ECOLOGICAL PATTERNS OF MICRO LAND SNAILS ALONG THE ALTITUDINAL GRADIENTS OF MOUNT MAKILING, PHILIPPINES

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ABSTRACT

Studies on the diversity and ecology of micro land snails (< 5 mm) are very limited in the Philippines. To address this information gap, the diversity and community composition of micro land snails were determined along the northeastern slope of Mount Makiling, Luzon Island, Philippines. The area was divided into seven elevation gradients, wherein five quadrats (25 m^2) were randomly set. From a total of 103 individuals sampled, 10 micro land snail species were identified belonging to four families (Ariophantidae, Diplommatinidae, Helicarionidae, and Subulinidae). The most abundant species was *Kaliella* sp. (21) while *Lamellaxis clavicum* (4) was the least. The UPLB Forestry Site 2 had the highest number of individuals (60), species richness (9) and diversity index (H' = 2.0). Among the study sites, UPLB Forestry Site (UFS) 7 was the least in species richness (1) and diversity (H'= 0.00), while UFS 4 had the least number of individuals (2). Species accumulation curve revealed efficient sampling (completeness ratio = 0.95) and β diversity pattern. Canonical correspondence analysis revealed the total distribution of the environmental variables with micro land snails. Among the environmental variables, soil pH and calcium were identified as significant limiting factors affecting the community assemblage of micro land snails. Using generalized linear mixed modelling, soil pH was discriminated as the main predictor for abundance while leaf litter depth for species richness. This study demonstrated that soil calcium and pH were the limiting factors for micro land snail diversity and abundance in the northeastern slope of Mt. Makiling.

Key words: diversity, ecology, species richness, Mount Makiling, micro land snails

INTRODUCTION

Mount Makiling is one of the first established natural parks in the Philippines and is widely recognized for its unique biodiversity (Myers et al. 2000). Various forest types have formed along its altitudinal gradients which are used in ecological studies. It also provides various ecosystem and anthropogenic services as sources for recreation, food, medicine, water and energy (Lapitan et al. 2011). However, Mt. Makiling, particularly its lower elevation, is also continuously exposed to anthropogenic threats such as encroaching human settlements, logging and practice of slash-burn farming that leads to forest resources degradation (de Chavez, 2014). Agricultural activities such as cultivation of upland vegetable, and the application of synthetic pesticides further threaten the area. The Mt. Makiling Forest Reserve, however, is not exposed to a serious threat of habitat degradation (Paquit and Pampolina 2017).

Mollusks such as land snails (macro- > 5mm and micro- < 5mm shell size), are an important biota in tropical rainforest ecosystem. These invertebrates aid in the decomposition and soil building processes, serve as prey items to different wildlife species, and are good environmental indicators (Jordan and Black, 2012). Globally, there are more than 35,000 species of land snails that have been described and majority remain undiscovered or yet to be described partly because of their often minute sizes, and its high specific habitat requirement (Stanisic 1990; Cowie 1995; Lydeard et al. 2004).

In the Philippines, de Chavez and de Lara (2011) determined the diversity, abundance, and spatial distribution of macro land snails in Mount Makiling, Luzon Island. From the 639 individuals sampled, five families (Achatinidae, Bradybaenidae, Camaenidae, Cyclophoridae, and Helicarionidae) and 16 species were identified. The most common species was *Ryssota otaheitana*. They also reported that the macro land snail community assemblage was influenced by environmental variables such as exchangeable calcium, temperature, canopy cover, and altitude. Furthermore, their study suggested that endemic land snails are more diverse in undisturbed rainforests. However, their study failed to account for the micro land snails.

This study, sought to determine the micro land snail diversity in the northeastern slope of Mt. Makiling and analyze the community composition of micro land snails under various environmental conditions and land uses. This preliminary study is the first attempt for micro land snail biodiversity assessment necessary for a science-based conservation programs of Mt. Makiling's malacofauna. It was limited to micro land snails along the 201-900 masl elevation, and only at the northeastern (UPLB-Forestry) slope of the Mt. Makiling Forest Reserve, under the supervision and jurisdiction of the Makiling Center for Mountain Ecosystems of the University of the Philippines Los Baños.

