

## LOCAL ECOLOGICAL KNOWLEDGE ON LAND SNAIL DIVERSITY IN MOUNT BANAHAW, PHILIPPINES

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### Abstract

*Local ecological knowledge (LEK) is a community-based conservation effort that promotes sustainable management of natural resources. However, studies on LEK are very limited in the Philippines. To address this information gap, LEK on land snails in Mount Banahaw, Luzon Island, Philippines was investigated. Key informant interviews and focus group discussions were conducted in the four communities (Dolores, Lucban, Tayabas and Majayjay) along the slope of the mountain. A snail calendar was used as a tool for identifying the hunting season and practices of these communities on land snails. The results showed that the communities were knowledgeable on macro land snails (>5 mm shell size) such as the introduced species, *Lissachatina fulica* and the endemic and edible, *Ryssota otaheitana*, but were unaware of the snails' ecosystem functions as a food source for other animals and agents of nutrient cycling. Additionally, sustainable hunting of *R. otaheitana* in communities was observed. Only adult *R. otaheitana* were harvested, leaving the juveniles to grow and reproduce. In Lucban, the people hunted while they were waiting for the harvest season of their crops. In Tayabas, the community observed that the snail was abundant during wet and moist soil conditions when leaf litter, its primary food, decomposed easily. In Majayjay, hunting was associated with the blooming of the flowering plant, *Erythrina variegata*. In Dolores, hunting was practiced after clearing farmland. This research underscores the importance of determining LEK in developing policies and regulations on sustainable utilization and conservation of land snails in a tropical forest setting.*

**Keywords:** *Local ecological knowledge; Land snails, Mount Banahaw; Key Informant Interview; Focus Group Discussion*

### Introduction

Local ecological knowledge (LEK), also referred to as “Indigenous Traditional Ecological Knowledge” (IEK) or “Traditional Ecological Knowledge” (TEK), is the knowledge held by a group of people in a specific location about their local ecosystem. It is a combination of practical and scientific knowledge, which may also involve a belief system [1-3]. Typically found in rural settings, LEK is site-specific and unique to the local environment.

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LEK is further defined as a body of knowledge that has three key characteristics: (i) it is a shared system of knowledge among people concerning ecological and environmental relationships (ii) it is developed through direct experiences in a physical setting, (iii) it is transmitted between or among generations [3-7]. Local ecological knowledge is recognized as a vital source of information that involves an interdisciplinary approach to find solutions for governance and sustainable management of natural resources, with minimal environmental degradation [3, 8]. Moreover, several studies have suggested that LEK complements scientific data and can broaden the information base required for making better decisions regarding ecosystems, sustainable resource management and conservation [5, 9, 10].

*M.A. Cebrián-Piqueras et al.* [11] emphasized that the management of protected areas typically focuses on achieving objectives related to scientific ecological knowledge of species and ecosystems. Nevertheless, sustainability science emphasizes the importance of incorporating local ecological knowledge, perceptions of ecosystem service provision and landscape vulnerability to enhance the sustainability and resilience of social-ecological systems.

LEK is widely used in fisheries and forest ecosystems. According to *K. Ruddle and A. Davis* [3], research on LEK in fisheries began in the 1970s and 1980s, with a focus on the practical use of fisherfolk knowledge for marine conservation [11- 21]. Other research focused on the use of LEK in understanding threatened marine species [22- 24].

LEK is also used in the sustainable management of forest ecosystems. Analyzing vegetation function and species using LEK helps in determining priority species for ecological, economic and social interest [8]. Additionally, some Indigenous forest-based management focuses on the restoration of damaged forests to decrease the occurrence of floods and other calamities [25].

In the Philippine setting, majority of the research on local ecological knowledge has also focused on fisheries and coastal resources management [26, 27]. There was only one study that focused on the local ecological knowledge of land snails, specifically on *Helicostyla daphnis*, which is endemic to Cebu, Philippines [28]. However, no studies have focused on the LEK of communities in a forest ecosystem regarding land snail diversity.

