SPECIES DIVERSITY AND DISTRIBUTION OF LAND SNAILS IN MT. MALINDANG NATIONAL PARK, PHILIPPINES

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Abstract. Land snails are crucial to ecosystem maintenance and function. Unfortunately, the importance of land snails has received little attention in biodiversity studies around the world. The study area was sampled using a combination of timed search and visual search methods to investigate the diversity and distribution patterns of land snail species. Twenty land snails were found in Mt. Malindang. Seven of the species gathered were endemic to the Philippines; four were indigenous, and two were introduced species. Their local distribution in connection to environmental variables revealed a 79.1% variance in species abundance and distribution by canonical correspondence analysis (CCA). Additionally, CCA shows that their distribution is most significantly correlated with vegetation type and altitude. Numerous other abiotic, biotic, stochastic, and scale factors are likely connected to the unexplained variance. The land snails identified were not uniformly distributed in the study area, indicating the presence of ecological specialists. The majority of the snails were found to be localized with low levels of abundance. Fourteen species were confined to one vegetation type, while six species were widely dispersed in different vegetation types. Species diversity, richness, and endemism were found to be high in the montane forest. The findings suggested that conservation of this area is necessary to sustain the molluscan diversity. The absence of live *Amphidromus malindangensis*, a rare endemic to Mt. Malindang, and the abundance of empty shells of *Helicostyla cryptica*, an endemic to the Philippines, both point to the importance of protecting the Mt. Malindang range.

Keywords: gastropod, land snails, malacofauna, malacology, mollusk,

INTRODUCTION

Land snails make up a significant fraction of the overall biomass in many ecosystems, making them an essential component (Cowie and Rundell, 2001). They provide as food for other animals and are significant nodes in the terrestrial food chain (Nordsieck, 2004). Land snails are important in the process of turning organic matter into basic compounds that can be used again by plants. Serious disruption would occur if these were removed from the food chain, which moves mass and stores energy through living and non-living components (Fahy, 2001). They are also useful indicators of biodiversity. Disturbances in the habitat can directly affect snail composition and diversity (Schilthuizen et al., 2003). Native species have decreased as a result of exotic species being unintentionally or deliberately introduced outside of their natural habitats. These introduced species may be actively displacing native species in some circumstances through competition and/or predation, while in other cases they may just be occupying altered habitats where the original species have already disappeared. Many of these species not only supplant the native habitat fauna but also pose significant ecological, agricultural, and health issues (Cowie and Robinson, 2001).

The work of nineteenth-century European, and American naturalists, who were the first to characterize, name, and illustrate the numerous species, laid the groundwork for modern scientific knowledge of land snails (Cowie and Robinson, 2001). The majority of land snail species in the world are found in the tropics, where they are mostly unknown and have little scientific documentation, in part due to under-exploration and in part due to their frequently tiny sizes. The diversity and endemism patterns of tropical land snails are very little known, and the literature falls almost entirely within the last few years. Therefore, more surveys, discoveries, descriptions, and identifications of land snail species are needed, particularly in light of the stresses humans are putting on the few surviving forests.

The Philippine Archipelago is home to the most interesting and beautiful group of land snail species in the world. There are an immense number of species and innumerable subspecies and varieties. The islands harbor an extremely diverse land snail fauna. However, few islands have been adequately surveyed. About 30% of the land snails in the country remain undescribed, and many lowland species will go extinct before they get names due to pressures caused by the rapidly increasing population. Land snails are more vulnerable to local extinctions, which frequently result in the complete extinction of endemic species and a local imbalance. Due to land snails' patchy distribution, a local imbalance might easily develop into a catastrophe. Some species might become extinct even before they are gathered and studied. Many terrestrial snails are minute and die silently. Being an indicator of biodiversity, the loss of tiny decomposers would be a signal of disaster for fragile ecosystems (Madyasta et al., 2000).

With regards to malacofauna, the Philippines is one of the least studied areas in Asia, but it is an area of considerable interest due to the great number of species it contains. In this research, additional information is provided on land snails in the country, particularly on Mt. Malindang. This is the first study to survey the diversity, and distribution patterns of land snails in Mt. Malindang. The overall results of the study provided ecological data as crucial information for crafting management and conservation measures for the malacofauna of Mt. Malindang.

MATERIALS AND METHODS

Study Area

Mt. Malindang is situated in the center of the Province of Misamis Occidental. It is the sole representative forest area of the distinct biogeographical zone of northwest Mindanao Island and at the northeastern tip of the Zamboanga Peninsula (Fig. 1). By virtue of Republic Act No. 6266, which was passed on June 19, 1971, it was designated a national park and watershed reserve. It has a total size of 53,226 hectares and a maximum elevation of 2,404 meters above sea level (masl) (PASA, 1993).With a maximum elevation of 2,404 meters above sea level (masl), it has a total area of 53,226 hectares (PASA, 1993).

A crater lake, mossy forest, and several river systems can all be found in the area. This is one of the few remaining areas where a significant population of unaltered montane dwellers can be found. It is one of the top priority areas in the National Integrated Protected Areas System (NIPAP, 1999). Almaciga forest, dipterocarp forest, mossy forest, and montane forest are the five vegetation communities that have been identified in the region (Amoroso et al., 2005).

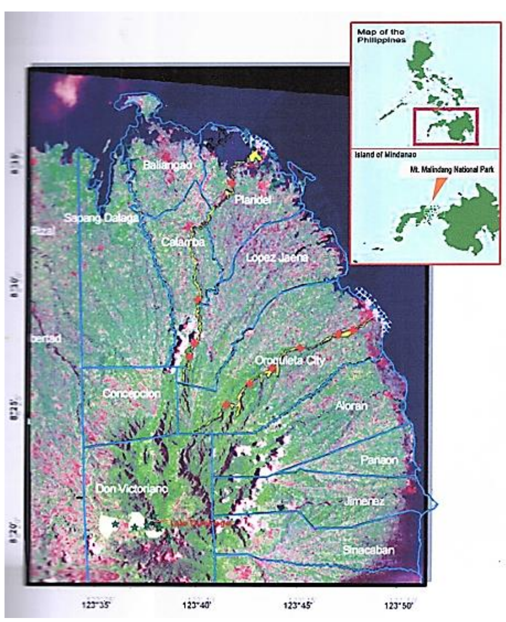

Figure 1. Location Map of Mt. Malindang National Park, Mindanao, Philippines.

Sampling Sites

About 54 plots were sampled in five vegetation types (Figure 2). Vegetation types include the mossy forest of Mt. Peak Tandayan (1,815-2,169 masl), the montane forest of Mt. Ulohan of Dapitan (1,490-1,769 masl), the almaciga forest of Old Liboron Mt. (985-1,375 masl), the dipterocarp forest of Mt. Capole (980-1,095 masl), and the agroecosystem of Brgy Mansawan (1,240-1,320 masl). Habitat was described following the description form of Haribon (2001). Vegetation data such as dominant plant species and forest communities were derived from the floral inventory conducted at the same site by the Biodiversity Research Program-Terrestrial Ecosystem Master Plan (BRP-TEMP) floral study group by Amoroso et al. (2005). Other important information with regard to habitat, such as on-site disturbances, was noted.

