December 1, 2023

Carmen Ramina S. Tubal
Chief
Department of Environment and Natural Resources
MIMAROPA Region

Dear Chief Tubal,

I hope this letter finds you in good health. I am Andrea Paula D. Aguilar, a 4th-year Biology student at Polytechnic University of the Philippines, writing to express our intent to obtain a Gratuitous Permit for our upcoming research project entitled "Taxonomic Survey of Land Snail in Lubang Island, Occidental Mindoro, Philippines." My fellow student, Ms. Kimberly S. Santos, and I are *eager* to conduct this study, contributing valuable insights into the malacofauna of Lubang Island.

Enclosed with this letter are the necessary documents for compliance with DENR regulations, including the Research Project Proposal, the endorsement letter from our concerned Dean, and prior clearance from the Municipal Mayor. These documents outline the scope, objectives, and ethical considerations of our proposed research.

We are committed to conducting this study with the highest ethical standards and environmental responsibility. Obtaining a Gratuitous Permit is integral to ensuring that our research aligns with DENR guidelines, emphasizing the responsible and sustainable exploration of Lubang Island's malacofauna.

We kindly request your support and approval for the issuance of a Gratuitous Permit to facilitate the successful implementation of our study. We believe that our research will significantly contribute to our understanding of the region's unique ecosystems while adhering to the principles of environmental conservation.

Should you require any further information or clarification, please do not hesitate to contact me at aguilar.ands04@gmail.com. I appreciate your time and consideration and look forward to the opportunity to collaborate with the Department of Environment and Natural Resources.

Thank you for your support.

Respectfully,

Andrea Paula D. Aguilar
BS Biology Student
Polytechnic University of the Philippines – Manila

Republic of the Philippines
PROVINCE OF OCCIDENTAL MINDORO
MUNICIPALITY OF LUBANG

OFFICE OF THE MUNICIPAL MAYOR

November 24, 2023

Andrea Paula D. Aguilar
BS Biology Student
Polytechnic University of the Philippines - Manila

Dear Ms. Aguilar,

Greetings from the Island Municipality of Lubang!

Anent to your email letter dated October 27, 2023, expressing your desire to undertake a research project on the island, specifically in the following areas:

1) **Community Structure of Family Cypraeidae**
2) **Taxonomic Survey of Land Snails**
3) **Taxonomic Survey of Sea Cucumbers**
4) **Community Structure of Genus Siphonaria**

Please be informed that your request is hereby **APPROVED**. We wish you good luck in your undertakings and hope that your research will be useful for the intellectual development of further research studies and for the people of the Municipality of Lubang.

Sincerely,

MICHAEL LIM ORAYANI
Municipal Mayor

POLYTECHNIC UNIVERSITY OF THE PHILIPPINES

TAXONOMIC SURVEY OF LAND SNAILS IN LUBANG ISLAND, OCCIDENTAL MINDORO, PHILIPPINES

A Thesis Proposal
Presented to the Faculty of Department of Biology
Polytechnic University of the Philippines
Sta. Mesa. Manila

In Partial Fulfilment of the Requirements for the Degree of
Bachelor of Science in Biology

by

Aguilar, Andrea Paula D.
Santos, Kimberly S.

November 2023

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Chapter 1

THE PROBLEM AND ITS SETTING

1.1 Introduction

Understanding and safeguarding ecosystems significantly depend on biodiversity investigations. The unique flora, fauna, and geological composition of Lubang Island in the Philippines categorize it as the ninth largest biogeographic zone in the country, both in terms of land area covered and the high level of biodiversity and endemism it hosts (Lit et al., 2011). The Lubang Group of Islands, located northwest of Mindoro and approximately 150 kilometers southwest of Manila, experiences two distinct weather patterns: dry and rainy seasons, with an annual temperature ranging from 23-31°C and annual rainfall from 9 to 623 mm. This climatic diversity fosters a broad array of species (Asinas, 2022). Moreover, the island is renowned for its rich biodiversity, owing to diverse habitats that encompass dense tropical forests and coastal areas. Since it is recognized as a biogeographic region, it also stands as one of the centers for flora and fauna species (Bacudo et al., 2006). While research efforts have predominantly focused on marine organisms in the Philippines' coastal islands, studies on other terrestrial biodiversity remain notably underexplored. Lubang Island provides an ideal setting for examining the presence of terrestrial organisms, particularly land snail species, as it is covered mostly by thick tropical virgin lowland rainforest and surrounded by moisture-dependent vegetation (Yulo & Cruz, 2011).

Terrestrial snails, belonging to the class Gastropoda, serve as decomposers and indicators of environmental health (Capinera & White, 2021). These organisms play vital

roles in ecosystems, yet malacofauna in the Philippines is one of the least studied areas in Asia (Mascariñas, 2023). The lack of research interest hinders efforts to investigate the crucial ecological interactions and processes that contribute to their ecosystem functioning and stability (Gheoca et al., 2023). Terrestrial organisms, such as land snails, play crucial roles in ecosystems, including nutrient cycling, pollination, seed dispersal, and population regulation (Wehner et al., 2019). Without a comprehensive understanding of their distribution, abundance, and ecological needs, critical habitats may be destroyed, species populations may decline, and ecosystem services may deteriorate (Nikolai & Ansart, 2017).

Despite a relatively small size, the distinct ecological features of Lubang Island such as lush forests, coastal ecosystems, and limestone formations, make it an ideal location for conducting comprehensive taxonomic studies on land snail groups (Caringal, 2019). Hence, a taxonomy study of land snails on Lubang Island will not only contribute to the existing knowledge of the biodiversity but will also provide insights into their broader ecological roles and conservation implications. Understanding the diversity of land snail species, distribution patterns, and population dynamics can provide an in-depth understanding of the island's overall ecosystem health and stability (Gheoca et al., 2023).

The diversity and distribution patterns of land snails provide important information about habitat quality, climatic changes, and the overall state of ecosystems (Nurinsiyah et al., 2016). The existing knowledge gap can impede the effective management and protection of ecosystems. As these organisms contribute to the intricate web of life, diminishing research efforts inhibit a comprehensive assessment of biodiversity. Therefore, this in-depth investigation aims to fill this information gap by examining the

taxonomy of land snail species on Lubang Island, highlighting the significance of these often-undervalued organisms within the context of the island's greater marine biodiversity.

A broader implication of understanding the diversity and distribution of land snails on Lubang Island is the potential for developing effective conservation programs that encompass both marine and terrestrial habitats. Therefore, field surveys will be conducted across Lubang Island encompassing various habitats to observe, identify, and record the land snail species present. The aim of this study is to provide a comprehensive report of the identification of different species of land snails through a combination of field surveys, morphological analysis, and collaboration with a professional in the field.

Establishing a baseline of land snail biodiversity can aid in identifying possible risks to land snail populations and their habitats, enabling more targeted conservation efforts. Investigating land snails on Lubang Island also presents educational opportunities for researchers, students, and the local community. By fostering environmental stewardship, involving citizens in initiatives, and facilitating knowledge exchange between academics and the community, this study can inspire a sense of commitment and involvement in preserving the island's natural heritage. Ultimately, this comprehensive investigation of terrestrial mollusks on Lubang Island aims to shed light on the land snail fauna, foster a deeper understanding of terrestrial ecosystems, and promote the preservation of these organisms and their habitats.

1.2 Theoretical Framework

This study is anchored in various theories including Theory of Island Biogeography and Phylogenetic Systematics which all provides comprehensive understanding of the diversity, distribution, and taxonomy of terrestrial snail species.

1.2.1 Theory of Island Biogeography

Developed by ecologists Robert MacArthur and Wilson in 1967, the Theory of Island Biogeography provides valuable insights into the factors influencing the richness and distribution patterns of land snails on islands. This suggests that the equilibrium between species immigration and extinction rates determines the number of species present on an island (Possingham et al., 2013). The migration rates of land snails may be influenced by the proximity of the island to the mainland and its distinct ecological features. According to the theory, islands closer to the mainland are more likely to experience a higher influx of migrant species (Hachich et al., 2020). The distance between the island and the mainland as well as potential pathways for snail colonization should be considered to understand the variables that influence the variety and composition of land snail species. Additionally, the theory also highlights the relationship between island size and species diversity. Larger islands, due to their larger habitats and lower extinction rates, generally support a greater number of species (Glassman et al., 2017).