MATERIALS AND METHODS

Study sites. Micro land snails were sampled along the northeastern slope of Mt. Makiling Forest Reserve. The seven sampling sites were located along the 700 m long belt transect at 100 m intervals: UPLB Forestry Site 1(201-300 masl), UPLB Forestry Site 2 (301-400 masl), UPLB Forestry Site 3(401-500 masl), UPLB Forestry Site 4(501-600 masl), UPLB Forestry Site 5(601-700 masl), UPLB Forestry Site 6 (701-800 masl), and UPLB Forestry Site 7 (801-900 masl).

General Sampling Design. For micro snail sampling, a 5x5m (25m^2) quadrat with five replicates (35 quadrats total) were randomly set per elevation. These quadrats were set at least 20 m apart. Geographic coordinates and altitude for each quadrat were determined using Garmin Hand-held Global Positioning System (Garmin International, Inc., USA). Air temperature was determined by suspending a thermometer at least 5 meters above ground. Canopy cover was estimated using spherical densitometer (Forest Suppliers, Inc., USA). Leaf litter depth was measured using a wooden ruler within five points (at the corners and the center) of the quadrat. The diameter of nearby trees at breast height (DBH) was measured. About 100g of top soil was collected from several points of the quadrat. Soil pH was analyzed at the Service Laboratory of the Department of Soil Science, College of Agriculture, UPLB using potentiometric method and exchangeable calcium analysis by EDTA titration ammonium acetate extraction. Vegetation profile was described by determining the relative distribution of trees, shrubs, vines, herbs and grasses per quadrat. Other relevant habitat information such as weather condition, distance to streams or rivers, human habitation, roads and other anthropogenic elements were also documented.

Collection and Identification of Micro Land Snails. Each quadrat was hand-searched for live micro snails specifically on stems and underneath the leaves. In addition, 3 kg of forest litters were randomly collected from each quadrat. All collected litters were placed inside polyethylene bags and sundried for 24 hrs before oven drying at 50°C for 6 hrs. The dried samples then passed through a series of cascade sieving using 3 mm, 2 mm, and 1 mm metal mesh. The empty micro land snail shells were then collected from the sieved samples.

The collected micro snails were examined using light microscope (Zeiss Stemi 2000-C) and scanning electron microscope (Hitachi S-530). The identification of the species and families were based on the works of Faustino (1930), Schilthuizen et al. (2015), and from the specimen collections deposited in the Natural History Museum in Berlin, Germany.

Species Abundance and Richness

Diversity Index of Species Composition. Individual counts for a species were considered as species abundance and the total number of species per site as the species richness. Diversity was estimated from Shannon-Weaver information statistic (H') (Shannon and Weaver, 1949), referred as the Shannon-Weaver Index of Diversity:

$$H' = -\sum_{i=1}^{s} (p_i \operatorname{Ln} p_i)$$

where s is the number of species recorded and pi is the proportion of the sample in the i-th species. Evenness (E) was estimated from the inverse of Simpson's index (Simpson1949):

$$E = 1 \Big/ \left(\sum_{i=1}^{s} p_i^2\right)$$

Both indices were computed using Paleontological Statistics (PAST) version 1.68 software (Hammer et al. 2001).

Sampling Efficiency. In order to see the sampling efficiency and completeness, species accumulation curve (SAC) was used to standardize samples among sites. It was evaluated by computing the completeness ratio (C.R. = estimated number of species/observed number of species) (Clements et al. 2008). The estimated species richness was the incidence-based coverage estimator (S_{ICE}) that was obtained from the extrapolated scores whereas the observed number of species (S_{OBS}) was from the Mau Tao. The shape of the SAC is also indicative of the type of diversity pattern exhibited by micro land snails across sites. The SAC was computed using the software Estimate S version 9.1.0 (Colwell, 2013).