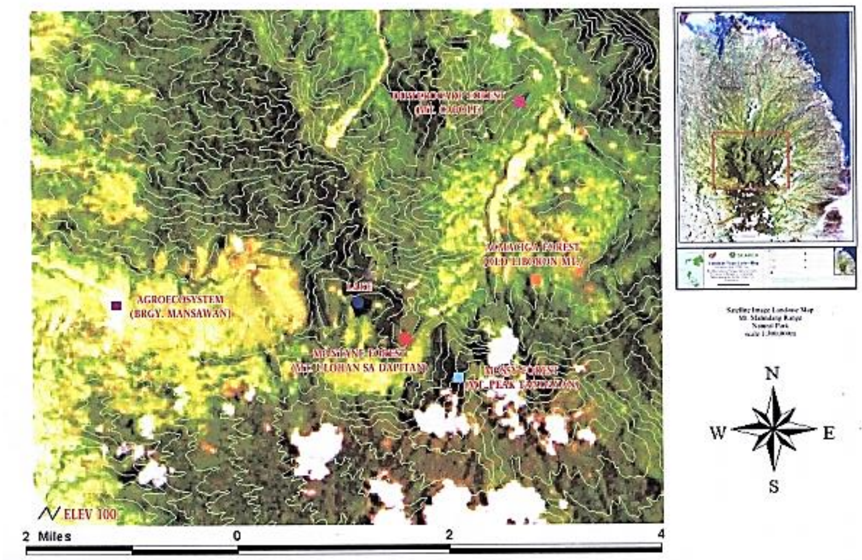

Figure 2. Topographic Map of Mt. Malindang National Park showing the sampling sites.

Field Methods

Time searching was for three collectors per hour per plot. It consisted of an hour-long search by the researcher and two trained local collectors. No samples of soil or litter were collected for laboratory investigation due to the patchy distribution of land snails in the area (Emberton et al., 1996; Cowie and Cook, 1999). For quantitatively sampling patchily distributed organisms, a timed search by skilled collectors is an approach that has been demonstrated to be effective (Coddington et al., 1991). Additionally, this study was intended as a species inventory survey with the goal of maximizing the number of species per unit effort.

The field team spent 30 minutes at each sampling site searching the above-ground vegetation (looking for leaves, trunks, under bark, and covering trees or shrubs within the plot) and the ground-level litter or soil for 30 minutes (looking under rocks and logs). Additional untimed samples were taken when interesting species were encountered. Visual searching was done at night.

Since the majority of snail species are essentially nocturnal, sampling was done throughout the day. Therefore, snail distributions during the day necessarily represent resting sites rather than sites of activity. However, field sampling was carried out during the rainy season, when snails appeared to be most active. Given that some species are small (2–10 mm) and probably do not travel far, the scale of the sampling method would be unlikely to allow resting and active sites to be distinguished. Field sampling was done for approximately 10–15 days at each site, for a total of 75 field days spent collecting land snails in the Mt. Malindang range.

Sorting and Identification of Land snail species

Land snails collected were sorted, counted, and identified. A representative of an unidentified specimen was coded and brought to the laboratory for further study and examination. Three individuals per species, relatively intact adult representatives, were chosen and photographed alive. They were then drowned in water, fixed, and preserved in 75% formalin. Live snails were returned to their original habitat after measuring and counting.

Specimens were classified as either alive or dead; the shell still had at least half of its periostracum, and the shell retaining its original color. This protocol eliminates the possibility of counting a single shell more than once and therefore does not influence the overall outcomes of the study.

Shell size was determined by measuring the adult shell's width and height. For uniformity, the following terms were considered for shell size: large, the longest shell dimension greater than 30mm; medium, the longest shell dimension between 10 and 30mm; small, the longest shell dimension between 3 and 10mm; and tiny, the longest shell dimension less than 3mm (Fahy, 2001). Shells were viewed in apical, basal, apertural, and abapertural views. The descriptions of shell shape, color, textural ornamentation, apertural shape, umbilicus opening, counting of whorls, animal features, and other descriptions follow Forsyth (2004). The biogeographic status of land snail species was indicated. Endemic species occur naturally only in the Philippines. Indigenous species occur not only in the Philippines but also outside the country. Introduced or alien species have been artificially brought to the Philippines.

All specimens were identified at the family, genus, or species level. For some juveniles, specific genera had unresolved taxonomy, making it impossible to give them a species name. Identification was based primarily on five books namely Compendium of Landshells (Abbott, 1989), The Philippine Landshells of the Genus Amphidromus (Bartsch, 1971), Tropical Landshells of the World (Parkinson et al., 1987), Shells of the Philippines (Springteen and Leobrera, 1986), and Foreign Land Shells (Webb, 1948). Further identification was made through internet sources.

All specimens identified were deposited in the collections of Mindanao State University – Iligan Institute of Technology Natural Science Museum.

Environmental Variables

For each site, six variables were recorded, namely elevation, canopy closure, soil temperature, vegetation type, litter type and abundance, and level of forest degradation. Elevation was measured using an altimeter and the Global Positioning System (GPS). Canopy closure was scored in the area in 12 classes, from 1 if the site was completely open to 12 if the canopy was more than 50% closed (Cowie et al., 1995). Using a thermometer, the soil temperature was measured at a depth of 0.5 cm. Five vegetation types were sampled based on the dominant trees or plants and these were mossy forest, montane forest, almaciga forest, dipterocarp forest, and agroecosystem. Litter type was divided into three levels: L1, closest to the soil, where leaves were black and could be classified as monocots and dicots because of composition; L2, brown dead leaves identifiable to family or species level; and L3, freshly fallen leaves, green-yellow brown. In many cases, the layer was artificially produced when trees were routinely pruned. Litter abundance was assessed using the following rating: 0 absent, 1 absent-scarce, 2 scarce, 3 scare-regular, 4 regular, 5 regular-abundant, 6 abundant, and 7 very abundant (Barrientos, 1998). Degradation of forests (cutting, burning, invasion by exotic vegetation, etc.) was scored in the field as: 0 one, 1 minor, 2 moderate, and 3 major (Emberton and Pearce, 1997).

Biodiversity Indices

For each station, total numbers of snail individuals (live collected plus dead shells) and species were tallied, and four indices were computed using the statistical program BIODIV PRO. Data analysis was performed on each of five response variables: relative abundance (RA), species diversity (H'), species richness (R), species evenness (E), and Sorensen's Index of Similarity (S).

Relative Abundance was computed using the formula:

$RA = n_i/\text{N} \times 100\%$ Where: n_i = the number of individuals per species
N= the total number of individuals

Species diversity (Shannon-Weiner)

$H = -\sum \pi \ln \pi$ Where: H=Shannon's Index
π = proportion of species I (i.e. number of individuals for species i relative to the number of individuals for all species)

Species Richness *R* = Total number of species

Species evenness

$E = H/ \ln R$ Where: H = Shannon-Weiner index
R= species richness per sampling site

Index of Similarity
Sorensen's index of similarity ISs = 2c/ A+B x 100

Where: A+B = total number of species in two sites
c=number of species common to both sites

Distribution Pattern of Land snails and Possible Relationships with Identified Variables

Canonical correspondence analysis (CCA) was used to link the abundance (combined number of live and dead individuals) of each species at each site to the six environmental variables, providing a more comprehensive picture of the fauna at each site and relating the distribution of snails to environmental factors. In studies of mollusks, which is frequently the case, CCA is particularly applicable when species exhibit a non-linear connection with environmental variables. The CCA is intended for assessments of species distribution along environmental gradients, or gradient analyses (Bishop, 1981).

