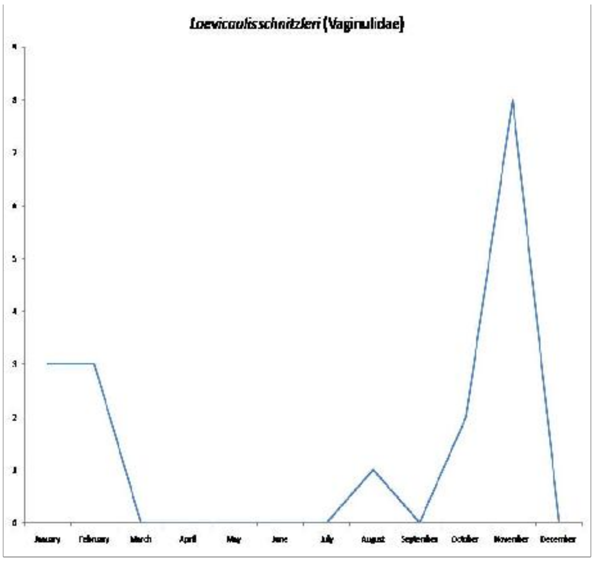
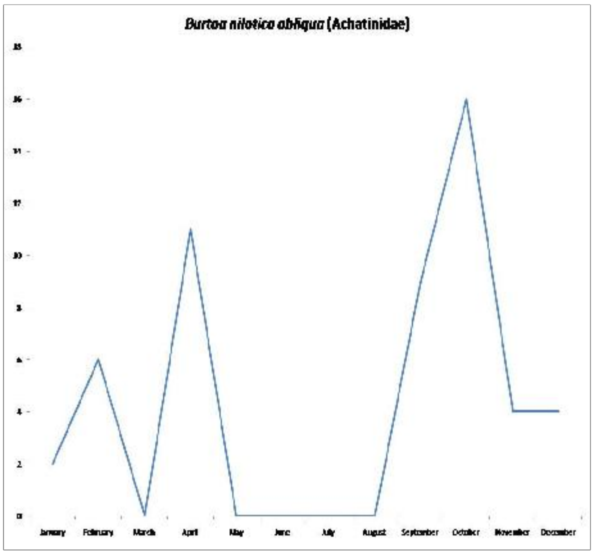
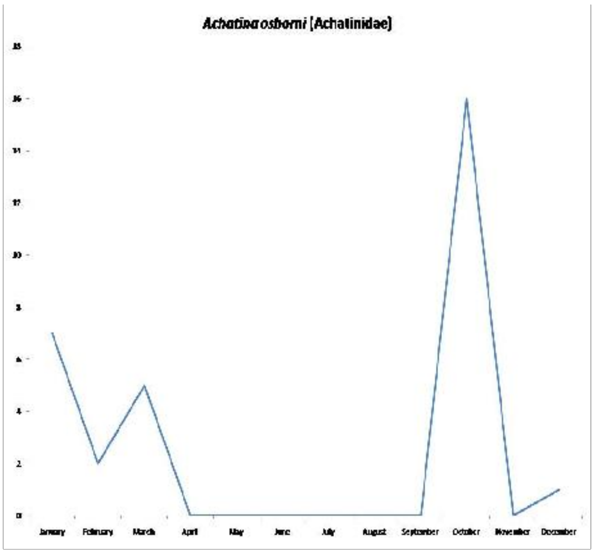
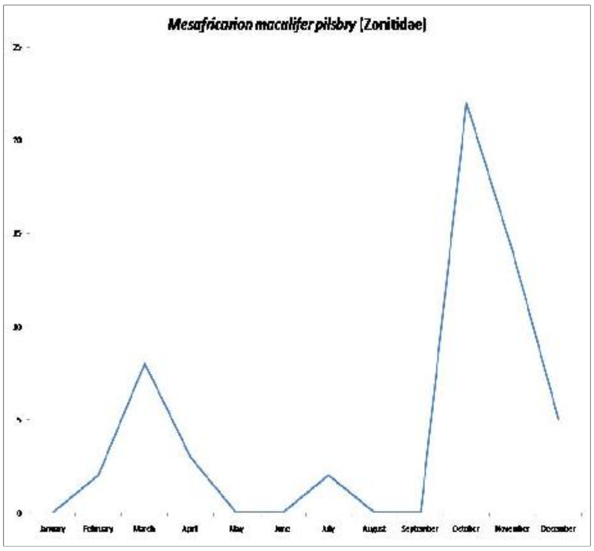