The application of Theory of Island Biogeography to the study of land snails on Lubang Island allows researchers to establish a framework for comprehending the factors that contribute to the diversity and distribution patterns of these organisms. This approach enables assessment of the interplay between immigration and extinction rates, island size, and other ecological factors that shape the land snail community on the island.

1.2.2 Phylogenetic Systematics

Willi Hennig, a prominent German zoologist, is known for championing the cladistic approach within phylogenetic systematics (Britannica, 2023). Phylogenetic systematics has emerged as the predominant framework within the realm of systematic biology (Wiley, 1981). It has deeply shaped the way researchers approach the study of evolution, yielding

numerous theoretical and practical advancements as the discipline has expanded (Guralnick, 1995). Designed for active systematists and phylogeneticists, it delves into both the philosophical and technical facets of the subject, while also encompassing broader practices in taxonomy (Schwartz, 2009). Serving as an extensive synthesis of the discipline, Phylogenetics is essential for scholars and practitioners in fields such as evolutionary biology, molecular evolution, genetics and evolutionary genetics, paleontology, physical anthropology, and zoology (Zander, 2010).

The application of Phylogenetic Systematics to the study of land snails on Lubang Island provides valuable reference materials for researchers and conservationists as this study progresses by thorough identification and classification of land snail species. Notably, any taxonomic revisions or new species discovered throughout the study are meticulously documented, adding to the understanding of the island's biodiversity.

1.3 Conceptual Framework

A conceptual framework acts as a roadmap that illustrates the flow of the study, allowing for an understanding of the relationships between different components. It provides a systematic way to organize ideas, hypotheses, and variables, guiding the research process from the input to the output. By incorporating this framework, the overall clarity and coherence of the study are enhanced, making it easier to interpret and effectively communicate the results.

Figure 1 shows the research process for investigating the present species of terrestrial snails in Lubang Island. The presence of understudied land snails in the island will be the input as it will be investigated to acquire the desired output, which is the taxonomy of land snail species. Meanwhile, the process covers field surveys as well as

the analysis and interpretation of data. This section includes selecting sampling sites, field surveys, and sampling of land snails.

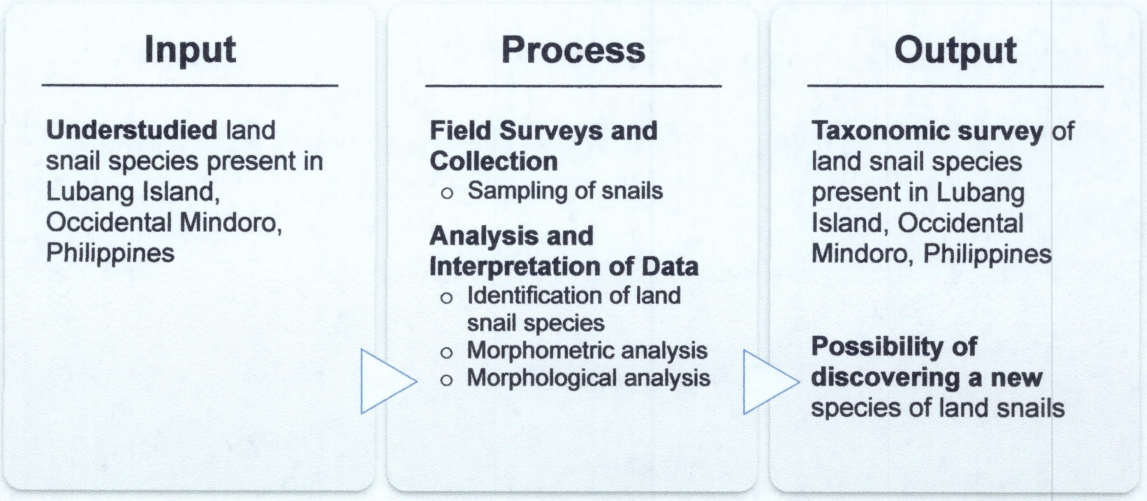

Figure 1. Conceptual Framework of the Study Using Input-Process-Output (IPO) Model

1.4 Statement of the Problem

This study aims to conduct a taxonomic survey of land snails in the island of Lubang in Occidental Mindoro.

Specifically, it seeks to answer the following questions:

1. What are the species of land snails are present in the island?
2. What are the specific morphological characteristics and shell variations that distinguish different land snail species in Lubang Island?
3. Are there land snail species on the island that exhibit endemic characteristics?
4. How may the classification of land snails on Lubang Island be contextualized within broader taxonomic frameworks, and are there distinct traits that require new taxonomic categories or revisions?

1.5 Scope and Limitation

This study will focus on identifying the taxonomy of land snail species found in Lubang Island in Occidental Mindoro. The scope of this study will include field surveys and specimen sampling in the Municipality of Lubang, Lubang Island. During the months of November and December 2023, the sampling of land snails will be conducted, coinciding with the wet season when land snails are typically abundant. Furthermore, the study will be limited to taxonomic survey of land snail species present in the island. Investigation of ecological factors and its effects to the diversity and distribution of the species will not be a part of the study. The presence and distribution of land snail species on an island are influenced by various environmental factors, and remote inaccessible areas may cause underrepresentation of some species. In addition, molecular analysis will be excluded in the process of identifying specimens. Only a morphological analysis will be conducted as conservation laws prohibit land snails and other wildlife from being taken from the wild without authorization. Regardless of these limitations, the main objective of the study is to offer significant knowledge about the taxonomic diversity of land snails in Lubang Island, thereby contributing to broader conservation and management initiatives in the area.

1.6 Significance of the Study

This study aims to significantly contribute to the scientific community. Specifically, the research prospects to be beneficial to the following:

Conservationists and Environmentalists. This taxonomic survey will present crucial information for conservation efforts, helping to identify and protect endangered or threatened species. The data may also enlighten the fact that land snails are ecological indicators and can be used to assess the state of their surrounding environment.

Policy Makers. The data from this taxonomic survey can aid in the development of effective conservation policies and management strategies for protecting land snails and their habitats. The survey results can inform land use planning and management decisions, ensuring that land snail habitats are considered during development activities.

Local Communities. This study may provide knowledge of land snail species which can be used for agriculture, economics, and tourism by the locals. Moreover, understanding that there are various land snail species can aid in habitat restoration initiatives. Local communities can work towards preserving and restoring suitable habitats, benefiting not only the snails but also other flora and fauna.

Ecotourism. Accurate identification of land snail species can enhance ecotourism opportunities. This will provide nature enthusiasts who wish to explore the chance to appreciate the biodiversity and learn about land snail species without causing negative effects on land snail populations.

Future Researchers. Taxonomic surveys offer valuable data for scientific studies, biodiversity research, and understanding ecological interactions between land snails and their habitats. Local researchers can collaborate with experts to investigate specific aspects of land snail ecology, potentially leading to new discoveries.

Educators and Students. Taxonomic data can enhance scientific knowledge and foster an interest in biology among students. Creating educational programs, workshops, or nature walks centered around land snails can promote environmental awareness and conservation.

1.7 Definition of Terms

The following terms are defined either operationally or conceptually:

Biodiversity. It describes the diversity of life on Earth, encompassing an array of ecosystems, species, and genetic diversity found both within and between species. It is a measurement of the diversity and complexity of organisms as well as their relationships and ecological functions. (Standford Encyclopedia, 2003)

Conservation. Protecting, managing, and sustainably using biodiversity and natural resources are all parts of conservation, which aims to save species from extinction and preserve ecological equilibrium. (Natural Resources Conservation Service, n.d.)

Ecosystem Services. It is any positive benefit that wildlife or ecosystems provide to people. The benefits can be direct or indirect—small or large (The National Wildlife Federation, n.d.).

Gastropoda. These are Gastropods, scientifically known as Gastropoda, constitute a prominent class within the mollusk group. Most gastropods feature a spiral or conical shell, although this shell can be significantly reduced in certain species or completely absent, as seen in slugs (British Geological Survey, n.d.).

Land Snail. They are mollusks classified as gastropods that live mostly on land. Their coiled shell and distinctly muscular foot are the distinguishing characteristics. Land snails are involved in many aspects of ecology, including seed dispersal, decomposition and bioindicator of pollution (Bayoumi et al., n.d.)