Statistical Analysis. Prior to data ordination, correlation analysis was done in order to determine the highly correlated variables using a cut-off value of r = 0.5. Highly correlated variables that were eliminated were air temperature, percent canopy cover and number of tree species. Canonical Correspondence Analysis (CCA) was performed to examine broad-scale relationships between land snail and environmental factors on the assumption exhibited at Gaussian distribution or optimal ecological peak using Paleontological Statistics (PAST) version 1.68 software (Hammer et al. 2001). It provided the relationship of the species, environmental variables, and sites. The relationships of species, environmental variables, and the different sites in the northeastern slope of Mt. Makiling were analyzed using CCA. The types of environmental variables were compared to the species composition of micro land snails. The vectors represented continuous environmental variables such as soil pH, leaf litter depth, soil calcium content, elevation, and tree diameter.

Generalized linear mixed-effect model (GLMM) is an information-theoretic approach that contains random effects in addition to the fixed effects. The species richness and abundance were coded as the response variables while the soil pH, soil calcium, leaf litter depth, and tree density were assigned as fixed factors. The quadrat per site was identified as the random variable. Each model was assigned a Poisson error distribution and a log link function. In the GLMM, the *lme4* and multi-model inference (*MuMln*) package were installed and the data were exported in R studio software. The codes for the command were entered and run. After running the code, the corrected Akaike's information criterion (AICc) was used to compare and rectify the relative model support for small sample size. This was used to assess model support, ranking each set using ΔAICc (Burnham and Anderson 2002). The biggest AICc weight is the most parsimonious model. The values were obtained by extracting the top five AICc.

RESULTS AND DISCUSSION

Micro land snail diversity in the northeastern slope of Mount Makiling

The habitat characteristics of the sampling sites along the northeastern slope of Mt. Makiling were mostly agroforestry and secondary growth forests subjected to various anthropogenic activities (Table 1, Table 2) from which a total of 103 micro land snails belonging to 10 species and four families were sampled. The 10 species of micro land snails were identified to be under the following families: Ariophantidae (4), Diplommatinidae (3), Helicarionidae (1), and Subulinidae (2) (Fig. 1, Table 3). Out of the 10 species there were four micro land snails that were unidentified up to the species level. The 103 collected samples are adequate enough since Mt. Makiling is a non-calcareous tropical forest that has mosaic types of disturbances. Micro land snails are mostly found on karst areas and are rarely found on non-calcareous areas (Uchida et al. 2001). Moreover, sample-based species accumulation curves for the northeastern slope of Mt. Makiling showed very close convergence and high yielding completeness ratio (0.95) (Fig. 2). The S_{OBS} showed β-dominated assemblage. The number of quadrats in the sampling areas was close enough to cover the number of species of micro land snails. A perfect completeness ratio (1.0) could be attained if elevations 100-200 masl, 200-300masl and 900-1000 masl were included, number of quadrats increased and the area of the quadrat were extended to few meters. Estimates of true species richness based on Chao 2 and Jackknife 2 gave values of 10 and 11.36, respectively (Colwell 2013). The actual value (10 species) was close enough to cover the estimated species obtained.

In general, UFS 2 had the highest individual counts (60) and UFS 4 (2) having the lowest count. Species richness was highest in UFS 2 (9) while UFS 7 had the lowest (1). Of all the sites, UFS 2 had the highest (51) abundance while UFS 4 had the lowest (2). The most diverse sites were UFS 2 (2.01) which was supported by Shannon-Wiener Index that had the most diverse micro land snail assemblage while UFS 7 (0.00) had the lowest. In addition, Simpson Index showed that UFS 2 (0.84) was the most even. Of all the species in the northeastern slope of Mt. Makiling, *Kaliella* sp. was the most abundant (21) and was numerous at UFS 2 and UFS 5 (8) while *Lamellaxis clavicum* (4) was the least (Table 3).

The abundance of micro land snails in the northeastern slope of Mt. Makiling was relatively low because it is a non-karst area which is generally known for low snail abundance. The density of land snails on limestone areas are possibly 2-10 times in contrast on non-limestone areas (Schilthuizen et al. 2003). Active forest litters increase the acidity of soil in rainforest areas causing the leaching of calcium (Schilthuizen and Rutjes 2001; Schilthuizen et al. 2003). Land snails need calcium carbonate for their growth and reproduction (Schilthuizen and Vermeulen 2003).