There is a clear explanation on how to interpret the ordination diagrams produced by CCA. The direction and length of an arrow representing the environmental variable indicate the importance of the variable in the formation of the axes: the smaller the angle between the arrow for a particular variable and its axis, the larger the contribution of the variable to the axis; the longer the arrow relative to the other arrows, the greater the contribution. Perpendicular lines or lines of angle of 90 degrees indicate that the respective environmental variables are not correlated. Environment-related variables are negatively correlated when lines run in the opposite way (Ter Braak, 2002).

RESULTS AND DISCUSSION

Land snail species in Mt. Malindang

Twenty species of land snails were recorded in Mt. Malindang (Table 1). Of the species collected, seven are endemic to the Philippines, four are indigenous, and two are introduced. For some juvenile snails from the genera Helicostyla and Chloritis, the taxonomy that is currently use is ambiguous, in which case assigning species name is impossible. Also, in the case of the genus Helixarion, very few species were identified or given names at the species level. Slugs are more difficult to identify than snails. Taxonomically, land snails collected were classified following Parkinson et al. (1987) for Subclass Prosobranchia (Operculates) and Abbott (1989) for Subclass Pulmonata (Pulmonates). The opeculates collected belong to the family Cyclophoridae under the genera *Leptopoma* and *Cyclophorus*. The family is mostly ground-dwelling and lives in tropical and warm temperate areas of Asia, Africa, Australia, and Melanesia. The pulmonates belong to eight families (Camaenidae, Ariophantidae, Bradybaenidae, Trochomorphidae, Zonitidae, Agriolimacidae, and Veronicelliae), which are assigned to 12 genera and 10 species.

Table1. List of land snail species collected in Mt. Malindang National Park.

Family	Genus	Species	Author and Year	Status	Local Distribution	World Distribution
Agriolimacidae	*Deroceras*	*reticulum*	Muller, 1774	Introduced	Native to Europe	Worldwide
Ariophantidae	*Hemiplecta*	*globose*	Mollendorf, 1898	Endemic		Philippines
	Hemiplecta	*sp.*				
	Microparmarion	*sp.*				
Bradybaenidae	*Helicostyla*	*cryptica*	Broderip, 1841	Endemic	Samar, Luzon and Mindanao Islands	Philippines
	Helicostyla	*simplex*	Jonas, 1843	Endemic	Mindoro, Tablas, Romblon	Philippines
	Helicostyla	*sp.1*				
	Helicostyla	*sp.2*				
	Chloraea	*psittacina*	Grateloup, 1840	Endemic	Norther Luzon	Philippines
Camaenidae	*Amphidromus*	*malindangensis*	Barstch, 1917	Endemic	Mt. Malindang	Philippines
	Chloritis	*sp.*				
Cyclophoridae	*Leptopoma*	*sericatum*	Pfeiffer, 1851	Indigenous		Philippines, Borneo,
	Leptopoma	*perlucidum*	Grateloup, 1840	Indigenous	Kidapawan, Palawan,	Sumatra, Java

					Northern Luzon	Southeast Asia, Papua New Guinea
	Cyclophorus	*reevei*	Hidalgo, 1890	Endemic	Palawan	Philippines
Helicarionidae	*Hemiglypta*	*webbi*	Barstch, 1917	Endemic	Middle and Southern Philippines	Philippines
	Geotrochus	*bongaoensis*	E.A. Smith, 1894	Indigenous	Sibutu and Bongao	Philippines, Borneo
	Helixarion	*sp.*	Martens, 1864	Indigenous	Islands, Palawan	Philippines, Borneo
Trochomorphidae	*Videna*	*bicolor*	Martens, 1864	Indigenous		Philippines, Borneo
Veronicellidae	Unidentified					
Zonitidae	*Zonitoides*	*nitidus*	Muller, 1774	Introduced	Native to Europe	Worldwide

Biodiversity Indices

A total of 3,024 specimens (live snails and empty shells) were collected on the field, representing 20 species. The majority of the specimens collected were alive. The mossy forest yielded between 2 and 560 specimens per plot (live snails and empty shells). In total, 602 specimens were found, representing four species. In the montane forest, there were 3 to 137 specimens each plot, for a total of 356 specimens from nine different species. In untimed sampling, seven additional specimens from four different species were gathered. A total of 108 specimens from four different species were found in the almaciga forest, with the number of specimens per plot varying from 5 to 78. A total of 255 specimens from four different species were found in the dipterocarp forest, with the number of specimens per plot varying from 4 to 195. Sampling in the agroecosystem yielded between 3 and 1,547 specimens per plot. In total, 1,696 specimens were recorded, representing four species (Table 2).

Table 2. List of land snail species collected on Mt. Malindang National Park showing Indices of Biodiversity.

Species	**Mossy Forest**	**Montane Forest**	**Almaciga Forest**	**Dipterocarp Forest**	**Agroecosystem**	**Total**	**RA (%)**
Amphidromus malindangensis	2 (100%)	0	0	0	0	2	0.07
Dereceras reticulum	0	0	0	0	1547	1547	51.28
Geotrochus bongaoensis	25 (52.08%)	23 (47.92%)	0	0	0	48	1.59
Helicostyla cryptica	0	98 (41%)	0	0	141 (59%)	239	7.92
Helicostyla simplex	0	11 (100%)	0	0	0	11	0.36
Helicostyla sp.1	15 (100%)	0	0	0	0	15	0.50
Helicostyla sp.2	0	6 (100%)	0	0	0	6	0.20
Helixarion sp.	0	8 (100%)	0	0	0	8	0.26
Hemiglypta webbi	0	28 (100%)	0	0	0	28	0.93
Hemiplecta globosa	0	36 (35.64%)	18 (17.82%)	47 (46.53%)	0	101	3.35
Hemiplecta sp.	0	0	5 (35.71%)	9 (64.29%)	0	14	0.46
Microparmarion. sp.	0	9 (45%)	7 (35%)	4 (20%)	0	20	0.66
Leptopoma sericatum	0	137 (33.41%)	78 (19.02%)	195 (47.56%)	0	410	13.59
Leptopoma perlucidum	560 (100%)	0	0	0	0	560	18.56
Zonitoides nitidus	0	0	0	0	5 (100%)	5	0.16
Unidentified	0	0	0	0	3 (100%)	3	0.10
Total	602	356, 7* 363	108	255	1,696	3,024	-----
Relative Abundance	19.95%	11.80%	3.58%	8.45%	56.21%	------	
Species Diversity	0.14	0.73	0.37	0.30	0.14	0.65	
Species Richness	4	13	4	4	4	4	
Evenness	0.22	0.77	0.62	0.50	0.23	0.54	