Molecular Analysis. This analysis identifies variations in one or multiple genes. This also unravels the specific sequence of an individual's genetic code, encompassing the arrangement of DNA's fundamental building blocks (nucleotides), utilizing a method termed DNA sequencing (Ishida et al., 2023).

Morphological Analysis. It involves the study and comparison of physical structures and characteristics of organisms to classify accordingly. It helps to identify and define taxonomic groups based on shared anatomical features (Villee, 2018).

Morphometric Analysis. This refers to the quantitative investigation and quantification of the dimensions of several land snail morphological characteristics. In order to explain and compare differences both within and between various species or populations, this kind of analysis involves the use of precise measurements of particular anatomical components, such as the shell, aperture, radula, and other body parts. (Madan et al., 2015)

Nutrient Cycling. It is a vital process in sustaining the nutritional balance of forest ecosystems, as it involves the movement of nutrients among various elements within cells, communities, or ecosystems. These nutrients undergo cycles that enable them to be recycled and reused by certain components within the system (Morris, 2004).

Taxonomy. It is a discipline of classification, more especially, the structural grouping of organisms according to similar traits. Organizing and classifying the enormous diversity of life on Earth is the aim of taxonomy, which offers a uniform and methodical approach to naming and grouping organisms in accordance with their evolutionary relationship (Northen Arizona University, n.d.)

Chapter 2

REVIEW OF LITERATURE AND STUDIES

This part of the study deliberates the findings of other research related to and relevant to the present study of land snail species on Lubang Island. The reviewed studies may discuss different methodologies used in previous studies. The content of this section was gathered from different websites, articles, and other secondary sources of studies and pieces of literature.

2.1 Lubang Island

National parks and protected areas play a crucial role in preserving endangered plant and animal species. However, a mere 7.8% of the Philippines' total land area is designated as protected (Ong et al., 2002). In response, the Philippine government has initiated conservation programs to safeguard the remaining endangered and rare species in its vanishing rainforests. Despite these efforts, the Lubang Group of Islands, situated in the Verde Passage and bounded by the South China Sea to the west and the Calavite Passage to the south, faces significant threats due to habitat damage and poorly planned resource development (Macabago et al., 2016). Recognized by the Department of Environment and Natural Resources (DENR) as a biodiversity conservation priority terrestrial area with an extremely high critical priority level, Lubang Island is part of the Verde Passage, protected for its coastal and mountain ecosystems (Ong et al., 2002). In the island's central region, there are moderately elevated mountains densely cloaked in forests, while the near the coastal areas are vast rice fields and grassy hills (McGregor, 1904). Although isolated islands like Lubang potentially serve as living laboratories for

biogeography studies, relatively little is known about their biota, including flora and fauna. Consequently, this protected area continues to yield the discovery of new species.

According to the study of Clench & Archer regarding the present land snails in the Lubang Island in 1931. The mollusk affinities are quite apparently with those of Luzon and not Mindoro, although there are a few species common to all three islands. Perhaps the most outstanding of the Lubang element is that of *Helicostyla cepoides Lea*. The affinities of this species are clearly with those of the *Helicobulinus* group of Luzon and the Central Philippines. Likewise, the presence of *H. pithogostra* on Lubang is another connecting link with the Luzon fauna. This species is widely distributed throughout Luzon and the Central Philippines but is not known to occur in Mindoro. *Helicostyla cincinniformis*, another species peculiar to the Island, belongs in the section *Hypselostyla*, a stock which is found largely in Luzon and the central Philippines, and probably had its start in Luzon. It has no known representatives in Mindoro.

2.2 General Morphology of Land Snails

The initial aspect that captures attention when observing organisms is their structure (Gans, 1985 cited in Trail, 2021). Morphological traits are commonly used by researchers to establish taxonomic categories as defining characteristics can be consistently linked to evolutionary lineages, even down to the level of individual species (Burnham-Curtis et al., 2015).

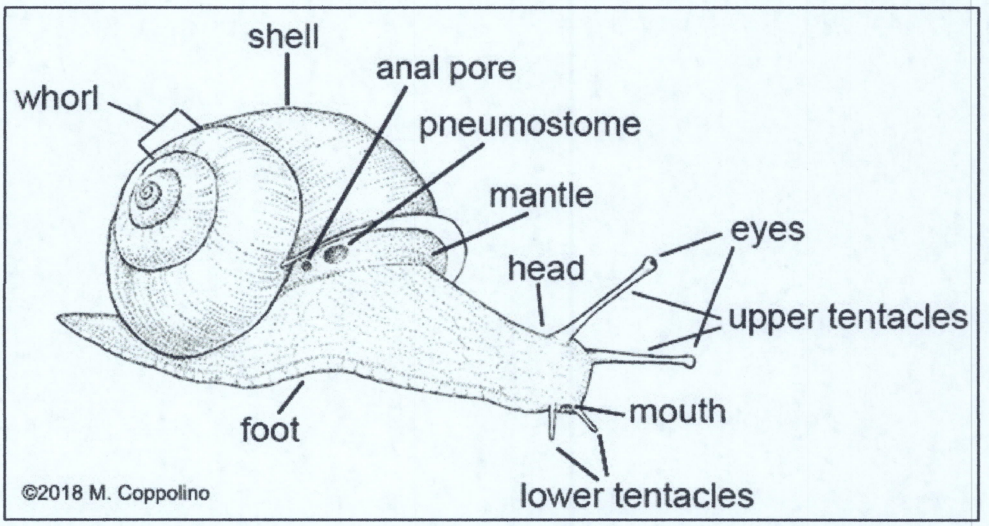

Figure 2. Body Structure of a Terrestrial Snail

In land snails, each body part plays a vital role in their survival and adaptation to life on land. Mollusk shells are often used for identification because they are durable and have easily seen characteristics, such as bumps, ridges, and spiraling traits (Missouri Department of Conservation, n.d.). Terrestrial snails take in oxygen through a network of thin-walled blood vessels located in the mantle cavity beneath their shells (Montana State University Agricultural Research Center, n.d.). However, they face a significant challenge with water loss during respiration. To combat this, they possess a thick fold of skin in the mantle that seals off the mantle cavity, providing protection against water loss (Machin, 2009). Mollusks have developed strategies to cope with extended periods of water scarcity, such as inactivity or aestivation, which allows them to endure desiccation by adapting to significant changes in body water content (Grant, 1955; Duval, 1930; Chew, 1961 cited in Machin, 2009). The snail breathes in air through a small opening known as the breathing pore or pneumostome, which that they can control using their muscles. Breathing involves the opening and closing of the breathing pore that acts as a lung and raising and lowering the floor of the mantle cavity, analogous to how vertebrates use the

diaphragm (Barnhart, 2019). In addition, the front part of the snail's body contains the head that has one or two sets of retractable tentacles: the upper pair or the longer, holds the snail's eyes, while the lower pair, shorter in length, is utilized for chemical sensing, including taste and smell (Missouri Department of Conservation, n.d.).

Many land snails are nocturnal, taking advantage of the cool and damp conditions at night. During dry periods, they seek suitable hiding places or enter a state of dormancy by crawling up plant stems and sealing the entrance to their shells with a slime seal (Dekle, 2021). This seal also helps them stick to the chosen surface. Due to their slow movement, the radius of activity for land snails is relatively small, making encounters with potential mates less frequent. Therefore, hermaphroditism (androgyny) is advantageous since it doubles their chances of reproduction with a low number of individuals (Pearce, 2001). Land snails can mate with any member of the same species they encounter, assuming both are ready to mate. Unlike sea snails, the development of land snails occurs in a closed egg, from which a fully formed young snail eventually hatches (Hotopp & Pearce, 2006).

2.3 Island Diversity and Distribution of Land Snails

According to the study of Perera et al. (2021), terrestrial mollusks do not exhibit a uniform distribution across the globe, even with a worldwide species richness estimated to exceed 25,000. It was also stated that while some island land snail populations have exceptional species diversity and high levels of endemism, making them a recognized hotspot for molluscan conservation, similar continental hotspots are not widely acknowledged. The diversity of invertebrates remains largely undocumented, and their taxonomy is often not sufficiently well-defined, emphasized by the author. The results of

the study were accomplished by conducting numerical biogeographical analyses and creating maps of species richness and endemism patterns.