Table 1. Characteristics of the various sampling sites along the northeastern slope of Mt. Makiling. Values are average of five replications. Mean soil pH ±SD, temperature ±SD, soil exchangeable calcium ±SD, leaf litter depth ±SD, statistically significant at *P*<0.05 (ANOVA).

Sampling Sites	Quadrat- coordinates	Elevation (masl)	Soil pH ± SD	Air Temperature (°C) ± SD	Calcium ± SD Content (me/100g soil)	Leaf Litter ± SD Depth (mm)
UFS 1	Q1- N 14°08'18.2 E 121°13'51.4 Q2- N 14°08'18.1 E 121°13'54.8 Q3 - N 14°08'18.5 E 121°13'56.6 Q4- N 14°08'18.5 E 121°13'56.6 Q5- N 14°08'20.5 E 121°13'57.3	290-300	7.44 ± 0.19	27.0 ± 0.00	20.22 ± 3.00	2.60 ± 1.06
UFS 2	Q1- N 14°08'13.9 E 121°13'16.1 Q2- N 14°08'15.6 E 121°13'17.6 Q3- N 14°08''14.8 E 121°13'14.4 Q4- N 14°08'9.2 8 E 121°13'12.3 Q5- N 14°08'10.7 8 E 121°13'13.2	375-411	7.06 ± 0.27	27.6 ± 0.55	22.48 ± 2.28	2.17 ± 2.25
UFS 3	Q1- N 14°07'49.2 E 121°12'47.9 Q2 N 14°07'50.1 E 121°12'50.3 Q3- N 14°07'51.1 E 121°12'53.5 Q4- N 14°07'51.4 E 121°12'57 Q5- N 14°07'51.2 E 121°13'1.5	451-503	6.54 ± 0.37	28.0 ± 0.55	17.09 ± 3.19	2.05 ± 3.13

Sampling Sites	Quadrat- coordinates	Elevation (masl)	Soil pH ± SD	Air Temperature (°C) ± SD	Calcium ± SD Content (me/100g soil)	Leaf Litter ± SD Depth (mm)
UFS 4	Q1- 14°08'6.9 E 121°12'24.7 Q2- N 14°08'28 E 121°12'28 Q3- N 14°08'3.5 E 121°12'29.8 Q4- N 14°08'1 E 121°12'30.2 Q5- N 14°08'58 E 121°12'30.8	594-610	6.98 ± 0.21	26.2 ± 0.55	13.87 ± 4.36	0.92 ± 0.75
UFS 5	Q1- N 14°08'19.4 E 121°12'14.5; Q2- N 14°08'20.4 E 121°12'15.8; Q3- N 14°08'19 E 121°12'16.8; Q4- N 14°08'19.1 E 121°12'18; Q5- N 14°08'18.4 E 121°12'19.3	700-710	6.32 ± 0.11	26.0 ± 0.00	16.89 ± 1.73	1.60 ± 0.37
UFS 6	Q1- N 14°08'21.2 E 121°12'56.6; Q2- N 14°08'19.3 E 121°12'57.1; Q3- N 14°08'18.8 E 121°12'57.9; Q4- N 14°08'18.8 E 121°12'57.9; Q5- N 14°08'19.1 E 121°12'3.1	765-810	6.50 ± 0.22	24.4 ± 0.71	15.18 ± 4.34	3.25 ± 1.79
UFS 7	Q1- N 14°08'15.9 E 121°12'49.2; Q2- N 14°08'15.5 E 121°12'50.7; Q3- N 14°08'15.9 E 121°12'50.5; Q4- N 14°08'17.3 E 121°12'52.1; Q5- N 14°08'18.2 E 121°12'53.2	850-900	6.26 ± 0.44	24.2 ± 0.45	16.17 ± 4.75	7.00 ± 1.36

Table 2. Vegetation characteristics and anthropogenic activities at various sampling sites along the northeastern slope of Mt. Makiling.