*specimens collected by untimed sampling

Relative abundance was higher in the agroecosystem (RA = 56.21%). Among the forest types, mossy forest (RA = 19.95%) holds the highest number of specimens. The abundance of specimens in the agroecosystem was approximately three times as high as in the mossy forest. There was significant difference between the two sites at the 0.05 level ($p = 0.000$). However, these differences are largely the result of one introduced slug, *Deroceras reticulum,* in the agroecosystem that yielded much greater numbers than other specimens. The findings clearly demonstrate how the composition of native species is impacted by changes in the structural and floristic composition brought on by forest degradation as more introduced species dominate in the area. Conversion of forest into agricultural land allows the introduced species *D. reticulum* to prosper and reproduce in high densities in the agroecosystem since food such as cabbages and tomatoes is plentiful. Non-indigenous species tend to flourish in the altered ecosystem, given that native species do not occupy similar niches. Furthermore, introduced species may compete and dominate, which would likely establish a tough competition with the native species (Cowie, 2000; Cowie and Robinson, 2001). Slugs, with their sticky slime, cannot be easily eaten by some animals (Nordsieck, 2004). This introduced species (native to Europe) that is correlated with agriculture is widely distributed worldwide. It feeds on a variety of vegetables such as lettuce, celery, carrots, tomatoes, and cabbages (Symondson, 1996; Hamilton, 1999; Weisenhorn, 2001).

The high elevation and very low temperature of the mossy forest seem to favorably support one indigenous species, *Leptopoma perlucidum,* which is the second most abundant snail recorded on Mt. Malindang. These factors could have limited the distribution of predators that feed on snails since many fauna could not thrive in the mossy forest, where the temperature is relatively low. For instance, the reptiles, being cold-blooded, could not tolerate the very low temperature in the mossy and montone forest (Nuneza et al., 2005). Therefore, this snail can take refuge and breed away from threats. Furthermore, the thick layer of leaf litter on the floor provides a breeding site and microhabitat for the eggs and juvenile snails. Food resources such as mosses could have supported the population of this snail. However, for some snail species collected in the mossy forest, the number of each individual is very low, and mostly empty shells were found except for one species, *Geotrochus bongaoensis,* which is a ground dweller. One major reason for the low number is that these species, *Heliococysta sp. 1* and the Malindang endemic *Amphidromus malindangensis* are tree snails. Predation by birds is most likely the reason for the empty shells. Bird species richness is high in the mossy forest, which is comparable to the species richness in the almaciga forest (Nuneza et al., 2005).

A high number of specimens were collected for one Philippine endemic, *Helicostyla cryptica*. However, empty shells collected in the agroecosystem are greater than live specimens. This generalist tends to remain in the disturbed habitat since food sources abound at this site, but it is less likely that it can survive for a longer period of time. The high level of disturbance in this area increases the chances of competition and predation since the site does not offer sufficient hiding places for predators. Perhaps predation is the reason for this species to move upward to the montane forest. Intact forest, such as montane forest, provides hiding places against predators. Although a few of these species were collected in the montane forest, most of them are live snails.

The low species abundance in the dipterocarp forest (8.45%) and almaciga forest (3.58%) could be attributed to the diversity of vertebrate predators such as birds, reptiles, and mammals in these vegetation types. The two adjacent vegetation types are located in Bgry. Sebucal, and perhaps in the same environs since both sites are situated in the same landscape where elevation is similar. The highest species richness of amphibians, reptiles, and birds was recorded in the dipterocarp forest, followed by the amalciga forest. The species richness of mammals was also high in the amalciga and dipterocarp forests (Nuneza et al., 2005). Many losses in snail populations are because of their predators. Snail-eating birds are kites, egrets, ravens, doves, and gulls. Mindanao endemic, the Blue-capped Kingfisher *Actenoides hombroni* found on Mt. Malindang eats small snails (Bourns and Worcester in Mcgregor 1909–1910), as cited by Birdlife International (2001). The toads (*Bufonidae*) also eat larger snails. Among the reptiles, there are also many snail eaters, such as skinks and snakes. Many mammals eat snails, such as the hedgehog, moles, shrews, and rodents (mice and squirrels). Introduced predators like black rats (*Rattus tanezumi)* have a negative impact on land snail populations as they feed on or destroy the eggs of snails, preventing any reproduction by the snails (Coppois, 2005). This rat was found common in Bgry. Lake Duminagat and Sebucal (Nenuza et al., 2005) Humans are also limiting factors in snail populations. Habitat destruction due to farming and timber extraction is detrimental to the living snail population. Many other insects also eat snails, such as ants, beetles, spiders, and harvestmen (Nordsieck, 2004).

The data on relative abundance clearly demonstrate the critical importance of lush forests for the long-term survival of the malacofauna. Land snails are important links in the food chain. The loss of land snails could adversely affect the vertebrate predators that rely on snails for food. On the other hand, ecological imbalance due to an increasing number of predators (both natural and non-indigenous) and parasites or pathogens may lead to the loss of rare and native snails. Results further indicate that conservation of the remaining forest is critical for land snails inhabiting the area. The support of local people is a key to preventing ecological imbalance, as they are the direct users of nature. There is a need to formulate a participatory approach to biodiversity management and conservation at the local level, where all communities in the area are involved.

The montane forest was found to be the most diverse (H' = 0.73) among the vegetation types studied. The difference between montane forest and that of mossy forest, agroecosystem, and dipterocarp forest is statistically significant at the 0.05 level ($p = 0.0380$). Species diversity in the montane forest seemed to be attributed to elevation and floral composition factors. Most of the land snails recorded in the area are highly dependent on forest plants such as mosses, unicellular algae, lichens, *Cyrtandra cumingii, and Colcasia sp*. for food. This ecologically distinct forest offers a diversity of plants used by the snails as food sources, breeding sites, and a humid environment. A floral survey of the Biodiversity Research Programme-Terrestrial Ecosystem Master Project (BRP-TEMP) revealed that the area had very high plant diversity based on species richness, endemism, and diversity value, which is considered to be the highest among all the vegetation types. There are 263 plant species recorded (Amoroso et al., 2005). This could explain the high snail diversity in the montane forest.

Species richness was high in the montane forest. Nine species belonging to six families were recorded: *Leptopoma sericatum, Hemiplecta globosa, Helicostyla cryptica, Helicostyla simplex, and Helicostyla sp. 2, Hemiglypta webbi, Geotrochus bongaoensis, and Helixarion sp.* and *Microparmarion sp*. Four additional species belonging to four families were collected in untimed sampling: *Chloraea psittacina, Videna bicolor, Cyclophorus reevei, and Chloritis sp*. Only four species belonging to four families were found in the mossy forest: *Leptopoma perlucidum, Amphidromus malindangensis, and Helicostyla sp. 1,* and *Geotrochus bongaoensis.* Almaciga and dipterocarp forests shared four species belonging to four families: *Leptopoma sericatum, Hemiplecta globosa, and Hemiplecta sp. and Microparmarion sp.*

A high number of endemic species (7) was recorded in the montane forest. However, a low number of each individual species was observed. Factors such as competition, predation, and on-site disturbances could be the reason for the very low number. The Malindang Range has a few remaining patches. Bgry. Mansawan stretch to Bgry. Gandawan and part of the Bgry. Lake is already denuded. Special attention has to be given to montane forests since these support a greater number of endemic species. The conservation of this habitat is therefore important for the survival and continued existence of snail species with critical populations.