Mount Banahaw, which is the highest mountain in the Calabarzon region (IV-A) with an altitude of 2,159 masl, is one of the ideal sites in the Philippines to conduct this study. It is the second largest protected area in the region, covering an area of 10,900.59 hectares [29, 30, 31], and supports high levels of biodiversity, with endemism ranging from 66 to 76 % [29, 31, 32]. The extensive forest cover of Mount Banahaw provides both economic and ecosystem services, such as food and fuelwood sources, water regulation and purification, nutrient cycling, primary production and habitat provision [33]. Mounts Banahaw and San Cristobal were declared as a protected area called the Mount Banahaw-San Cristobal Protected Landscape (MBSCPL) through Proclamation No. 411 in R.A. 9847 in 2009 [31, 34]. This is in accordance with environmental laws such as the National Integrated Protected Areas System (NIPAS Act of 1992) or R.A. 7586, which recognizes the critical importance of preserving the natural biological and physical diversities of the environment. The successful management of these protected areas requires collaborative efforts and cooperation among stakeholders, including local and national governments, private organizations and local communities [35, 36]. Moreover, the Wildlife Resources Conservation and Protection Act of 2001 or R.A. 9147 aims to conserve and protect wildlife resources and their habitats; regulate the collection and trade of wildlife; and support scientific studies on biodiversity conservation [36].

Despite the presence of environmental laws and the proclamation of Mount Banahaw as a protected area, it remains vulnerable to numerous threats. Unsustainable farming practices and encroachment into forest areas for permanent agriculture are still prevalent due to intensified economic pressures. Additionally, the extraction of natural forest products, such as timber and

plants, as well as hunting and poaching of wildlife resources, continue to pose significant risks to the area. For instance, the *Ryssota otaheitana* (Férussac, 1821), a native land snail, was collected by local communities for its meat. This practice of bushmeat hunting can lead to overcollection and overexploitation, ultimately putting further strain on the environment [37, 38]. The area also receives a significant number of occasional hikers and mountaineers, particularly during the summer months (March and April), with up to 5,000 hikers and 300,000 pilgrims and hikers during the Holy Week [39, 40]. This influx of visitors puts considerable pressure on the natural environment. In fact, human disturbance in the area resulted in an ecosystem imbalance, leading to a five-year moratorium on visitation from 2004 to 2008 [41]. This moratorium has since been extended and is still in effect today [42- 44].

Conserving forest ecosystems is crucial because land snails play important roles in the ecosystem. They serve as a food source and aid in forest decomposition, nutrient cycling and soil formation [45, 46]. Moreover, land snails can be used as indicators of conservation areas as they thrive in places with good habitat quality [47]. Protecting and conserving land snails and their habitat can be achieved by identifying and analyzing potential threats. Conservation efforts should include species and habitat monitoring and management, taxonomy research and information education campaigns to highlight the importance of snails and the ecosystem services they provide [48, 49]. *E.G. Funesto and M.J. Flores* [28], suggested that effective conservation programs require adequate knowledge about the species being protected, in line with environmental conservation principles. Conducting social research on Local Ecological Knowledge (LEK) is the first step towards achieving this goal. Such research can help understand the qualities, attributes and implications of human condition/behavior on ecological content and resource management [3].

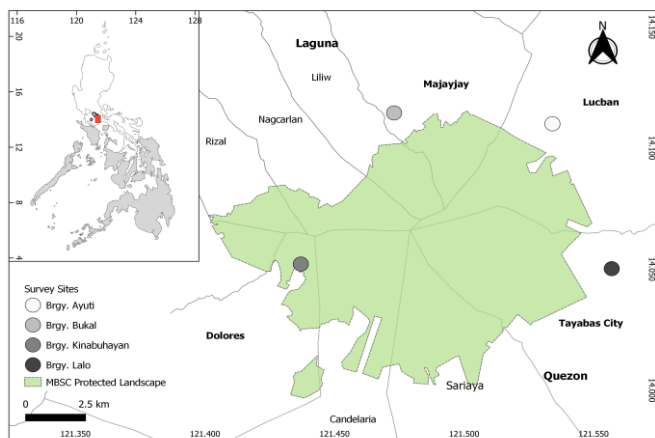
Moreover, *F. Berkes* [50], noted that “traditional knowledge” and “institutional learning” are the heart of “resilience thinking” that provide the essential social-ecological linkages. Thus, it is important also to preserve local knowledge as it helps protect local traditions with positive social and ecological values, contributing to sustainable development. [51].