Meanwhile, the study conducted by Chiba and Cowie (2016) explores the evolution and extinction patterns of land snails on oceanic islands. The factors contributing to the high diversity and vulnerability of land snails on these islands were examined. The study highlights that land snails, particularly those on oceanic islands, have experienced significant evolutionary processes and extinction events. Oceanic islands provide unique environments that have led to the diversification of land snail species over time. Factors such as geographic isolation, limited dispersal abilities, and diverse habitats have contributed to the high species richness observed in these islands. The researchers emphasized that land snails on oceanic islands are highly vulnerable to extinction. Human-induced anthropogenic impacts, such as habitat destruction, invasive species, and climate change, have greatly affected land snail populations. Moreover, nonmarine molluscs including land snails have experienced the highest number of recorded extinctions due to human activities. Land snails on oceanic islands have served as valuable model systems for studying evolution, as high species diversity and geographic variation provide opportunities to test hypotheses. Snails have also been used as models to understand species loss and the impacts of anthropogenic disturbances. Hence, understanding the ecology and evolutionary processes of land snails is crucial for conservation.

2.4 Island Biogeography of Land Snails

In 2012, Cameron et al. tested the general dynamic model of oceanic island biogeography using linear mixed effect models with a focus on snails. The researchers investigate the factors influencing the richness, abundance, and composition of snail communities on oceanic islands. They also examined the effects of island area, isolation,

age, and topography on snail biodiversity patterns. The researchers also focused on three diversity metrics: the count of native species, archipelagic endemic species, and single-island endemic species. To assess the models, they employed linear mixed effect models and considered both log-transformed and untransformed diversity data. The study finds that island area and isolation are significant predictors of snail richness, with larger and more isolated islands supporting higher species diversity. Additionally, older islands tend to have higher snail abundance. The researchers also highlight the importance of topography, as steep and rugged islands show greater snail species turnover. The findings support the general dynamic model of island biogeography, which suggests that island characteristics and colonization processes influence species richness and community composition.

The study by Gray and Cavers (2013) also focused on island biogeography, the impact of taxonomic effort, and the significance of niche diversity for single-island endemic species. The relationship between species richness and the intensity of taxonomic sampling on islands were explored. The results showed that higher taxonomic effort leads to increased species discovery, indicating that the true species richness of islands is often underestimated. Furthermore, it also emphasized the importance of considering niche diversity in understanding the distribution of single-island endemic species. Islands with greater niche diversity tend to support more endemic species, suggesting the role of ecological processes in shaping island biota. The study highlights the need for comprehensive taxonomic sampling and the consideration of niche diversity to accurately assess species richness and understand the dynamics of single-island endemism.

2.5 Mollusks in the Philippines

The Philippines is renowned for its exceptional biodiversity and is often compared to the Galapagos Islands due to the abundance of unique species found on every island, regardless of its size (Heaney & Regalado, 1998 cited in Flores, 2014). However, the country is also considered a significant biodiversity hotspot, meaning that there is a high risk of species extinction. One of the primary drivers of biodiversity loss is the destruction of natural habitats, particularly the lowland tropical rainforests (Flores, 2014). These habitats have been extensively transformed for economic purposes, leading to severe environmental consequences and a decline in biodiversity. Among the diverse range of invertebrate groups, mollusks hold the distinction of being the second most abundant. It is estimated that there are between 80,000 to 135,000 species of mollusks, with land snails being a prominent subset, especially in tropical regions (Abbott 1989; van Bruggen, 1995 cited in Rosales et al., 2020). Within the Philippines, approximately 31% (around 22,000 out of 70,000 species) of all described mollusks can be found, although there is a relatively low level of endemism, ranging from 2% to 4% (Vallejo, 2002 cited in de Chavez & de Lara, 2011). However, it is important to note that a significant number of mollusk species in the Philippines remain undiscovered and undescribed.

2.6 Diversity of Land Snails in the Philippines

de Chavez (2014) stated that several endemic land snails are found in the Philippines but are in danger due to the invasion of invasive species and habitat loss. The effects of anthropogenic-induced disturbance on the community structure of native and invasive land snails were studied to address this. On Mount Makiling, Luzon Island, quadrat sampling was carried out for four years along a gradient of forest disturbance (old-growth, secondary, plantation forests, and former slash-and-burn sites). The results show

that in comparison to invasive snails, native pulmonates and prosobranchs have lower disturbance values. Only native prosobranchs and pulmonates were found in old-growth forests. Secondary forests with species from different ecological successional phases have the highest levels of diversity. Native prosobranchs are absent from plantations and old slash-and-burn sites, although tolerant native pulmonates and invading species are present. According to the results of the GLMM, forest disturbance was the primary predictor of land snail species richness, whereas abundance was impacted by several variables. The results of this study showed that land snails have the potential to replace vertebrates as effective and non-intrusive models for assessing habitat quality.

Table 1. Native and invasive land snail species found in Mount Makiling identified in the study conducted by de Chavez (2014)

Family	Species
Achantinidae	*Achatina fulica* (Bowdich, 1842)
Cyclophoridae	*Cyclophorus appendiculatus* (Pfeiffer, 1886)
	Cyclophorus mp2
	Cyclophorus mp3
	Cyclophorus mp4
Bradybaenidae	*Helicostyla bicolorata* (Lea, 1840)
	Helicostyla carinata rugata (Lea, 1840)
	Helicostyla ovoidea (Bruguiere, 1792)
	Helicostyla mirabilis (Ferussac, 1820)
	Helicostyla roissyana (Ferussac, 1840)
	Helicostyla rufogaster (Lesson, 1891)
	Calocochlia chrysochiela (Sowersby, 1841)
	Chloraea dryope (Broderip, 1841)
	Bradybaena similaris (Ferussac, 1821)
Helicarionidae	*Ryssota otaheitana* (Ferussac, 1821)
	Hemiglypta sp.
	Hemiglypta mp2

	Hemitrichiella sp.
Camaenidae	*Obba marmorata* (Lamarck, 1821)

Parcon et al. (2020) also conducted a study on land snail diversity in the Karst areas of Sta. Teresita, Cagayan Province, Luzon Island, Philippines. The researchers established 25 quadrats measuring 5 x 5 m^2 in randomly selected locations within the karst landscape. A total of 1,206 land snails belonging to 45 species, 36 genera, and 17 families were sampled during the study. The family Camaenidae was the most represented, comprising 10 species. Luzonocoptis antennae stood out as the most abundant species, accounting for 25.1% (303 individuals) of the total samples across all stations. Additionally, the study recorded five genera that were new distribution records in the Philippines, indicating the presence of previously undocumented land snail species in the region. The diversity indices demonstrated a robust and diverse land snail fauna in Sta. Teresita is in the province of Cagayan. Therefore, it has been designated as a priority site for malacofaunal conservation. The abundance and diversity of land snails show the ecological relevance of this region's karst environments.

Table 2. Land snails recorded in the karst areas of Sta. Teresita, Cagayan Province, Philippines identified in the study conducted by Parcon et al. (2020)

Family	Species
Achantinidae	*Lisachatina fulica* (Ferussac, 1821) *
Ariophantidae	*Ariophanta* sp. **
	Euplecta sp. **
	Microcystina sp. **
Assimineidae	*Acmella polita* (Möllendorff, 1887) **
Camaenidae	*Bradybaena fodiens* (L. Pfeiffer, 1845) *
	Calocochlia festiva (Donovan, 1825) **