Trihotoxon maculatum perforatum (Urocyclidae)
January February March April May June July August September October November December

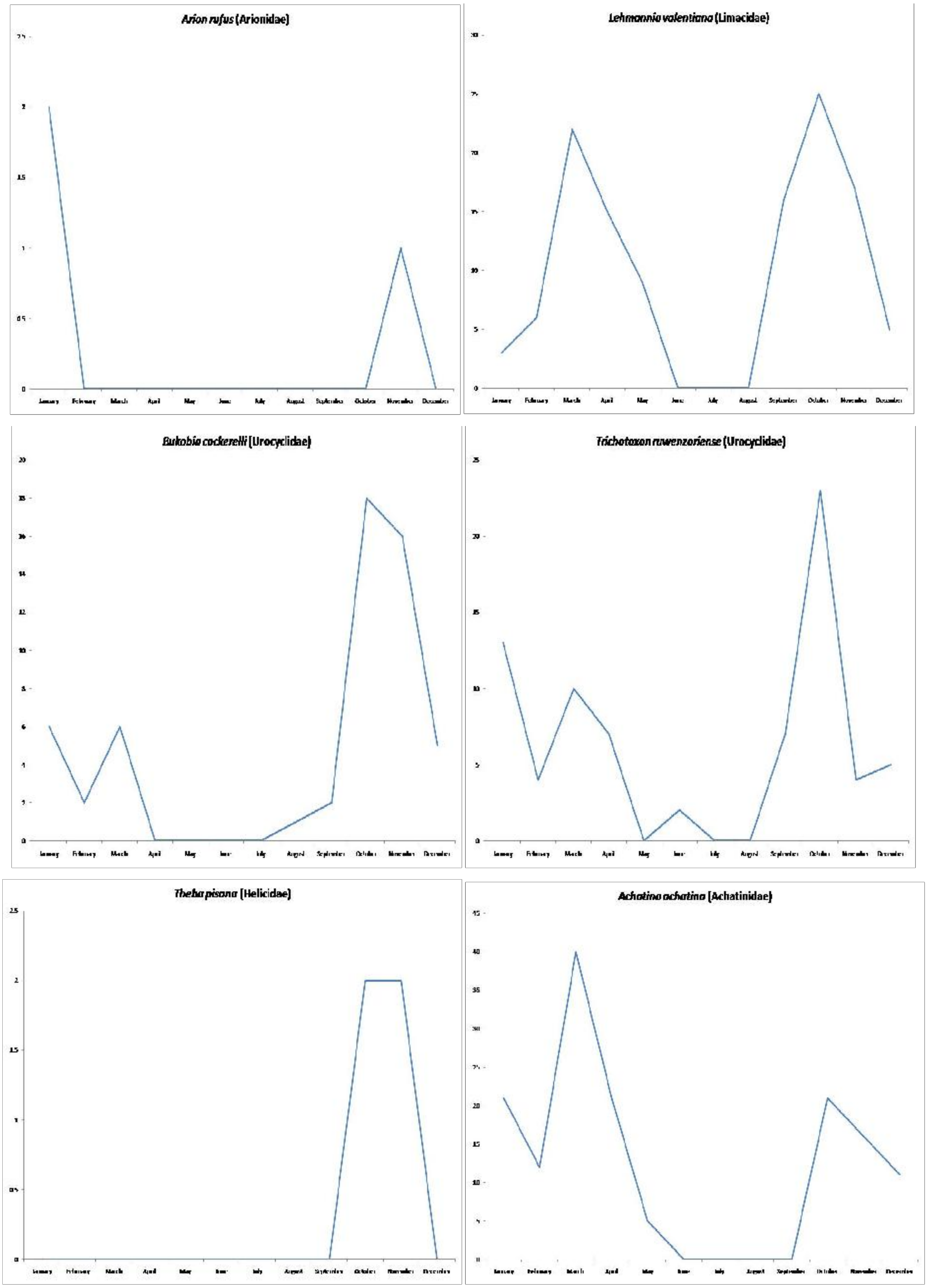

Pleuroprocta silvatica (Vaginulidae)
January February March April May June July August September October November December