However, valid comparisons of species richness can actually be made in terms of area. This local species richness appears equivalent to that of other parts of the world, which ranges up to about 30 species but usually fewer (Solem, 1984; Cameron, 1992). A greater number of species might be found in particularly diverse areas, but the species might not be sympatric on a small scale. The most prominent exception is the discovery of over 70 species that were genuinely suggested to be "microsympatric" in small patches of woodland in New Zealand. Other areas (in the Caribbean and Australia) are also known to host large quantities of microsympatric snail species. The fact that there are so few species in the current study compared to other islands with higher species richness, such Palawan, indicates that the majority of Philippine land snails are geographically extremely confined (lowland, rainforest, etc.). Furthermore, it is not surprising that some of the current materials represent unnamed species given that collections have not previously been collected in the research area.

Land snails on Mt. Malindang are unevenly distributed (E = 0.54). This result indicates a clear cluster of land snails in the survey area. Ground-dwelling herbivores, *Hemiplecta globosa*, occur more commonly in the moist areas grown with *Elatostema species* at lower elevations of the dipterocarp, almaciga, and montane forests. Two relatively abundant species have very opposite habitat preferences. One species, *Leptopoma perlucidum*, is completely restricted to undisturbed mossy forest. This is confined to moist or humid microhabitats at this higher elevation. On the contrary, widespread *Helicostyla cryptica* can tolerate disturbed habitats. This species is often associated with human disturbances in cultivated areas. Many native land snails are quite habitat-specific and normally occupy a suitable microenvironment that offers breeding sites, a humid environment, sufficient cover, and an abundant supply of food (Goldberg, 1998). Microclimate, competition among organisms in the different vegetation types, and variation in the distribution pattern of resources are factors to consider for the differences in their distribution. Disturbance and anthropogenic land use changes are considered to be key factors influencing the patchiness of land snails. This occurs when there are ecological changes in the area that can lead to a decline in population or even the loss of these species. Factors such as abiotic and biotic factors are also known to influence species distributions (Cowie et al., 1995).

Similarity indices of sampling sites showed that the montane and dipterocarp forests are 57.94% similar (Table 3). Two snail species in the montane forest can be found in the dipterocarp forest. The result implies that these snails, *Leptopoma sericatum* and *Microparmarion sp*. that inhabit these sites showed similar relative densities. This could be attributed to floristic composition. These snails feed on common and widely distributed plants in the study area. For instance, lichens and unicellular algae are food for *Leptopoma sericatum,* while *Colocasia sp.* is also food for *Microparmarion sp.* Almaciga and dipterocarp forests are 57.85% similar. These two adjacent sites have similar species compositions. The similarity in species composition could be attributed to the similarity in soil temperatures (18 °C). Four species were found to inhabit the almaciga and dipterocarp forests. However, one *Hemiplecta sp.* was found restricted to these forest types. Snails can frequently be found in a range of settings, however many species have preferred habitats. The presence and number of species in a given type of habitat were governed by variations in moisture and vegetation related with elevation (Labuane and Magnin, 2001).

Table 3. Similarity Index Values of the five stations in Mt. Malindang National Park.

	Mossy Forest	Montane Forest	Almaciga Forest	Dipterocarp Forest	Agroecosystem
Mossy Forest	*	4.80%	0	0	0

Montane Forest	4.80%	*	44.40%	57.94%	9.55%
Almaciga Forest	0	44.40%	*	57.85%	0
Dipterocarp Forest	0	57.94%	57.85%	*	0
Agroecosystem	0	9.55 %	0	0	*

Distribution of Land snail species in Mt. Malindang

On the two axes of the Canonical Correspondence Analysis (CCA), the ordination diagram (Fig. 3) illustrates the relationship between species and vegetation in respect to the vegetation-related variables (Table 4). Since there is a strong link between species and environment (r values range from 0.993 to 0.995), environmental factors can be used to explain how different species are distributed. The cumulative percentage variance of species-environment relationships is 79.1%, meaning that environmental factors account for 79.1% of the variance in species abundance per site. The findings of the global permutation test show that there is a strong correlation between species and environmental factors. The test of significance based on the sum of all canonical eigenvalues is 2.143, and the resulting p-value is 0.0010, indicating that the measured environmental variables significantly explain the species composition at the 0.05 level.

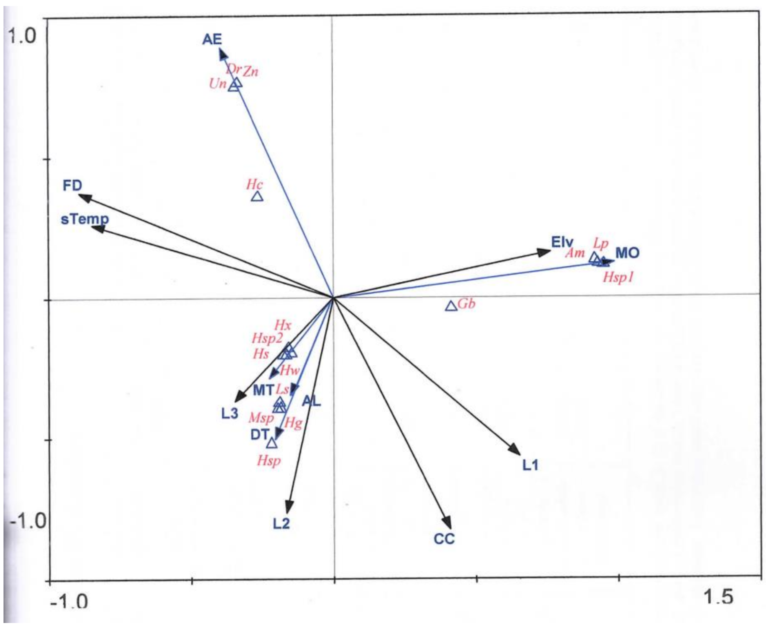

Figure 3. Ordination diagram showing sites and species distribution on axes 1 and 2 of the CCA. The sites are indicated by vegetation type: MO-mossy forest, MT- montane forest, AL- almaciga forest, DT- dipterocarp forest and AE-agroecosystem. Snail species are represented by Am-*Amphidromus malindangensis,* Dr-*Dereceras reticulum*, Gb-*Geotrochus bongaoensis*, Hc-*Helicostyla cryptica*, Hs-*Helicostyla simplex*, Hsp1-*Helicostyla sp.1*, Hsp2-*Helicostyla sp.2*, Hx-*Helixarion sp.*, Hw-*Hemiglypta webbi*, Hg-*Hemiplecta globose*, Hsp-*Hemiplecta sp.*, Msp-*Microparmarion. sp.*, Ls-*Leptopoma sericatum*, Lp-*Leptopoma perlucidum*, Zn-*Zonitoides nitidus*, and Un-Unidentified. The other arrows represent the vegetation-related variables: Elv-Elevation, CC-canopy cover, FD-forest degradation, sTemp-soil temperature and Litter and abundance in L_1 L_2 and L_3.

Table 4. Summary of Environmental data collected in Mt. Malindang National Park.