	Chloraea psittacina (Deshayes, 1861) **
	Chloraea bifasciata multifasciata (Möllendorff, 1898) **
	Chloraea smaragdina (Grateloup, 1840)**
	Pachysphaera sphaerica (G.B Sowerby I, 1841) **
	Hypselostyla carinata (Möllendorff, 1897)**
	Calocochlea lignaria (L. Pfeiffer, 1846) +
	Ganesella sp. **
	Obba moricandi (Pfeiffer, 1842)
Charopidae	*Charopa* sp. ****
Chronidae	*Hemitrichiella setiger* (G.B. Sowerby I, 1841) **
	Hemiglypta cuvieriana (I. Lea, 1840) **
	Kaliella micropetasus (Möllendorff, 1893) **
	Kaliella microconus (Mousson, 1865) **
	Kaliella sp. **
Cyclophoridae	*Aulopoma* sp. ****
	Cyclophorus woodianus (Lea, 1862) **
	Leptopoma helicoides (Grateloup, 1840) **
	Lagocheilus sp. ***
Diapheridae	*Diaphera strophostoma* (Quadras & Möllendorff, 1896) **
Diplommatinidae	*Palaina cristata* (Quadras and Möllendorff, 1893) **
	Arinia pallida (Möllendorff,1896) ***
	Diplommatina kochiana (Möllendorff,1887) **
	Diplommatina microstoma (Möllendorff,1887) ***
	Diplommatina sp. ***
	Luzonocoptis angulata (Pall Gegely & Hunyadi, 2017) ***
	Luzonocoptis antennae (Pall Gegely & Hunyadi, 2017) ***
Dyakiidae	*Dyakia* sp. (Juvenile) ****
Helicinidae	*Ceratopoma cagayanica* (Bartsch, 1921) **
	Sulfurina citrina (Grateloup, 1840) **
Hydrocenidae	*Georissa carinulata* (Quadras & Möllendorff, 1896) ***
Pupinidae	*Pupinella pupiniformis* (Sowerby, 1842)**

Subulinidae	*Allopeas clavulinum* (Potiez & Michaud, 1838) *
	Allopeas gracile (T. Hutton, 1834) *
	Opeas nitidum (Quadras & Möllendorff, 1893) *
Trochomorphidae	*Geotrochus conus* (Philippi, 1841) ****
	Videna metcalfei (Pfeiffer, 1845) **
Vertiginidae	*Nesopupa malayana* (Issel, 1874) **

*Note. + endemic species, * invasive species, ** native species, ***karst-endemic, ****new country record.*

The study conducted by Pogado et al. (2022) also examined the diversity of macro land snails in selected forest fragments of Leyte Island. Quadrats in three sampling sites of varying area sizes (Inopacan, Baybay, and Maasin) were put and macro land snail species and their associated families were identified. The researchers identified 22 macro land snail species and five families. The dominant groups were endemic Eupulmonates (Order Stylommatophora) and Caenogastropods (Order Architaenioglossa). The most diverse family was Camaenidae with 10 species. Caenogastropods were represented by seven species in the family Cyclophoridae. The study also documented 15 new records of macro land snail species, while 33 previously recorded species were not encountered. The results provided are crucial insights into the community ecology patterns and land snail diversity within the fragmented forests of Leyte Island. The presence of both endemic and invasive species highlights the need for monitoring and control measures to safeguard native biodiversity.

Table 3. Macro land snails among the three fragmented forests in Leyte listed in the study conducted by Pogado et al. (2022)

Family	Species
Camaenidae	*Amphidromus maculiferus* (Sowerby I, 1838)
	Trachystyla cryptica (Broderip, 1841)

	Helicostyla dubiosa (Pfeiffer, 1846)
	Calocochlea valenciennii (Eydoux, 1838)
	Chloraea puella (Broderip, 1841)
	Chloritis leytensis (Moellendorff, 1890)
	Helicostyla faunus (Broderip, 1841)
	Helicobulinus sarcinosa (Férussac, 1821)
	Hypselostyla boholensis (Broderip, 1841)
	Obba bigonia (Férussac, 1823)
Trochomorphidae	*Geophorus* sp. (Fischer, 1885)
	Videna sp. (H. Adams & A. Adams 1855)
Helicarionidae	*Hemiglypta semiglobosa* (L. Pfeiffer, 1845)
Achatinidae	*Subulona cyclindracea* (Bourguignat, 1890)
	Lissachatina fulica (Bowdich, 1822)
Cyclophoridae	*Leptopoma sericatum* (Pfeiffer, 1853)
	Leptopoma perlucidum (Grateloupe, 1840)
	Cyclophorus appendiculatus (Pfeiffer, 1854)
	Cyclophorus linguiferus (Sowerby I, 1843)
	Cyclophorus sp. 1 (Montfort, 1810)
	Cyclophorus sp. 2 (Montfort, 1810)
	Cyclotus auriculatus (Kobelt, 1884)

In addition, Sosa et al. conducted a study in the year 2014 which aims to evaluate the biodiversity of land snails in Marinduque as well as to prepare a comprehensive list of snail taxa by using opportunistic sampling. As opposed to most lowland areas, which have been partially cleared due to logging and the slash-and-burn farming method, sampling sites per municipality were concentrated in the upland barangays of each municipality, where the anthropological effect was minimal and remote from any human settlements. In addition to being situated close to bodies of water like rivers, streams, or puddles, these regions contain a thick to moderately thick forest cover. As a result, the study identifies

ten previously unrecorded species of Stylommatophoran species and six species of terrestrial Prosobranch snails in Marinduque. This discovery brings the total number of known terrestrial snail species on the island to 24 or 26. It was concluded that Marinduque has a very high species richness and diversity based on the diversity indices from the study. However, it was also noted that there is low species distribution and evenness across the island, which could be caused by habitat loss and degrees of disturbance.

Table 4. Summary of the snail species found in the province of Marinduque identified in the study conducted by Sosa et al. (2014)

Family	Species
Bradybaenidae	*Helicostyla rufogaster* (Lesson, 1831)
	Helicostyla pithogaster (Ferrusac, 1821)
	Helicostyla marinduquensis (Hidalgo, 1887)
	Helicostyla fischeri (Hidalgo, 1889) *
	Helicostyla subcarinatamoellendorfi (Mollendorff, 1897)
	Helicostyla simplex (Jonas, 1834) *
	Helicostyla sphaerica (Sowerby, 1841) *
	Chloraea fibula (Reeve, 1842) *
Camaenidae	*Obba listeri* (Gray, 1825) *
Trochomorphidae	*Trochomorpha metcalfei* (Pfeiffer, 1845) *
	Trochomorpha schmakerii (Moellendorf, 1894) *
Helicarionidae	*Ryssota lamarckiana* (Lea, 1852)
	Ryssota otaheitana (Ferrusac, 1821)
	Hemiglyptosis fouillioyi (Mollendorf, 1893) *
	Nipponochlamys semisericata (Pilsbry, 1902) *
	Achati nafulica (Ferrusac, 1821) *
Cyclophoridae	*Cyclophorus woodianus* (Lea, 1862)
	Cyclophorus fernandezi (Hidalgo, 1888) *
	Cyclophorusdaraganicus (Hidalgo, 1888) *
	Cyclophorus fulguratus (Pfeiffer, 1852) *
	Leptopoma woodfordi (Sowerby, 1889) *

Leptopoma pileus (Sowerby, 1843) *
Leptopoma sericinum (Kobelt, 1886) *
Leptopoma sp. (Pfeiffer, 1847)

*Note. * - new records for the island. Achatina fulica was not counted, being an introduced species, although its presence was noted in the areas it was found.*

Rosales et al. (2020) focused on the species composition, relative abundance, and distribution of land snail species in Mount Latoy key biodiversity area in Cebu. The objective was to establish an inventory of land snail species data in Mt. Latoy. The researchers established sampling plots around the key biodiversity area of Mount Latoy which is part of the protected landscape of Argao-Dalaguete Watershed Forest Reserve. The focus of collection efforts was on habitats that land snails particularly like, such as leaf litter, rotting logs, bark, and the undersides of plant leaves. The sample species were then sorted into groups and identified their corresponding groups using the published keys and reference guides by Hidalgo (1901), Springsteen & Leobrera (1986), and Abbott (1989). A total of 872 individuals, represented by 25 species from 15 genera and 9 families, are listed in the study. The air-breathing pulmonate order, Stylommatophora, consists of seven families: *Bradybaenidae, Camaenidae, Trochomorphidae, Achatinidae, Ariophantidae, Helicarionidae*, and *Helicinidae. Cyclophoridae* and *Pupinidae* were two of the families that made up the prosobranch group, Order Caenogastopoda. Ten (10) new island record species were collected and identified, including three (3) endemic species and four (4) rare species. While other species were geographically restricted to only a few research sites, widespread species appeared to be more prevalent.