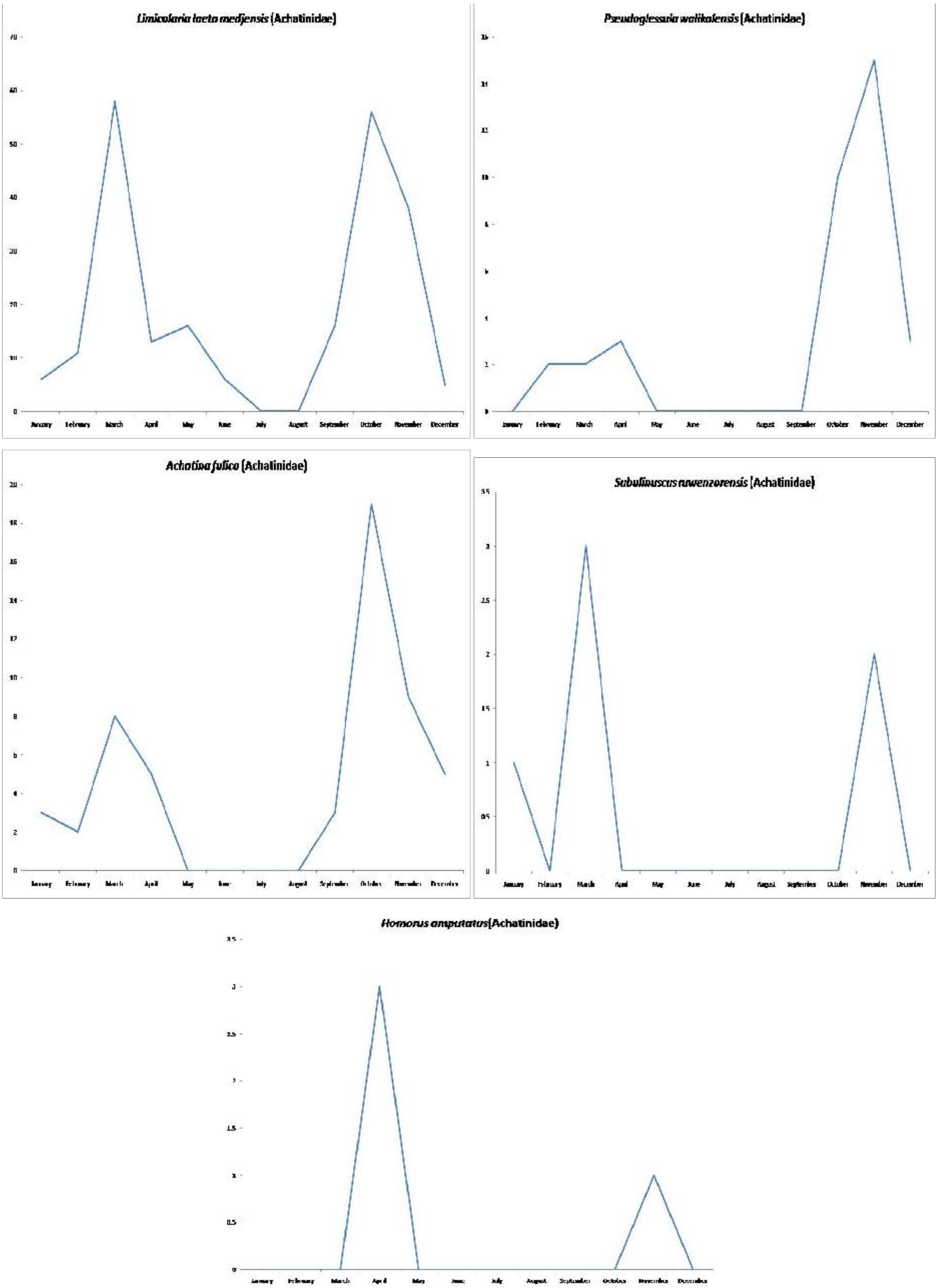

Laevicaulis schnitzleri (Vaginulidae)
January February March April May June July August September October November December


Burtoa nilotica obliqua (Achatinidae)
January February March April May June July August September October November December


Achatina osborni (Achatinidae)
January February March April May June July August September October November December


Mesafricarion maculifer pilsbry (Zonitidae)
January February March April May June July August September October November December


Arion rufus (Arionidae)
Lehmannia valentiana (Limacidae)
Bukobia cockerelli (Urocyclidae)
Trichotoxon ruwenzoriense (Urocyclidae)
Theba pisana (Helicidae)
Achatina achatina (Achatinidae)