Station	**Type of Vegetation**	**Dominant Vegetation**	**Elevation**	**Soil Temp (°C)**	**Canopy Closure**	**Litter type and Abundance**			**Degradation of Forest**
						L1	**L2**	**L3**	
Mt. Peak Tandayan	Mossy Forest	*Ascarina philippinensis* and *Xanthomyrtus diplycosifolium*	>1,815	13	10	6	2	1	0
Mt. Ulohan of Dapitan	Montane Forest	*Clethra lancifolia* and *Impatiens*	1,490-1,769	16	11				2

		montalbanica				5	3	3	
Old Liboron Mt.	Almaciga Forest	*Agathis philippinensis* and *Cinnamomum mercadoi*	985-1,375	18	11	4	3	2	1
Mt. Capole	Dipterocarp Forest	*Ficus minahassae* and *Bichofia javanica*	980-1,095	18	9	4	3	2	2
Brgy Mansawan	Agroecosystem	Vegetable*: Sechium edule* and *Allium fistulosum*	1,240-1,320	20	1	1	1	1	3

Canopy closure was scored in 12 classes: 1 if the site was completely open, to 12 if the canopy was more than 50% closed; Litter type was divided into three levels: L1 closest to the soil, L2 brown dead leaves and L3 freshly fallen leaves; Litter abundance was assessed using the following rating: 0 absent, 1 absent-scarce, 2 scarce, 3 scarce-regular, 4 regular, 5 regular-abundant, 6 abundant and 7 very abundant; Degradation of forest: 0 none, 1 minor, 2 moderate and 3 major

A biplot visualizes the correlation between species and environmental variables. The blue lines in Figure 3 represent the five vegetation types. The black lines correspond to the vegetation-related variables, and the species are denoted by a triangle symbol. Lines pointing in the same direction indicate that the corresponding explanatory variables are correlated with each other. Shown in the diagram are the three vegetation types: montane, almaciga, and dipterocarp forests. These vegetation types have thick accumulations of leaf litter types in L2 and L3. Some of the species in the montane forest are also found in the almaciga and dipterocarp forests. The species that inhabit these sites prefer habitats with abundant litter types in L2 and L3. Furthermore, almaciga and dipterocarp forests are collinear, which implies that the two vegetation types are similar in species composition. Vegetation-related variables such as forest degradation and soil temperature are correlated to each other and are also closely related to forest types. However, long lines are more important than short ones. The longer the arrow relative to the other arrows, the greater the contribution of the variable to the formation of the axes.

Lines pointing in opposite directions are negatively correlated. Shown in the diagram are the agroecosystem and vegetation-related variables such as canopy closure, litter type and abundance in L1. The denuded forest in the agroecosystem area resulted in an increase in soil temperature with no accumulation of leaf litter. Lines with an angle of 90 degrees indicate that the two variables are uncorrelated. Shown in the diagram are the mossy forest and agroecosystem. Undisturbed mossy forest has the highest altitude, dense canopy cover, thick accumulation of leaf litter in L1, and lowest temperature, whereas an agroecosystem regarded as the degraded montane forest and an open area have the highest temperature recorded. However, the mossy has few accumulations of litter types in L2 and L3. The agroecosystem and three forest types (montane, dipterocarp, and almaciga) are also uncorrelated. This could be attributed to the absence of canopy cover in agroecosystems in contrast to the dense canopy cover in forest types as well as the abundance of leaf litter. Mossy forest is also uncorrelated with the three forest types (montane, dipterocarp, and almaciga), which seemed to be attributed to the thick accumulation of leaf litter in L1 and their differences in species composition. Forest degradation appears related to montane forests. This shows that slight forest degradation in the area was linked to lower snail densities but did not negatively affect species diversity. It was observed that only a few individuals were collected for each type of species. The same integration holds for species. The land snail species close to a particular variable are highly correlated. The clear clustering of species in the diagram suggests that there are strong associations among snail species. However, the species plot close to the center of the ordination diagram also indicates no strong association with any of the environmental variables incorporated in the analysis (Ter Baak, 2002).

In the present study, the canonical coefficients revealed that mossy forest is highly and positively correlated with the first axis, with a correlation of 0.9828 (G test: p-value = 0.0010). This vegetation type is the most important variable among those included in the study. Elevation, litter type, and abundance in L1 and canopy closure are also positively and highly correlated with the first ordination axis, with a correlation of 0.7593, 0.6517, and 0.4085, respectively (Fig. 3, Table 5). Litter and abundance in L1 and canopy closure appear related to almaciga, dipterocarp, and montane forest but not elevation. The suitable microenvironment provided by mossy forest yielded a much greater number of specimens as compared to other forest types. This may be attributed to its undisturbed environment. In effect, its conditions, such as the relatively dense canopy cover that affords a great deal of protection from desiccation and the thick layer of thick leaf litter, provide microhabitat for snails. Most snails thrive in places where there is shade, moisture, and an accumulation of litter (Fahy, 2001). Leaf litter abundance was strongly correlated with snail density, but only for a few rare species (Emberton et al., 1996). Species associated with mossy forests were *Leptopoma perlucidum, Amphidromus malindangensis, and Helicostyla sp. (1), and Geotrochus bongaoensis*. Of these, only *Leptopoma perlucidum* is at all common, being the overall second most abundant species recorded. The low number of other species is possibly a reflection of their rarity. A study by Barrientos (1998) revealed that live snails and eggs were strongly correlated with litter type and abundance in L1.

Table 5. Canonical coefficients of the environmental variables incorporated with the first two axes of the CCA.

Variable	**Axis 1**	**Axis 2**
Mossy Forest	0.9828	0.1204
Montane Forest	-0.2258	-0.2855
Almaciga Forest	-0.1410	-0.3443
Dipterocarp Forest	-0.2033	-0.4973
Agroecosystem	-0.3927	-0.8843
Elevation	0.7593	0.1598
Litter type and abundance L1	0.6517	-0.5596
Litter type and abundance L2	-0.1642	-0.7584
Litter type and abundance L3	-0.3460	-0.3657
Soil Temperature	-0.8399	0.2589
Canopy Closure	0.4085	-08182
Forest Degradation	-0.8868	0.3704

In axis 2, the agroecosystem is highly and positively correlated with the second axis, with a correlation of 0.8843 (G test: p-value = 0.0010). Forest degradation and soil temperature appear closely related to agroecosystems, with a correlation of 0.3704 and 0.2589, respectively (Fig. 3, Table 5). Barangay Mansawan (the site selected as an agroecosystem) was once a diverse forest land but was disturbed due to logging and conversion of land use to an agroecosystem. The soil temperature is higher as compared to other vegetation types. A high density of introduced species in degraded forests (agroecosystems) could have created new ecotonal habitats and supported non-indigenous species.

Rarity and patchiness were also observed. Seven species were found only in very low numbers and/or in very specific vegetation (with specimens of not more than 10). Six species were found in the montane forest*: Helixarion sp*. (8), *Helicostyla sp. 2* (6), and four species collected in untimed sampling: *Cyclophorus reevei* (1), *Chloraea psittacina* (1), *Videna bicolor* (3), and *Chloritis sp.* (2). The absence of live individuals of *Amphidromus malindangensis* explains the relative rarity of the study area. This species was recorded in very low numbers (only two specimens were found) from the mossy forest at higher revelation. The absence of rare species from other vegetation communities may also be related to the rarity of the snail species (Cowie et al., 1995). However, this rarity of species may only be a local phenomenon and does not reflect overall rarity in the Philippines.