Table 5. List of collected land snails in Mt. Lantoy KBA, Cebu Island, Philippines specified in the study conducted by Rosales et al. (2020)

Family	Species
Bradybaenidae	*Chloraea fibula* (Reeve, 1842)
	Helicostyla amagaensis (de Chavez, 2015)
	Helicostyla phitogaster (Férussac, 1821)
	Helicostyla daphnis (Broderip, 1841)
Camaenidae	*Obba marginata parmula* (Broderip, 1841)
	Obba horizontalis (Piefffer, 1845)
	Conchlostyla camelopardalis (Broderip, 1841)
	Anixa zebuensis (Broderip, 1841)
Trochomorphidae	*Trochomorpha repanda* (Möllendorf, 1890)
	Trochomorpha schmarkerii (Möllendorf, 1894)
	Trochomorpha metcalfei (Pfeiffer, 1845)
Achatinidae	*Achatina fulica* (Férussac, 1821)
Ariophantidae	*Sitala acuta* (Salvat, 1966)
Helicarionidae	*Ryssota oweniana* (Lea, 1852)
	Euplecta apicata (Blanford, 1870)
Helicinidae	*Geophorus acutus* (Pfeiffer, 1847)
	Geophorus acutus acutus (Pfeiffer, 1847)
	Geophorus acutus siquijorensis (Bartsch, 1918)
	Helicina clappi (Pilsbry, 1909)
Cyclophoridae	*Cyclophorus daraganicus* (Hidalgo, 1888)
	Cyclophorus fulguratus (Pfeiffer, 1847)
	Leptopoma woodfordi (Sowerby, 1889)
	Leptopoma nitidum ancilis (Bartsch, 1918)
	Moulinsia fusca (Gray, 1841)
Pupinidae	*Moulinsia fusca erythrostoma* (Möllendorf, 1890)

The paper authored by Baoanan and Obanan (2021) focused on the assessment of land snail diversity in Mt. Polis, located within the Central Cordillera Mountain Range in

Luzon, Philippines. The researchers randomly explored 28 quadrats across four sites using the timed search method. Each quadrat measured 20 m2. A total of 321 samples were collected, representing four families and 13 species. The family *Helicarionidae* was found to have seven known species, including *Nanina globulus*, *N. lucidella*, *N. azpeitiae*, *Ryssota otaheitana*, *Lepidotrichia segitera*, *Hemitrichiella segitera*, and *Vitrinoconus sinaetensis*, along with one unidentified species. Additionally, an unidentified species belonging to the family *Pupillidae* was observed. The family *Cyclophoridae* comprised three species, namely *Cyclophorus sp., Leptopoma sp.,* and *Cyclotus sp.* The family *Bradybaenidae* was represented by a single species, *Cochlostyla carinata*. *Nanina lucidella* (29.45%) and *V. sinaetensis* (15.51%) were identified as the relatively abundant species, while the remaining species were considered rare (less than 15%). The results of this study emphasize the importance of preserving the mossy forest habitats in Mt. Polis to safeguard the land snail species and maintain the overall biodiversity of the region.

Furthermore, in a study conducted by Lipae et al. (2020), a new subspecies of endemic microsnail called *Hypselostoma latispira masungiensis subsp. nov.* was discovered and described based on both shell morphology and molecular characteristics. This newly identified subspecies differs from the *H. latispira* found in Baguio City, Benguet Province in several ways. It exhibits a relatively larger major width size, possesses additional apertural teeth (interpalatal plica), has a larger body whorl and apertural width, and shows clustering based on location. The samples collected from Masungi Georeserve in Rizal Province are considered an eco-phenotype, as indicated by their unique site that corresponds to the separation of the Masungi and Baguio *H. latispira* clades. Thus, the *H. latispira* specimens obtained from Masungi Georeserve are proposed as a new subspecies due to differences in shell size, shell shape variations, the presence of

additional apertural tooth (interpalatal plica), and the distinct clade separation of Masungi and Baguio *H. latispira.* Additionally, this study reports a new distribution of *H. latispira* beyond its originally known location. Eight novel sequences of *H. latispira* were also produced during the research.

2.7 Endeavors about Land Snails in the Philippines

The study of Uy et al. (2018) states that the Philippines lacks studies focusing on the diversity and ecology of micro land snails measuring less than 5 mm. An investigation was conducted to determine the diversity and community composition of micro land snails along the northeastern slope of Mount Makiling on Luzon Island, Philippines. A total of 103 individuals were sampled, resulting in the identification of 10 micro land snail species belonging to four families: *Ariophantidae, Diplommatinidae, Helicarionidae*, and *Subulinidae*. The most abundant species observed was *Kaliella sp.* (21 individuals), while *Lamellaxis clavicum* (4 individuals) was the least abundant. Canonical correspondence analysis revealed the overall distribution of environmental variables influencing the presence of micro land snails. Soil pH and calcium were identified as significant limiting factors affecting the community composition of micro land snails. Generalized linear mixed modeling indicated that soil pH was the main predictor for abundance, while leaf litter depth influenced species richness. The study findings highlight the importance of soil calcium and pH as limiting factors impacting the diversity and abundance of micro land snails on the northeastern slope of Mount Makiling.

In addition, the study conducted by de Chavez and de Lara (2011) that was also conducted in Mount Makiling regarding the diversity and spatial distribution patterns of macro land snails in its forest reserve aimed to determine the diversity, relative abundance, and spatial distribution of macro land snails with a measurement of greater than 5mm in

shell diameter and height. A random selection of quadrats was made within each site (400 square meters) and 36 quadrats were set up for a sampling of macro land snails. A total of 639 land snails belonging to 5 families and 14 species were identified using the published literature of Faustino (1931), Bartsch (1932), and Springteen & Leobrera (1986), with the highest number of individuals and species found in Puting Lupa slope and the lowest in MakBan slope. The study also indicated that intact and undisturbed forests support a higher abundance and diversity of endemic macro land snails. The strong association of *helicostylids* with the native forests suggests their potential as indicators of a healthy ecosystem.

Meanwhile in 2017, Madjos and Demayo also conducted a study in Mindanao, Philippines to assess the population abundance, host plant utilization, and behavior of the invasive giant African snail, *Achatina fulica*. The research was conducted in protected mountainous areas and suburban ecosystems. *A. fulica* is a rapidly spreading invasive pest that feeds on a wide range of plants and is considered one of the most ecologically damaging land snails. It is listed as the second worst alien invasive species globally. This pest causes significant crop losses through herbivory, spreads plant pathogens, and increases pest control costs. It also competes with indigenous gastropods, leading to adverse effects on their populations. The assessment revealed that out of the twenty-five plant species identified, *A. fulica* showed a preference for succulent food plants such as *Carica papaya*, *Colocasia esculenta*, and *Operculina turphetum*. The researchers also observed that they aggregated in plant litter, possibly to access moisture. The feeding behavior of *A. fulica* was found to be influenced by the composition of the plant community, as well as the quality and quantity of available food. The absence of native gastropod species may be attributed to their inability to compete with *A. fulica*. The results indicate

that the phytopolyphagous nature of *A. fulica* contributes to its successful establishment and population growth.

Valdez et al. (2021) also conducted a study to explore the land snail diversity and spatial distribution in limestone ecosystems in the Masungi Georeserve. 120 randomly placed quadrats in both karst and non-karst sites were utilized and data on environmental factors were collected. A total of 1,283 land snails belonging to 45 species and 12 families were sampled. Three distinct land snail communities were identified, with preferences for different habitat types. Karst sites exhibited higher species richness, while non-karst sites had greater species evenness. The findings highlight the importance of protecting the Masungi Georeserve as a refuge for land snail diversity and provide valuable insights for conservation and habitat management efforts.

2.8 Biodiversity and Ecological Significance of Land Snails

The study conducted by Nurinsiyah et al. (2016) focused on using native and introduced land snail species as ecological indicators in different land use types in Java. The objective is to assess the suitability of land snails as indicators of environmental conditions and land use impacts. The abundance and diversity of land snail communities in different land use types including agricultural areas, forests, and urban areas were compared for this study. The sampling method started by selecting 40 plots of 10m x 10m, 10 plots each from the primary forest, teak plantation bordered by primary forest, and teak plantation bordered by agroforest. Within the several land use areas, the plots were distributed at random. The study reveals that land snail communities exhibit distinct patterns in response to land use types. Agricultural areas show lower species richness and abundance compared to forests, while urban areas have the lowest diversity and are dominated by introduced species. The researchers suggest that native land snails can

serve as indicators of ecosystem health, while introduced species can indicate human-mediated disturbances. The findings highlight the potential of land snails as valuable ecological indicators in assessing the impacts of land use and guiding conservation efforts in Java.