Figures 3. Monthly variations of each land snail species collected from the studied sites

3.3.2 SEASONAL VARIATIONS OF THE RECORDED LAND SNAIL SPECIES.

Seasonally, the total catch of land snails showed its high value during rainy season (98.2%), whereas the low catch was recorded in dry season (1.8%), figure 4 beneath.

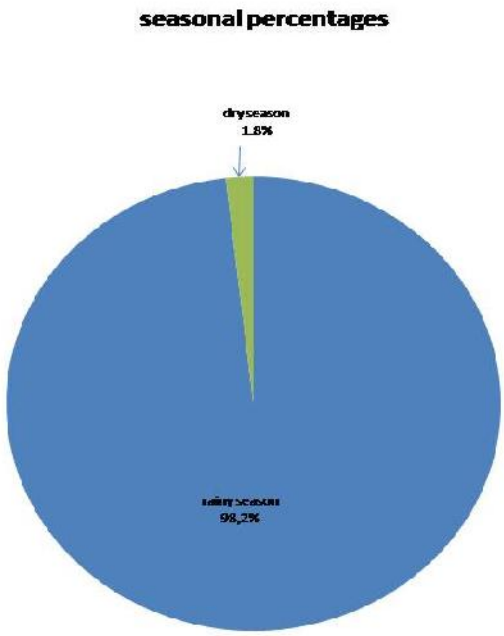


Figure 4. The seasonal percentages of the snail species collected from the studied sites.

3.3.3 ANNUAL VARIATIONS OF THE RECORDED LAND SNAIL SPECIES

In general, during all the year, the land snails showed the highest peak in October as shown by the figure 5 below and dry season has the high percentage of land snails than the dry season as shown by the figure 2 below too.