At present, there are no studies on the Local Ecological Knowledge (LEK) of the communities surrounding Mount Banahaw regarding land snails. To address this information gap, this study sought to determine the LEK on land snails in four communities (Dolores, Tayabas, Lucban and Majayjay). Specifically, the study aims to determine the knowledge and practices of these communities on land snails and differentiate and analyze their LEK. This preliminary study is the first attempt to document the LEK on land snail diversity in a forest ecosystem community in the Philippines. The findings from this study are for designing a conservation program for the malacofauna of Mount Banahaw.

## Experimental part

### *Study Area*

The study was conducted in four areas situated around Mount Banahaw (northeast-Lucban, northwest-Majayjay, southeast-Dolores and southwest-Tayabas) which is located in the provinces of Laguna and Quezon on Luzon Island in the Philippines (Fig. 1). The study covered four barangays (Brgy. Ayuti in Lucban, Quezon (14.1100° N, 121.5341° E), Brgy. Kinabuhayan in Dolores, Quezon (14.0521° N, 121.4370° E), Brgy. Lalo in Tayabas, Quezon (14.0502° N, 121.5570° E) and Brgy. Bukal in Majayjay, Laguna (14.1145° N, 121.4730° E) that were selected based on their agricultural and residential significance.



**Fig. 1.** Sampling sites for the KII and FGD

**Methods**

The corresponding author collected data for this research as part of a series spanning January 2017, October and November 2017 and February 2018. Both qualitative and quantitative approaches were employed to gather information on the local ecological knowledge of the respondents. The study utilized Key informant interviews (KII) and focus group discussions (FGD) in accordance with the approach outlined by *A. Davis and J. Wagner* [52].

The key informants were identified as expert sources of information and considered to be the most knowledgeable regarding the utilization, management, protection and conservation of the protected area and the surrounding community [53]. Table 1 presents the sample of the study, which consisted of 8 informants, with 2 from each study area. Details of the respondents are also presented in the table. Purposive sampling was used to select key informants for in-depth face-to-face interviews [51, 53-55], which were audio recorded with the informants’ consent [28]. For the focus group discussions (FGDs) participants were systematically gathered through peer recommendations by asking local individuals who had actual experience with land snails in the forest, including those who hunt or eat an edible snail such as *Ryssota otaheitana* (3). Snail hunters were also included in the FGDs.

**Table 1.** Distribution of the Key Informants in the study areas

Category	Method	Instrument	Dolores	Tayabas	Lucban	Majayjay	TOTAL
Parks officer			1				1
Tourism officer			1				1
Forest Conservation officer					1		1
President of biodiversity and conservation group	In-depth interview	Guide Questions		1			1
Member of biodiversity monitoring system				1			1
Local guide					1	1	2
Head of community conservation unit						1	1
<b>TOTAL</b>			<b>2</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>8</b>

The snail hunters were asked two questions based on the research methods of *E.G. Funesto and M.J. Flores* [28]:

1. Who, other than yourself, do you believe knows the most about 'suso' (land snails)?
2. Do you think that there are other individuals who possess significant knowledge about 'suso' (land snails)?

The snail calendar was a modified cropping calendar in agriculture prepared by the corresponding author to help answer questions about the life cycle and seasonal harvesting practices of land snails by the locals. This tool was presented to the community and participants provided answers during the FGDs. In addition, timeline analysis was done to identify anthropogenic activities such as land-use change or forest cover conversion to different habitat gradients (old-growth forest, young secondary forest and agroforest) throughout time, starting from the 1960s up to the present.

Overall, the study included 60 research informants; consisting of 8 key respondents and 52 participants who took part in focus group discussions. The participants were grouped according to age: teenagers and young adults (12-25 years old), adults (26-45 years old), middle-aged (46-65 years old) and elderly ( $\geq 66$  years old). In-depth discussions were conducted with both the key informants and FGD participants on various pre-determined topics, including their local ecological knowledge (LEK) on land snails, specifically their familiarity with macro ( $>5$  mm) and micro land snails ( $<5$ mm) found in Mount Banahaw.