The CCA indicates a strong influence on any of the vegetation variables on snail species distribution. The group of snail species close to the vegetation variables indicates a strong association with any of the vegetation variables incorporated in the analysis. Vegetation is recognized as one of the determinants of snail distribution and abundance (Labuane and Magnin, 2001). A patterning of the distribution of the snail species in the research region may be indicated by the presence or absence of specific snail species in particular vegetation (Table 6). In the ordination diagram, groups of species were confined to a particular vegetation type: three in mossy forest, three in agroecosystem, and four in montane forest. Almaciga and dipterocarp forests are collinear, which means that both have similar species composition.

Table 6. Presence (+) or absence (0) of land snail species with vegetation type.

Species of Land snails	Vegetation Type				
	Mossy Forest	Montane Forest	Almaciga Forest	Dipterocarp Forest	Agroecosystem
Amphidromus malindangensis	+	0	0	0	0
Chloraea psittacina	0	+	0	0	0
Chloritis sp.	0	+	0	0	0
Cycloporus reevei	0	+	0	0	0
Dereceras reticulum	0	0	0	0	+
Geotrochus bongaoensis	+	+	0	0	0
Helicostyla cryptica	0	+	0	0	+
Helicostyla simplex	0	+	0	0	0
Helicostyla sp.1	+	0	0	0	0
Helicostyla sp.2	0	+	0	0	0
Helixarion sp.	0	+	0	0	0

Hemiglypta webbi	0	+	0	0	0
Hemiplecta globosa	0	+	+	+	0
Hemiplecta sp.	0	0	+	+	0
Microparmarion. sp.	0	+	+	+	0
Leptopoma sericatum	0	+	+	+	0
Leptopoma perlucidum	+	0	0	0	0
Vedina bicolor	0	+	0	0	0
Zonitoides nitidus	0	0	0	0	+
Unidentified	0	0	0	0	+
Total	4	13	4	4	4

Furthermore, direct observation of the data indicates that the distribution of land snails was influenced by the availability of food resources in the area. A study by Pomeroy (1969) reveals that when food is removed from field plots, snails migrate to other areas where the food source is more readily available. Two species, *Hemiplecta globosa* and *Hemiplecta sp.* have a similar distribution, being absent in the upper elevations but abundant in the lower elevations of the study area. The distribution of these species appears to be correlated with the presence of *Elatostema sp.*, which is only recorded at lower elevations of the almaciga and dipterocarp forests. According to Clayton-Greene and Wilson (1985), the herb *Elatostema sp.* prefers moist and deeply shaded conditions. The snails were observed feeding on the fleshy stem of *Elastema sp.* One species, *Leptopoma perlucidum,* confined to the mossy forest, was positively associated with mosses. This species feeds on mosses coating tree trunks and fallen logs (Vermeulen and Schilthuizen, 2004). *Microparmarion sp.* and *Leptopoma sericatum* are widely distributed in the montane, dipterocarp, and almaciga forests. These snails were observed to feed on common and widely distributed plants in the study area. The lichens and unicellular algae are food for *Leptopoma sericatum,* while *Colocasia sp*. is food for *Microparmarion sp.*

The snail habitat preferences and shell structure also indicate land snail distribution. Snails with depressed shells are ground dwellers that prefer to crawl on horizontal surfaces (Fahy, 2001). They inhabited the surfaces under vegetation, feeding on the detritus of the forest floor, fallen fruits, herbaceous stems, tender roots of plants, and leaf vegetables (Abbott, 1989). They cannot tolerate very steep or cliffy areas. Snails with conical or high-spired shells tend to climb saplings, shrubs, and trees. Tree snails, or canopy-dwelling snails, will browse on algae, fungi, sooty molds, and lichens that grow on the trunks (Parkinson et al., 1987). Most of the ground dwellers collected inhabited the forests at lower elevations. Tree snails such as *Amphidromus malindangensis* and *Helicostlya sp.* can be found only in the highly dissected, steep-sloped, mossy forest. Slugs are both ground and arboreal snails. *Deroceras reticulum* climbs plants for food and lays eggs on the ground (Forsyth, 2004).

The nine species that are only found in the montane forest were positively correlated with the high plant diversity in the area. The majority of the snails were seen eating on tender plant leaves. *Helixarion sp*. is was seen eating immature *Cyrtandra cumingii* leaves, which are unique to montane forest. Perhaps some biological connection or varied habitat preferences between snail species are shown by the vegetation pattern. The interaction with vegetation communities may be more crucial for the species as the CCA showed a much stronger influence on vegetation compared to other environmental variables included in the analysis.

The total eigenvalue of the CCA shows that 79.1% of the overall variation in species abundance by site was explained by the environmental variables included in the study. Other abiotic and biotic factors may contribute to the remaining variance's explanation (Cain, 1983). Snail distributions abroad are known to be influenced by abiotic conditions such soil pH, humidity, and calcium availability, though their impacts are not always clear-cut (Bishop, 1891). Unfortunately, the necessary information was not available to include these variables in the current investigation. The spatial distributions or abundance of land snails have rarely been shown to be influenced by competitive interactions, predations, historical events, or spatial structures, despite the possibility that these factors could produce biogeographic patterns on a local or regional scale (Labuane and Magnin, 2001). Although historical influences have been demonstrated to be significant (Cameron and Dillon, 1984), very few studies have focused on this issue. The relative significance of these variables in connection to the unexplained variance in the current study cannot be speculated. Such studies are unusual in that a sizable portion of the variance is left unexplained. However, the variables that are discovered to have a significant impact might still have a role in the community under study's organization (Borcard et al., 1992). But it's also conceivable that environmental variability on a much finer microscale than that taken into account in the current analysis has a significant impact on how widely the species are distributed.

The total eigenvalue of the CCA indicates that the environmental variables incorporated in the study explained 79.1% of the overall variance in species abundance by site. The remaining variance may be partly explained by other abiotic and biotic factors (Cain, 1983). Abiotic factors such as calcium availability, soil pH, and humidity are known to influence snail distributions elsewhere, although their effects are not always straightforward (Bishop, 1891). Unfortunately, it was impossible to obtain appropriate data to incorporate these variables into the present study. Competitive interactions, predations, historical factors, and spatial structures have rarely been demonstrated as influencing the spatial distributions or abundance of land snails, although these factors could generate biogeographic patterns on a local or regional scale (Labuane and Magnin, 2001). This is suggested by the highly significant differences in species diversity between montane forest and other vegetation types.

Of the overall variance, the first two axes of the CCA explain only 79.1%. These two axes appeared to be related most closely to vegetation type. In the mossy forest, one species, *Leptopoma perlucidum,* is sufficiently abundant to suggest that its recorded distribution relates to vegetation type and altitude. This clear relation between the distribution of some snail species and the overall association of the floral composition with altitude may be related to factors such as temperature and rainfall. Certainly, climate factors have frequently been considered of fundamental importance in determining snail distributions (Asami, 1993; Baur and Baur, 1993). There is a gradient, at least in temperature and perhaps in rainfall, related to altitude in the study area (Amoroso et al., 2005), although the range is small and variation on a microhabitat scale might be important. But, in the absence of appropriate data on the temperature tolerance, resistance to desiccation, and other factors of the snail species, further speculation is not justified.