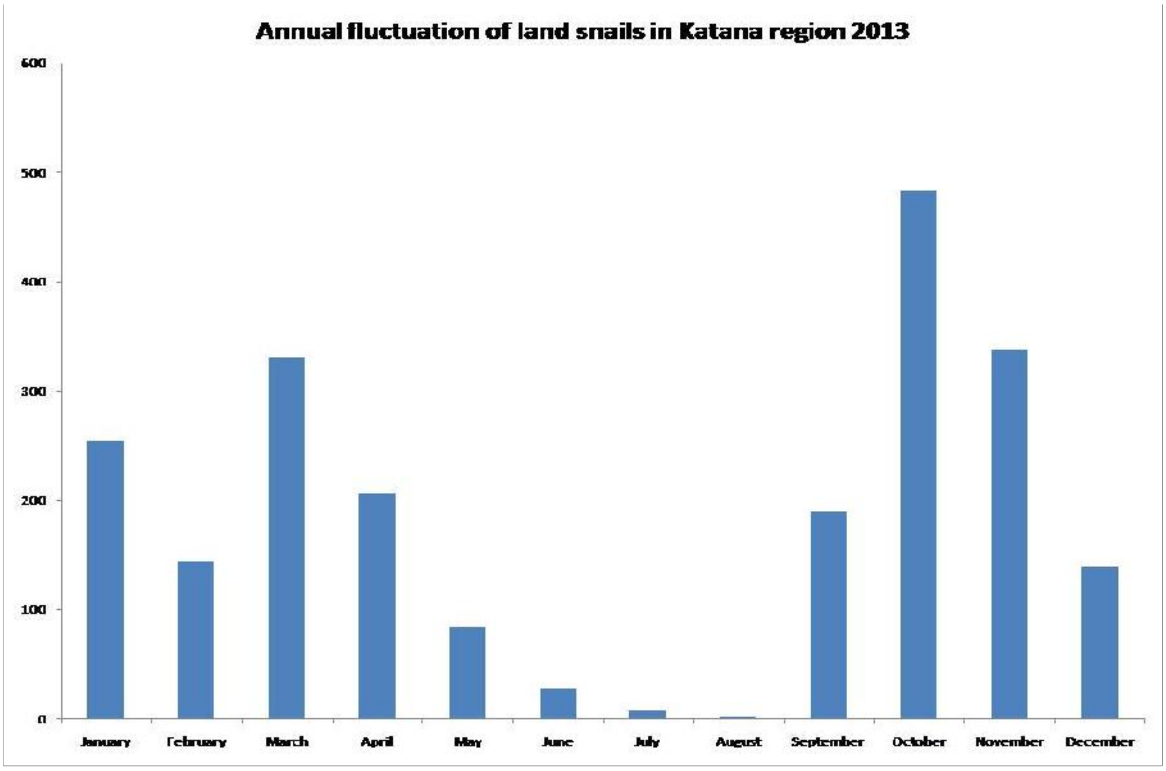


Figure 5. Annual variations in the density of each land snail species collected from the studied sites

3.4 RELATIONSHIP BETWEEN THE ENVIRONMENTAL FACTORS AND THE SNAIL SPECIES

Table4. Correlation coefficients for association between different species with geo-physical factors during the period of investigation