Tables 1 and 2 provide a breakdown of the participants and their respective age groups.

During the study, the ecological roles of snails and the problems they cause in farming were explored. The participants were also asked about the forest value and ecosystem services it provides. Various activities such as land use change, slash-and-burn farming, wildlife hunting and poaching; and ecotourism were discussed in relation to Dolores (*puestos* or pilgrimage sites) and Majayjay (Bukal Falls). Additionally, the participants' familiarity and awareness of environmental laws and regulations were evaluated from the Barangay level up to the National level. This included laws such as R.A. 9847 (Mount Banahaw-San Cristobal Protected Landscape/MBSCPL), R.A. 7586 (National Integrated Protected Areas System/ NIPAS Act of 1992) and R.A. 9147 (Wildlife Resources Conservation and Protection Act of 2002). Lastly, the key informants and the FGD respondents were asked about the consequences of habitat degradation on land snail communities and whether efforts should be made towards snail conservation.

The plant specimen was identified in the Plant Biology Division, Institute of Biological Sciences, University of the Philippines Los Baños. The research data were analyzed in a qualitative descriptive manner.

**Table 2.** Demographic information of the participants in Focus Group Discussion (FGD)

Category	Sub-category	Dolores	Tayabas	Lucban	Majayjay	Total	%
Gender	Male	9	8	9	10	36	69
	Female	4	7	0	5	16	31
Ages	Teenagers (12-25 years old)	2	0	1	0	3	6
	Adults (26-45 years old)	6	1	3	10	20	38
	Elder (46-65 years old)	5	13	4	5	27	52
	Old-age (66 + years old)	0	1	1	0	2	4

## Results and Discussion

### Local Ecological Knowledge

#### *Familiarity with Macro land snails*

The results of key informant interviews and focus group discussions showed that the locals in Mount Banahaw were knowledgeable about the diversity of macro land snails. The macro land snails that were identified with a 100% response frequency on all the slopes were *Ryssota otaheitana* (Férussac, 1821), *Helicostyla rufogaster* (Lesson, 1832), *Videna metcalffii* (L. Pfeiffer, 1845) and *Lissachatina fulica* (Bowdich, 1822) (Fig. 2). Among these snails, the most familiar to the locals was the edible and endemic land snail *R. otaheitana*, known locally as “*bayuko*” in Laguna and “*bikuyo*” in the Quezon side of the mountain. Moreover, the locals used common names for the land snails based on their Local Ecological Knowledge (LEK) of the size, shape and origin of the land snails. For example, *H. rufogaster* was commonly called “*bayukong tulis/ bikuyong tulis*” because of its elongated high-spired shape, while the introduced invasive land snail *L. fulica* or the Japanese garden snail was commonly called “*bayukong hapon/ bikuyong hapon*”. On the other hand, the locals do not have any local name for *V. metcalffii*.



**Fig. 2.** Macro land snails in Mount Banahaw: (a) *Ryssota otaheitana* (Férussac, 1821); (b) *Lissachatina fulica* (Bowdich, 1822); (c) *Helicostyla mirabilis* (Férussac, 1821); (d) *Helicostyla rufogaster* (Lesson, 1832); (e) *Helicostyla woodiana* (I. Lea, 1840); and (f) *Videna metcalffii* (L. Pfeiffer, 1845)

When asked about micro land snails, 80% of the respondents expressed unawareness of their existence, stating that they had not paid attention to them due to lack of economic value as they are not edible. Some respondents incorrectly identified them as juveniles of the macro land snails, while others cited their small size, which makes them difficult to find in the forest. Through focus group discussions, participants became increasingly aware of the existence of micro land snails and their ecological importance.