A number of associations of certain species with vegetation are clear. However, it is not exactly clear what real variables are associated with vegetation that are influencing these associations. The vegetation-related variables incorporated in the study were not strongly related to the snail fauna's composition. The other variables associated with the vegetation may be important for the snails. The vegetation might influence such factors as soil chemistry and depth and the decomposition rate of litter. It is difficult to precisely define the determinant factors that explain land snail distribution and abundance because most variables are interrelated. In addition, the present study has generally examined only a limited number of environmental variables, yielding a partial and local description.

The land snail fauna is recognized as being under serious threat of extinction, with many species already gone. Seddon (2002) stated that terrestrial mollusks are among the most severely threatened organisms. Nearly 65% of the extinctions of modern times are from mollusks (Madhyastha et al., 2000). Unfortunately, no baseline data was available on the present status of land snails in the Philippines, let alone the status of threats to this significant group of invertebrates. The abundance of empty shells of one species, *Helicostyla cryptica,* in the present study might reflect a recent increase in mortality of this species and the possibility that it may become locally extinct in the near future. The significant reduction in snail numbers worldwide probably resulted from habitat change, which is likely to be highly detrimental to the land snail fauna. The greatest threat to land snails is habitat destruction due to deforestation. Other factors to consider are farming, logging, the introduction of non-indigenous species, and the extraction of native species. Predation by backyard chickens and perhaps introduced birds, rodents, and other introduced animals are all serious threats to the endemic snail community. However, the importance of land snails as food resources for larger animals makes it more significant to study this organism.

CONCLUSIONS

A malacofaunal survey at elevations between 985 and 2,169 masl in the Mt. Malindang range recorded 16 species using the timed search method, with an additional four species collected by untimed sampling. Five sites were sampled, representing different vegetation types. The land snails of the area are composed mostly of endemic species. Seven are endemic to the Philippines (*Cyclophorus reevei, Amphidromus malindangensis, Hemiplecta globosa, Helicostyla cryptica, Helicostyla simplex, Chloraea psittacina,* and *Hemiglypta webbi);* four are indigenous *(Leptopoma sericatum, Leptopoma perlucidum, Geotrochus bongaoensis,* and *Videna bicolor);* and two are introduced species *(Zonitoides nitidus and Deroceras reticulum*) found in the agroecosystem.

Assessment of land snail faunal diversity revealed that the montane forest is relatively rich. The area is the most diverse in terms of both the total number of species and the number of endemic species. A total of 13 species were recorded in this area, while only four species were found in other vegetation types. The considerably high species richness recorded in the montane forest seemed to be attributed to the complexity of vegetation composition and structure in this area.

The 20 species are not uniformly distributed across the study area, indicating the presence of ecological specialists. Groups of land snails were confined to particular vegetation types: three species in the mossy forest

(*Leptopoma perlucidum*, *Amphidromus malindangensis* and *Helicostyla sp.1*), eight in the montane forest (*Hemiglypta webbi, Helicostyla simplex*, *Helicostyla sp.2*, *Cyclophorus reevei, Chloraea psittacina, Chloritis sp.*, *Helixarion sp.* and *Videna bicolor*), and three in the agroecosystem (*Zonitoides nitidus, Deroceras reticulum* and unidentified species belonging to family Veronicellidae. Fourteen species were restricted to only one vegetation type and six species were widespread in the study area (*Leptopoma sericatum*, *Hemiplecta globosa*, *Hemiplecta sp.*, *Microparmarion sp.*, *Helicostyla cryptica* and *Geotrochus bongaoensis*). Calculation of the similarity index showed that almaciga and dipterocarp forests had similar species composition, indicating similarity in habitat types as compared to other vegetation.

The relatively high number of land snail specimens occurring in the agroecosystem may be attributed to the increased availability of food plants, although one species, *Deroceras reticulum*, has been identified to dominate this area. Among the forests, the mossy forests hold the highest number of specimens. *Leptopoma perlucidum* was the most abundant species in the mossy forest. The widespread *Leptopoma sericatum* dominated the montane, almaciga, and dipterocarp forests. The number of specimens at each site may have been affected by changes in vegetation structure and floristic composition with altitude.

The pattern of species richness and diversity observed in Mt. Malindang was not consistent with the widely accepted general pattern that has been demonstrated for many fauna, that is, species diversity and richness declining with increasing elevation. Montane forest with elevation from 1,490-1769 masl was observed to be the most diverse in terms of species richness, number of endemic species and diversity indices. Mossy forest (1,815-2,169 masl), almaciga forest (985-1,375 masl), dipterocarp forest (980-1,095 masl), and agroecosystem (1,240-1,320 masl) were observed to have low species diversity and richness.

Canonical Correspondence Analysis (CCA) demonstrated significant relationships between snail species distribution and environmental variables. Local patterning in the land snail distribution in relation to vegetation type and vegetation-related variables explained 79.1% of the variance in distribution and abundance. The unexplained variance is probably related to other abiotic, biotic, stochastic, and scale factors. The CCA results seemed most strongly related to vegetation and altitude.

Vegetation-related variables such as canopy closure, elevation, litter type, and abundance are associated with forest types, while forest degradation and soil temperature are related to the agroecosystem. The survey area has no previous collection, and the assessments of the present species distribution may suggest that the species recorded are representatives of the faunal characteristics of Mt. Malindang. The structural organization of the habitat was inferred to be the greatest factor influencing the distribution of land snails. Anthropogenic activities such as timber extraction and farming (the "kaingin system) are considered to be key factors that have influenced the patchiness of land snails. Physical factors like humidity and temperature, along with biotic interactions such as competition and predation, were considered to have affected diversity and abundance.

The highest snail diversity was recorded in the montane forest (The highest snail diversity was recorded in the montane forest (H' = 0.73), implying that a special conversation in this habitat is necessary for the retention of the broadest molluscan diversity. The majority of species in the montane forest were found only at very low levels of abundance. The area is therefore of particular significance in the conservation of what remains of this unique and highly diverse family. The observation that one rare species, *Amphidromus malindangensis*, endemic to the mountain, was recorded in the mossy forest further suggests that conservation of the entire Mt. Malindang forest is critical for efficient molluscan conservation. Of the 290 species of land snails recorded in the Philippines, about 7% are found on Mt. Malindang. The majority of the species were recorded at low levels of abundance and are probably declining; therefore, investigation of the ecology of snails by examining a wide range of environmental factors to understand factors that influence the snail's diversity is recommended.

Land snails play an important role in the ecosystem. They serve as food for birds, frogs, chickens, and other animals in the forest. Consequently, snail biomass is of great ecological significance to the biodiversity of Mt. Malindang. Some habitat destruction and disturbances observed in the area could result in the decline of a number of land snail species and other fauna. With these threats identified, it is apparent that there is a need for an effective management and conservation program in Mt. Malindang, a kind of program that aims to improve and encourage understanding of ecosystems and promote education and awareness on the use of biological resources sustainably. The use and management of biological resources in a sustainable manner will maintain healthy and functioning ecosystems in the long term.

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