Species	Temperature (°C)	Relative humidity (%)	Precipitation (mm)
Periderlopsis fallsensis (Achatinidae)	0.6141	0.18077	0.42827
Gullela pupa ituriensis (Streptaxidae)	0.52318	0.036003	0.10302
Limicolaria distincta (Achatinidae)	0.73858	0.051809	0.21097
Nothapalus paucispira xanthophaes (Achatinidae)	0.86188	0.26213	0.37728
Curvella bathytoma (Achatinidae)	0.16661	0.063445	0.35305
Cerastus bequaerti (Enidae)	0.83016	0.48357	0.81248
Burtoa nilotica emini (Achatinidae)	0.95971	0.052739	0.069546
Achatina tincta (Achatinidae)	0.14911	0.041208	0.061961
Pachnodus rutshuruensis (Enidae)	0.39455	0.14803	0.056563
Mesafricarion putzeysi (Zonitidae)	0.83709	0.037879	0.08984
Helixarion insularis (Zonitidae)	0.46577	0.12877	0.29767
Gymnarion aloysii-sabaudiae (Zonitidae)	0.94387	0.060753	0.03113
Ataxon faradjense (Urocyclidae)	0.56044	0.061502	0.26422
Trichotoxon pardus (Urocyclidae)	0.45495	0.011439	0.051266
Trihotoxon maculatum perforatum (Urocyclidae)	0.11628	0.024237	0.021397
Pleuroprocta silvatica (Vaginulidae)	0.35339	0.28812	0.4357
Loevicaulis schnitzleri (Vaginulidae)	0.691	0.38337	0.81733
Burtoa nilotica obliqua (Achatinidae)	0.37574	0.23083	0.49686
Achatina osborni (Achatinidae)	0.7085	0.48285	0.74869
Mesafricarion maculifer pilsbry (Zonitidae)	0.73164	0.36136	0.45409
Arion rufus (Arionidae)	0.41179	0.36428	0.7417
Lehmannia valentiana (Limacidae)	0.83706	0.052004	0.049059
Bukobia cockerelli (Urocyclidae)	0.94569	0.24227	0.32156
Trichotoxon ruwenzoriense (Urocyclidae)	0.50625	0.16596	0.32175
Theba pisana (Helicidae)	0.56373	0.59142	0.80464
Achatina achatina (Achatinidae)	0.38012	0.0145	0.055701
Limicolaria laeta medjensis (Achatinidae)	0.73015	0.16041	0.15083
Pseudoglessula walikalensis (Achatinidae)	0.75848	0.25892	0.44354
Achatina fulica (Achatinidae)	0.93244	0.16778	0.23277
Subulinuscus ruwenzorensis (Achatinidae)	1	0.20147	0.12103
Homorus amputatus (Achatinidae)	0.63143	0.32231	0.73066

From table (4), there was a positive correlation between geo-physical factors (temperature, relative humidity and rainfall) and all land snail species. The present results indicated that abiotic factors (geo-physical factors: temperature, rainfall and relative humidity) are positively correlated with land snails, they increase with increasing abiotic factors.

4 DISCUSSION

The results of this study clearly indicate that the densities of the recorded land snails in Katana region underwent changes in numbers during the year of investigation. Several environmental factors appear to affect the land snail populations, in particular, the rainfall, temperature and relative humidity of the Katana region which maybe the cause of the number variation in population of land snails of Katana region. These are in accordance with [54] and [55] who suggested that gastropod variability may be explained by abiotic factors like rainfall, relative humidity and temperature. Also [56] indicated that the occurrence of many gastropod species is affected by the quality of vegetation abundance and reported that the most suitable substrate for snails in terrestrial medium is a moist soil covered with thin layer of organic matter, However, [23] found that faunal variation appears to be more closely related to rainfall levels, than to altitude per se or the other environmental variables examined. The effects of rainfall on land snails could either be direct, or indirect via its effects on soils or vegetation, but the study suggests that direct effects are more important. Land snails are sensitive to small changes in microclimate and plant species composition, which are often brought about through edge effects and the invasion of non-indigenous plant species, accidentally carried as seeds via roadways; Furthermore, given the small geographical range sizes of many of Belau's land snail species, cutting down even small tracts of rainforest could severely impact some land snail populations [57].

Our results in different sites showed that cultivated area and wetland were rich in land snails, this observation is due to these two sites are characterised by fresh plants on which land snails feed, penetrate substrate with organic matter in which land snails can be hided during dry season can penetrate for laying and clay-sandy substratum with decaying matter and a lot of vegetations. The same conclusions have been observed by [58] who showed that land nails eat mostly living plants as well as decaying plants. They also chew on fruits and young succulent plant barks and that many molluscs eat plants (herbivores) or plant cell materials in the water; terrestrial snails like to eat fresh leaves and decomposing materials. This can be beneficial because they break down decomposable materials, but land snails can also become pests when they turn their attention to garden crops and vegetables.