Sampling sites	Vegetation				Forest type	Anthropogenic activities	Canopy (%) ± SD	Tree ± SD DBH (cm)
	No. of tree species	Dominant tree species	Shrubs	Grass				
UFS 1	7-10	*Shorea contorta*	Few	Rare	Agroforesty	Farming	61.33 ± 40.27	28.12 ± 5.85
UFS 2	3	*Swietenia macrophylla*	Few	Rare	Mahogany Plantation	Tourism, Nature Hike	93.34 ± 14.31	15.71 ± 3.15
UFS 3	4-7	*Diplodiscus paniculatus*	Common	Rare	Secondary Growth	Nature Hike, Settlements	58.00 ± 39.85	31.12 ± 4.29
UFS 4	3-7	*Ficus minahassae*	Common	Rare	Secondary Growth	Nature Hike	36.07 ± 40.65	34.21 ± 13.80
UFS 5	3-7	*Ficus congesta*	Few	Rare	Secondary Growth	Nature Hike	66.68 ± 17.26	25.27 ± 4.01
UFS 6	2-5	*Ficus minahassae*	Common	Rare	Secondary Growth	Nature Hike	86.66 ± 32.35	26.40 ± 4.13
UFS 7	2-6	*Ficus nota*	Common	Rare	Secondary Growth	Nature Hike	80.00 ± 32.35	31.84 ± 5.85

Fig. 1. Shells of the 10 micro land snail species collected from the different elevations of the northeastern slope of Mt. Makiling. (a) *Microcystina crystallina*, (b) *Microcystina* morphospecies 1, (c) *Microcystina* morphospecies 2, (d) *Microcystina* morphospecies 3, (e) *Diplommatina microstoma*, (f) *Diplommatina antheae*, (g) *Palaina quadrasi*, (h) *Kaliella* sp., (i) *Lamellaxis graciles*, and (j) *Lamellaxis clavicum*. Scale bar = 1 mm

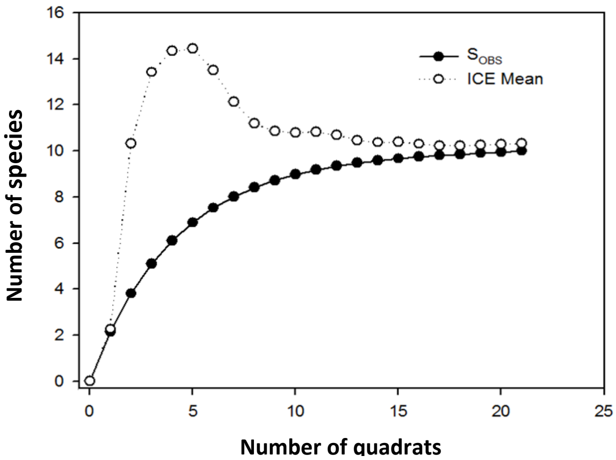

Fig. 2. Sample-based species accumulation curve showing observed (S_{OBS}) and estimated (S_{ICE}) species of land snails in the different elevation of the northeastern slope of Mt. Makiling.

Table 3. Occurrence of micro land snails in the different elevations in the northeastern slope of Mt. Makiling.

Family Species	Northeastern (UPLB- Forestry) slope							Abundance
	UF S 1	UF S 2	UF S 3	UF S 4	UF S 5	UF S 6	UF S 7	
Ariophantidae								
Microcystina crystallina	0	6	2	0	0	0	0	8
Microcystina morphospecies 1	4	2	2	0	0	3	8	19
Microcystina morphospecies 2	3	0	0	0	0	3	0	6
Microcystina morphospecies 3	0	4	2	0	2	0	0	8
Diplommatinidae								
Diplomatinna antheae	0	17	0	0	0	0	0	17
Diplomatinna microstoma	1	6	0	0	1	0	0	8
Palaina quadrasi	0	3	1	1	0	0	0	5
Helicarionidae								
Kaliella sp.	2	8	0	0	8	3	0	21
Subulinidae								
Lamellaxis graciles	1	1	2	1	2	0	0	7
Lamellaxis clavicum	0	4	0	0	0	0	0	4
Total Individuals Collected	11	51	9	2	13	9	8	
Total Number of Species	5	9	5	2	4	3	1	
Shannon-Wiener	1.47	2.01	1.58	0.69	1.07	1.10	0.00	
Simpson Index of Evenness	0.74	0.84	0.79	0.50	0.57	0.67	0.00	