#### *Habitat and Biological Requirements*

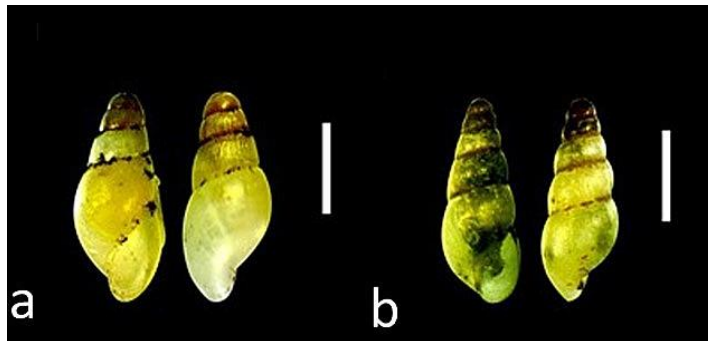
The key informants and the participants in the FGD reported that land snails inhabit various environments. They are sighted in or around farms, agroforestry areas and gardens, with some attached to leaves and others found on understory of trees, bamboos and rocks. Some are found on the ground amidst leaf litter, referred as a “*layak*” in Quezon Province, while others can be found near bodies of water such as streams and rivers. Their diet consists mainly of leaf litter and decomposing materials in forest environments. The specific habitat preferences of these snails are dependent on what species are present in the mountain.

The local ecological knowledge (LEK) of the communities on the habitat and biological requirements of land snails aligns with existing published literature. Observations made in the forest have contributed to their knowledge of land snails. The habitat preferences of land snails vary depending on the species and region, but they generally reflect their fundamental survival requirements, including moisture, food, shelter and a source of calcium for shell-building and physiological processes [56, 57]. Specifically, land snails require habitat with high amounts of calcium and shaded areas with full canopy [58, 59]. Land snails depend on microhabitats characterized by having large accumulations of coarse woody debris commonly found in relatively undisturbed forests [60, 71]. Land snails have diverse feeding habits, including predation, algae scraping off rocks and scavenging, herbivory and some terrestrial species being serious garden and agricultural pests [61].

#### *Ecological Roles*

LEK findings indicate that the local communities have a keen awareness of the ecological roles played by snails, including their importance as a food source for various animals, their role as decomposers in terrestrial environments and their contribution to nutrient cycling and soil formation. Ecologically, land snails are also known to serve as a vital food source for many organisms such as lizards and birds [62]. They play a crucial role in breaking down plant remains and distributing detritus, which help to recycle nutrients and enhance soil structure and formation by increasing soil calcium concentration [63-65]. Moreover, snails are considered good biological indicators of a healthy environment, according to *D.D. Douglas et al.* [66] and *A.S. Nurinsiyah et al.* [67].

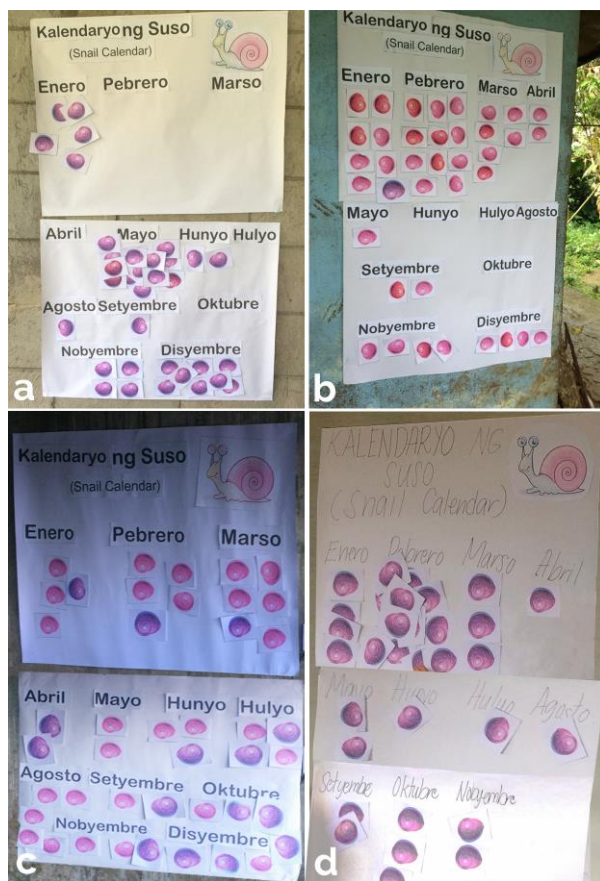
Although the locals have mentioned the ecological roles of land snails on all slopes, some land snails are considered pests as they eat crops, fruits and leaves of plants in the garden. Invasive species of macro land snails, such as *Lissachatina fulica* (Fig. 2c), are often encountered in the garden and vegetable farms and are typically disposed by either being thrown or killed by stepping on them. On the Lucban slope, *Allopeas clavulinum* (Potiez & Michaud, 1838) and *Allopeas gracile* (T. Hutton, 1834) (Fig. 3a and b), are considered pests on vegetable farms, particularly on cucumbers (*Cucurbita maxima*).