Moreover, Douglas et al. (2013) also conducted a study in which the different levels of human-induced disturbances and their effect on the diversity of land snail species were investigated. Surveys in different sites with varying degrees of human impact, ranging from relatively undisturbed areas to heavily disturbed locations were conducted. The findings indicate that land snail diversity is significantly influenced by anthropogenic disturbance. Sites with lower levels of disturbance exhibited higher land snail species richness and abundance, while heavily disturbed areas had reduced diversity. This suggests that land snails are sensitive to human activities, and their presence and abundance can reflect the degree of disturbance in an ecosystem. In addition, the results also emphasized the importance of considering land snail diversity in ecological assessments and conservation efforts as they play essential roles in ecosystem functioning and can serve as valuable indicators of habitat quality and the impacts of human activities.

2.9 Land Snail Conservation

The study conducted by Ovando et al. (2019) focuses on identifying priority areas for invertebrate conservation, using land snails as models. The researchers argued that protecting invertebrates is crucial for maintaining ecosystem balance and overall biodiversity. It was also stated that invertebrates are often overlooked in conservation efforts, with more focus given to more vertebrate species. Using land snails as representative invertebrate models, the researchers propose a framework for identifying priority areas for their conservation considering various factors including species richness,

endemism, threat levels, and representation of different habitats. The study reveals that priority areas for land snail conservation are often associated with high levels of endemism and habitat diversity. These areas are characterized by unique land snail species that are not found elsewhere, and they often contain diverse habitat types that support different snail species. The researchers suggest that conservation efforts should focus on protecting these priority areas to ensure the survival of land snail populations and promote overall invertebrate conservation.

Chapter 3

METHODOLOGY

This chapter presents the methods to be conducted in this study to answer the research questions posed in the statement of the problem.

3.1 Research Design

The research concept includes a taxonomic study of land snail populations on Lubang Island, Occidental Mindoro, Philippines. Purposive sampling based on earlier research will be used across barangays of the island. Collected specimens will be collected and subjected to morphological analysis as well as thorough photographic documentation. The identification will be based on established references. After undergoing primary identification, it will be authenticated by a malacologist. Moreover, ethical norms will be followed through permit acquisition and adherence to conservation regulations. This method ensures a thorough analysis of land snails while demonstrating ethical awareness and responsible research behavior.

3.2 Sampling Site

The study will be conducted in the Municipality of Lubang under the jurisdiction of the Lubang Island, province of Occidental Mindoro (13° 51' 31.00" North latitude, 121° 07' 22.00" East longitudes). Elevation at these coordinates is estimated at 11.2 meters or 36.6 feet above mean sea level. Lubang Island is situated northwest of the Island of Mindoro and off the deep waters of the Verde Island passage, which separates both island from Luzon. Municipality of Lubang has an approximate area of 113.10 square kilometers or 43.67 square miles, and roughly has a coastline length of 97.40 kilometers or 60.52 miles.

The municipality of Lubang comprises several barangays namely Cabra (13.8894°,120.0478°), Tagbac (13.8416°, 120.0879°), Tangal (13.8452°, 120.1014°), Surville (13.7942°, 120.1381°), Binacas (13.7784°, 120.1181°), Maligaya (13.8579°, 120.1287°), Maliig (13.8470°, 120.1498°), Vigo (13.8246°, 120.1788°), Tilik (13.8163°, 120.2000°), and Poblacion which encompasses Araw at Bituin (13.8588°, 120.1233°), Bagong Sikat (13.8600°, 120.1199°), Banaag at Pag-asa (13.8598°, 120.1210°), Likas ng Silangan (13.8580°, 120.1263°), Maginhawa (13.8603°, 120.1178°), Ninikat ng Pag-asa (13.8584°, 120.1246°), and Paraiso (13.8596°, 120.1219°).

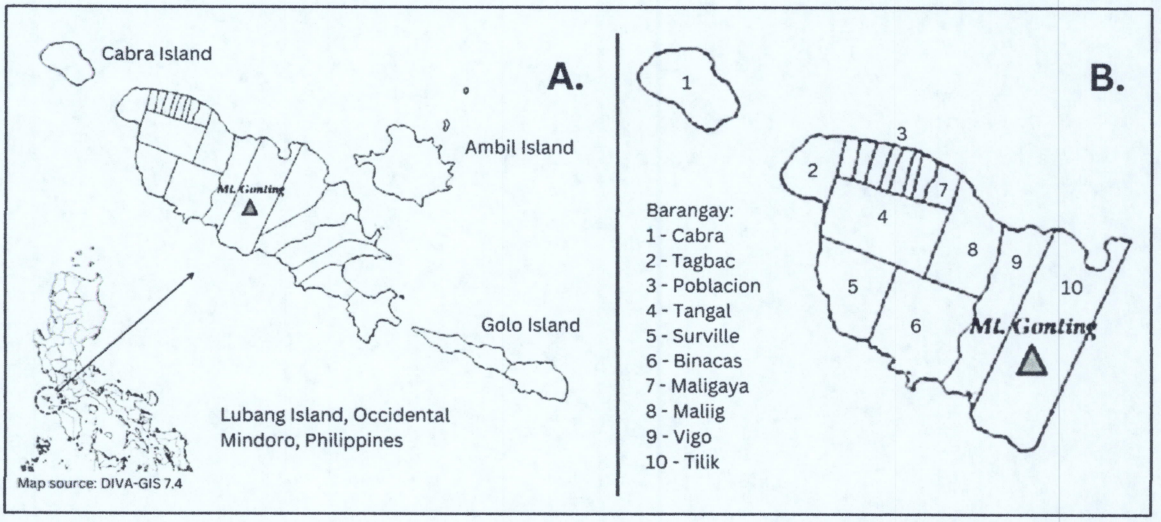

Figure 3. (A) Location of Lubang Island in the Map of the Philippines, (B) Map of Municipality of Lubang

3.3 Sampling Technique

The sampling technique of the study will be adopted from the previous studies conducted by Heryanto (2001 and 2020) and Paller et al. (2019), which mainly involves purposive sampling as a method of data collection. Implementing this approach needs a specific criterion as a guide in selection of sampling site and collection of land snail

specimens. Therefore, sampling exclusively targets areas within the barangays that harbor preferred microhabitats for land snails. Specifically, attention will be directed to surveying areas within the barangay that exhibit qualities such as:

1. **Active gardens and cultivated areas.** Land snails may be found in gardens and cultivated areas, especially in abundant vegetation as they feed on plants and decaying organic matters.
2. **Near river and stream.** Proximity to the bodies of water ensures a relatively high level of moisture in the soil, thus can be a potential habitat of land snail as they benefit in these damp conditions.
3. **Karstic formation.** This habitat is characterized by high carbonate deposits considered as evolutionary hotspots for calcium-dependent animals, such as land snail.
4. **Tree buttress.** Buttresses of large trees creates microenvironment with increased humidity, providing more suitable habitat and pathway for snails to move between ground canopy level.
5. **Decaying logs.** Decaying woods are preferred habitat of land snails as it provides shelter and food source for the organism.
6. **Leaf litter.** Leaf litter helps retain moisture and it provide shelter and protective insulation to the eggs of land snail. Moreover, it contains organic materials where land snails can feed on.
7. **Marshes and Wetlands.** This offers a high level of moisture availability which is suitable for land snail to inhabit.
8. **Residential/ Urban Areas.** Due to their ability to adapt to their environment, land snail can be found in parks, garden, roadside, and trail.

This targeted approach ensures a comprehensive exploration of land snail diversity within microhabitats that are conducive to their presence. Areas lacking these specified microhabitats will be intentionally excluded to maintain the precision of the survey and focus efforts where the likelihood of encountering land snails is higher. Moreover, documentations will be conducted to support the taxonomic analysis such as the location and description of the sampling site. Specific geographic coordinates and altitude for each study area will be determined using the Global Positioning System (GPS).

3.4 Sample Collection

Both live and dead land snails will be the primary samples of this study. Specimens will be thoroughly searched during an extensive two-hour sampling effort. The dead shells will be placed polyethylene plastic bags that will serve as temporary container. Meanwhile, the live specimens will only be photographed to capture its morphological characteristics, underscoring the commitment to their conservation.