Another possible cause for low abundance could be due to the degradation of the forest in Mt. Makiling as can be seen in the forest types (Table 2). In addition, land snails are prone to natural and anthropogenic disturbances. Micro land snails are more susceptible to ecological perturbations due to its limited mobility and dispersal (Baur and Baur 1988). Forest disturbances are known to alter the land snail diversity and community for decades. Majority of the sampling sites were exposed to human activities such as agro-farming, hiking, road constructions, and clear cuttings which can affect land snail diversity (McMillan et al. 2003). Majority of the forests of the northeastern slope of Mt. Makiling were already categorized as a secondary growth. Old growth forests contain high organic layer accumulation that provides moisture to micro snails to prevent them from desiccation (Martin 2000; Kappes et al. 2006). Older and more pristine forests have greater land snail diversity and community compared to the younger and strongly disturbed forests, hence, older and less disturbed forests are critical for preserving biodiversity. This suggested that micro land snails could be a good indicator of land use change in tropical forest ecosystems (Douglas et al. 2013).

Ecological patterns of micro land snail

Canonical correspondence analysis (CCA) revealed the distribution pattern of environmental variables with micro land snails. The distribution of *Microcystina* morphospecies 1 were on areas with high leaf litter depth, elevation, and DBH. *Microcystina* species were observed to be commonly found on leaf litters and the distribution of *M.* morphospecies 3, *M. crystalina, D. antheae, P. quadrasi, D. microstoma, L. clavicum, L. graciles,* and *Kaliella* sp. in areas associated with pH and calcium. CCA 2 showed the distribution of *Microcystina* morphospecies 3, *D. antheae, P.quadrasi, L.clavicum, L. gracilles*, and *D. microstoma* in areas associated with high soil calcium and soil pH. The distribution of micro land snails was due to the type of vegetation, soil properties, and degree of disturbance present on the site, and reflected the adaptive capacity of the micro land snails (Fig. 3). Moreover, *D. antheae* was only recorded in UFS 2, an area found to exhibit high soil calcium content. CCA showed the close association of *D. antheae* to soil calcium. Studies of Tweedie (1961) and Schilthuizen (2002) demonstrated that most diplommatinid species are found on calcium rich areas.

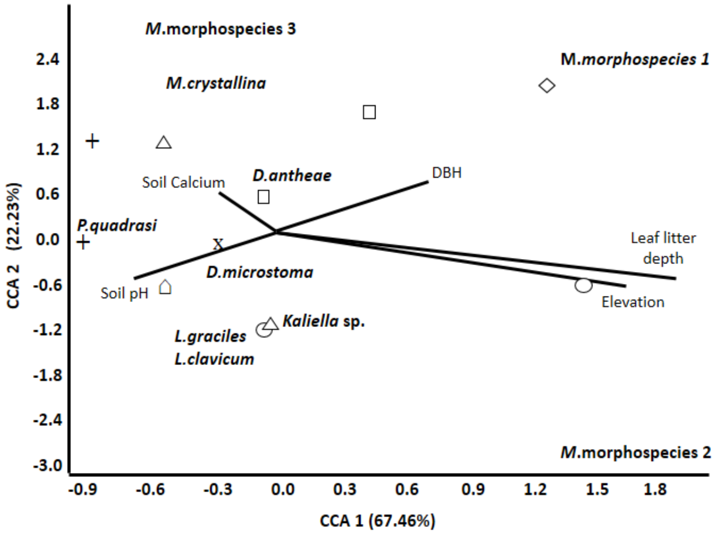

Fig. 3. Canonical correspondence analysis of micro land snail species and environmental variables in the northeastern slope of Mt. Makiling. The biplots stands for the continuous environmental variables (vectors), (⌂) UFS 1, (+) UFS 2, (□) UFS 3, (x) UFS 4, (Δ) UFS 5, (○) UFS 6, and (◊) UFS 7.