However, the geo-physical factors influence the variation in land snail species fauna, our results shown that when rainfall increases in Katana region, the number of land snail species increases also, but the temperature is almost the same during all the year. Then, one can conclude that temperature does not influence the variation of the land snail species in Katana region, although among environmental factors, temperature affects the variation in land snail species [58]. Our data show no difference ($p = 0.0748 > 0.05$) in either abundance or diversity of land snails between the rainy and dry seasons. Indeed, the so-called "dry" season has the same level of atmospheric humidity as the rainy season [59]. There is dew in the morning all year long, and land snails probably do not suffer from a shortage of water in the "dry" season: for the period of investigation, on average, 8.3% (121.925 mm) of the annual rainfall occurred during the long rainy season. However, some species seem to be more abundant during one part of the year, probably because of such behavior as aestivation/hibernation (animals are more concealed part of the year), or because they have a life cycle of one year or less. The fact that in the twice-sampled sites, the number of species is significantly higher at the beginning of the dry season than during the rainy season also suggests that there could be seasonality in the life cycle of some species. The present result agrees with [60] where they found that late Summer and Autumn had the optimal temperature required for breeding and reproduction of snails, and partially agrees with [61]; they stated that April, May and June showed the highest number of snails in Sinai Peninsula, while the lowest number was recorded during January and February.

However, we cannot rule out the fact that results from the sites sampled twice could be influenced by disturbance, or recolonisation factors following the first sampling. The paucity of data regarding life history of land snails in tropical Africa prevents any firm conclusions on seasonality. But similar results have been found in other studies [62].

The results regarding seasonality are biased by the fact that sieving the leaf-litter produces many dead individuals (empty shells), which are not necessarily representative of the fauna at a given time of the year. Seasonality would be better studied with live individuals only, but as was indicated in the Methods section, it is difficult and time-consuming to sort out animals collected alive from those collected dead, especially for minute species.

All molluscs must have food, oxygen and moisture to be alive. Most molluscs live in the ocean or, if on land, in moist places such as under leaves or in soil, some need a sandy, ocean environment. All molluscs require moisture to stay alive [58]. The desert dwelling snails are no exception as they maintain their own moisture inside their shell by means of a trap doors or a mucus plug. Some mollusks are carnivores (eating such things as fish and other molluscs) and some are even parasites (living within another living host). Molluscs can be found in gardens, in ponds, deserts and oceans. Some live in the tops of trees and others high in the mountains. Snails have many natural enemies; they include ground beetles, snakes, toads, turtles and birds, including chickens, ducks and geese. Snails are among the animal groups that everybody knows a little. After rains, snails can be seen crawling around in bushes, trees, walls and roads at a proverbially slow pace and mainly at nights. Besides the characters typical for molluscs, there can also be found characters typical for all snails, whatever they may look like from outside [58]. Abundance and diversity of snails are likely to be lower in deserts. Because arid regions typically have high temperatures with extreme daily and monthly temperature ranges, low and infrequent rainfall, low humidity, and many sunny days with high light intensity, molluscs of arid regions consist mainly of forms with a wide tolerance for temperature, moisture, and sunshine. Snails can be found in the desert regions of the American southwest, in eastern and southeastern California, Arizona, New Mexico, northern Mexico, and the western parts of Texas [50]. Open meadows and pasturelands, including those with forest cover, are usually poor for snails unless there are many logs [46], but one can find a few species near grass roots [45]. Trampling may influence the low abundance of snails in pastures [23]. When humans clear forests for agriculture, snail diversity and abundance decrease, and species composition changes [63].

5 CONCLUSIONS

The results of this study clearly indicate that the densities of recorded land snails in Katana region underwent changes in numbers during the year of investigation. Several environmental factors appear to affect the land snail populations, particular the rainfall and the relative humidity which may be cleaned to reduce the populations of land snails. Thus, for informed conservation measures to be implemented, detailed studies on land snail systematics, on threats to survival and on identifying “hot-spots” for narrow range endemics are urgently needed.

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