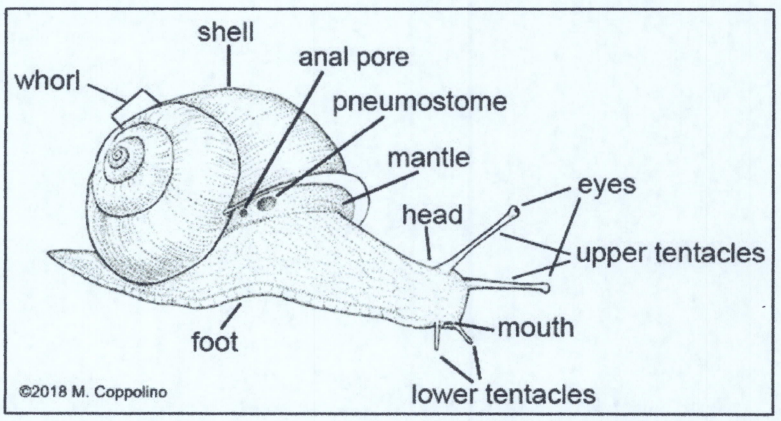

Figure 4. Morphological Features of Land Snails

The sampling period is scheduled during the month of December 2023. Sampling activities are planned during the periods specifically between 0600-0900h and/or 1600-

1800h, when the visibility and activity of land snails are at peak levels (de Chavez, 2014). Moreover, the specimens will be photographed from various angles to ensure comprehensive documentation. This involves capturing images from the dorsal and lateral view, including the anterior and posterior end of the land snails to provide a thorough visual record.

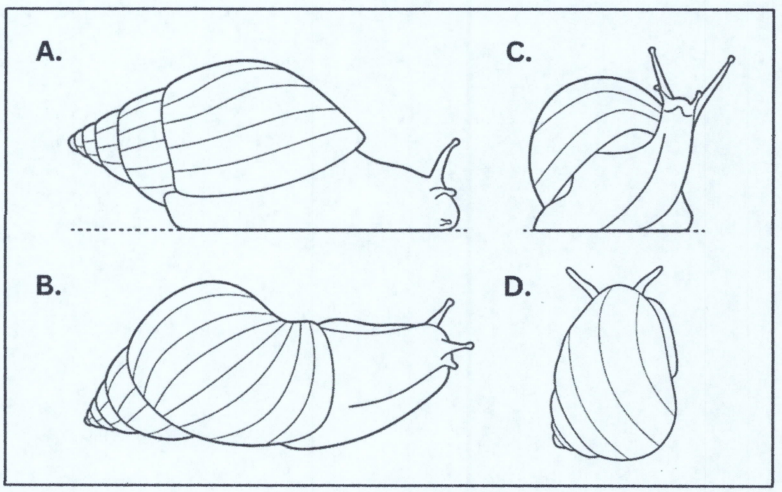

Figure 5. (A) Lateral View of a Land Snail, (B) Dorsal View, (C) Anterior End, and (D) Posterior End

3.5 Land Snail Identification

Upon collection of specimen photographs, the land snails are to be analyzed and will be systematically categorized into groups based on shared morphological characteristics. The identification will also employ morphometric analysis which involves a quantitative examination that relies on the dimensions and proportions of various samples to assess characteristics as well as the forms and dimensions of different specimens. Various characteristics related to the size and shape of the shell and body will be measured such as:

1. **Shell Height.** Vertical measurement from the base to the apex (top) of the shell.
2. **Shell Width.** The measurement across the widest part of the shell.

3. **Aperture Height.** The height of the opening of the shell.
4. **Aperture Width.** The width of the opening of the shell.
5. **Whorl Count.** The number of spirals or turns in the shell.
6. **Body Whorl Diameter.** The diameter of the last whorl.
7. **Radial Sculpture.** The presence, absence, or characteristics of radial markings on the shell.
8. **Spiral Sculpture.** The presence, absence, or characteristics of spiral markings on the shell.
9. **Body Length.** The length of the soft body of the snail.
10. **Body Width.** The width of the soft body of the snail.

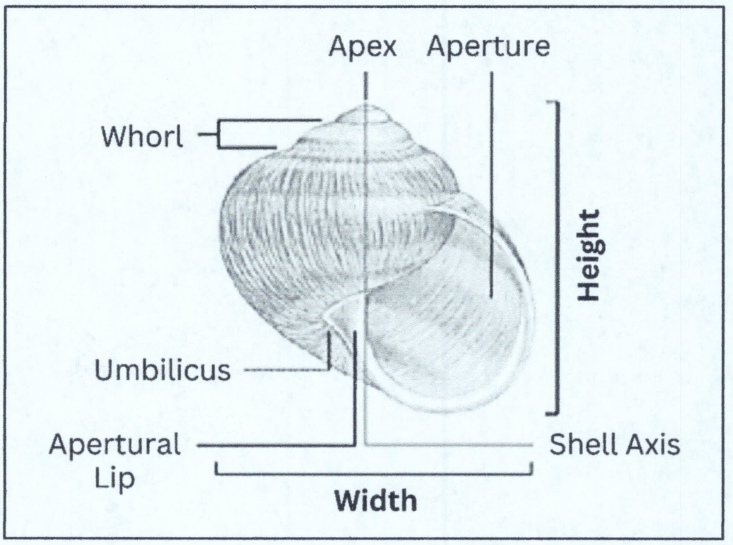

Figure 6. Shell Characters to be Used for Identification

The morphometrics will provide quantitative data that researchers can use to analyze variations in size and shape among different individuals or populations of land snails, aiding in taxonomic classification, ecological studies, and evolutionary analyses. The key and reference guide by Eversham (2018), Holland (2009), Springsteen and

Leobrera (1986), and Faustino (1930) will be used to identify the samples. After which, the initial identification will be subjected for authentication by a malacologist, which is an expert in the field.

3.6 Ethical Statements

Prior to initiating any sampling activities, the researchers will diligently secure ethical clearance from the university to ensure that the study is conducted in strict compliance with ethical standards and guidelines. Additionally, the researchers will obtain a Wildlife Gratuitous Permit, a permission granted to individuals, academics, research institutions, or organizations, enabling them to capture, harvest, and transport wildlife species from their natural habitats for scientific and other authorized purposes (Biodiversity Management Bureau, 2023). The guidelines outlined in Republic Act No. 9147, also known as the "Wildlife Resources Conservation and Protection Act," will be strictly adhered to, as it is explicitly prohibited to harvest or remove specimens from their natural habitat without obtaining a permit from the Department of Environment and Natural Resources, MIMAROPA Region (Republic Act No. 9147, 2001).

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Republic of the Philippines
POLYTECHNIC UNIVERSITY OF THE PHILIPPINES
Office of the Vice President for Academic Affairs
College of Science

November 29, 2023

CARMEN RAMINA S. TUBAL
Chief
Department of Environment and Natural Resources
MIMAROPA Region

Dear Chief Tubal:

Good Day!

I trust this letter finds you well. I am writing to express my full endorsement and support for the Gratuitous Permit application submitted by our 4th-year students pursuing a Bachelor of Science in Biology major in Animal Biology, Ms. Andrea Paula D. Aguilar, and Ms. Kimberly S. Santos.

The research project titled "Taxonomic Survey of Land Snails in Lubang Island, Occidental Mindoro, Philippines" aligns with the College of Science's commitment to academic excellence, ecological understanding, and community engagement. The project aims to address a critical knowledge gap concerning the malacofauna of Lubang Island, contributing to a more comprehensive understanding of the region's unique ecosystems.

The students have outlined a rigorous methodology involving photographic documentation, species identification, and authentication procedures, showcasing a dedication to scientific rigor. This research not only advances academic knowledge but also supports conservation efforts to safeguard the fragile ecosystems of Lubang Island.

I am confident that the students' work will not only contribute significantly to the scientific community but also reflect positively on our institution. Your favorable consideration of their Gratuitous Permit application is highly appreciated, as it plays a crucial role in ensuring the legal and ethical progression of their research endeavors.

Thank you for your time and consideration.

Respectfully,

Lincoln A. Bautista
Dean
College of Science
Polytechnic University of the Philippines – Manila