GLMM revealed the effect of the single and combined environmental variable on the species richness and abundance. In a global model using GLMM, environmental variables affected the species richness and abundance of micro land snails in the northeastern (UPLB Forestry) slope of Mt. Makiling. Species richness was highly affected by pH (E= 1.2012, $p < 0.01$), DBH (E= -0.05330, $p < 0.01$), and soil calcium content (E= 0.09120, $p < 0.01$). Abundance was highly affected by leaf litter depth (E= 0.3328, $p < 0.01$) followed by soil calcium content (E= 0.1802, $p < 0.01$), DBH (E= -0.1007, $p < 0.01$), and soil pH (E= 1.3501, $p < 0.01$) (Table 4).

Table 4. Generalized linear mixed models testing each environmental variable on the species richness and abundance of micro land snails on the altitudinal gradient in the northeastern slope of Mt. Makiling.

Parameter	Estimate	Standard Error	*P*	Relative Importance
Species Richness				
Intercept	-4.0072	4.5704	0.409	
Soil pH	1.2012	0.4497	2.314	0.59
Tree Diameter	-0.0533	0.0325	1.422	0.08
Soil Calcium Content	0.0920	0.0565	1.411	0.08
Leaf Litter Depth	0.1286	0.0946	1.177	0.05
Abundance				
Intercept	-1.5451	4.5638	0.329	
Leaf Litter Depth	0.3328	0.1041	2.944	0.60
Soil Calcium Content	0.1802	0.0712	2.188	0.24
Tree Diameter	-0.1007	0.0361	2.399	0.22
Soil pH	1.3502	0.5925	1.991	0.20

Model averaging was implemented to generate the final sub-models in order to explain the responses by considering the top variables since the estimate values were relatively close to one another (Table 5). In terms of species richness, soil pH revealed to be the most essential (ΔAIC_c = 0.0, $wAIC_c$ = 0.59). Leaf litter depth (ΔAIC_c = 0.0, $wAIC_c$ = 0.33) was the most essential in terms of abundance.

Table 5. Summary statistics of model averaging for species richness and abundance of micro land snail on the altitudinal gradient in northeastern slope of Mt. Makiling (n = 21). Models are ranked based on Akaike's information criterion corrected for small sample size (AIC_c) where AIC_c weights ($wAIC_c$). Predictor variables: Soil pH, Tree Diameter, Soil Calcium, and Leaf Litter Depth.

Model component	***k****	**AIC_c**	**ΔAIC_c**	**$wAIC_c$**
Species Richness				
Soil pH	4	51.29	0.00	0.59
Tree Diameter (TD)	4	55.32	4.02	0.08
Soil Calcium Content (Cal)	4	55.40	4.11	0.08
Leaf Litter Depth (LLD)	4	56.16	4.87	0.05
Abundance				
LLD	4	77.04	0.00	0.33
Cal	4	78.80	1.76	0.14
LLD+ TD	5	79.10	2.06	0.12
LLD+ pH	5	79.19	2.16	0.11
Ph	4	79.59	2.55	0.09
TD	4	79.74	2.70	0.08
Cal+ LLD	5	80.87	3.83	0.05
Cal+ pH	5	81.49	4.45	0.04

**k- number of parameters*

GLMM revealed that pH was the best predictor of species richness, and leaf litter depth for abundance. High pH values typically go along with high calcium. Low pH promotes calcium leaching and hastens bioerosion of shells. Calcium is a limiting factor for many snail species including those belonging to Diplommatinidae family. Most terrestrial micro land snails are detritivorous, and spend mostly in leaf litters hence it is indirectly affected by the DBH or with canopy cover. An increase in leaf litter thickness may increase snail species diversity (Solem et al. 1981; de Winter and Gittenberger 1998). According to Wareborn (1979), leaf litter had different calcium content depending on the plant species. Calcium deficiency cannot sustain the ideal habitat preferences for the micro land snails (Schilthuizen 2002).

SUMMARY AND CONCLUSION

A total of 103 of micro land snails were recorded at the northeastern slope of the Mt. Makiling Forest Reserve. This corresponds to 10 species belonging to four families. Also, the species compositions of micro land snails gave a significant correlation with habitat preferences present in the sites. CCA and GLMM suggested that calcium was a limiting factor in the area as it goes along with soil pH. Leaf litter depth and tree diameter at breast height influences the diversity and species richness of micro land snails. Furthermore, micro land snails thrived in less disturbed areas, thus, these could serve as potential indicators for land use change and conversion.

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