**Fig. 3.** Micro land snails considered as pest in agriculture and garden:  
 (a) *Allopeas clavulinum* (Potiez & Michaud, 1838) and (b) *Allopeas gracile* (T. Hutton, 1834)  
 Scale bar= 1 mm

#### *Hunting trends*

A modified version of the cropping calendar in agriculture, the snail calendar, was used per slope to determine which months the people usually started collecting *bayuko* and which months they stopped the practice. The snail calendar also provides information on the different hunting seasons and practices of the locals per slope (Fig. 4).



**Fig. 4.** Snail calendar done by the respondents of the Focus Group Discussion revealed the months of snail hunting in (a) Dolores, Quezon; (b) Lucban, Quezon, (c) Tayabas, Quezon and (d) Majayjay, Laguna

All the locals from the four communities (100% frequency) have answered that snails such as *bayuko* are abundant during wet season, which lasts from June to November. Local ecological knowledge (LEK) from Majayjay and Tayabas locals indicates that during the wet season, leaf litter (*layak*) which is a food source of *bayuko* decomposes easily, making it one of the major requirements for land snails. Another contributing factor is the cold weather and wet, moist soil, which creates a suitable microclimate for land snails to thrive in and reproduce. As result, during the dry season, only a few can be seen on the forest floor and the majority hide from the heat of the sun to prevent dehydration. Dolores and Lucban residents have noticed that during the dry season, the flesh of the snail shrinks and is not as large compared to when they catch them during the wet season. Additionally, a lot of empty shells of *bayuko* can be found on the forest floor during the dry season, majority of which are already bioeroded.

The timing of hunting varied across slopes. In Dolores, hunting typically starts in February and ends in April, after clearing farmlands. In Tayabas, locals typically hunt during November and December, while abstaining from hunting during dry months. In Lucban, *bayuko* gathering occurs from September up to February and stops during March. Hunting is often linked to the farming practices of the Lucban people. Similar to Tayabas, November and December are popular harvest months, as farmers have no work and await the harvest season of their crops. *Bayuko* harvesting also takes place in February, as the snails are commonly found in



cleared or slash-and-burned areas for establishing vegetable farms. *Bayuko* hunting stops during March, which marks the start of the dry season. Between June and August, as well as October, there is no harvesting of *bayuko*, as locals are busy tilling the farmland. Thus, hunting is done while waiting for the harvest season of their crops.

Hunting in Majayjay was frequently associated with the blooming of *kasundet* (*Erythrina variegata*) plants (Fig. 5). Lowland forests, slash-and-burn sites, agricultural areas, moist areas and areas near bodies of water such as rivers, streams, or waterfalls were popular hunting locations. Snails are not found at higher elevations because the forest floor can easily dry out due to sunlight exposure.



**Fig. 5.** *Kasundet* (*Erythrina variegata*) flowering part, associated with the hunting of *Ryssota otaheitana* in Brgy. Bukal, Majayjay, Laguna

#### *Hunting skills and practices*

The most common skill among the locals on all slopes is gathering *bayuko* by creating a hole in the shell and skewing them using a rope made of abaca, making them easy to carry as the hunter's roam around the forest in search of more snails (Fig. 6). Some collectors put their haul in sacks or pails, while others bring their snails home and cook them immediately. However, residents of Dolores and Majayjay have different practices. In Dolores, they placed *bayuko* in containers like pails or metal cages, where they collect as much as they can (Fig. 7). They feed the *bayuko* with vegetables such as chayote (*Sechium edule*). Respondents note that domesticated *bayuko* can last up to a week or a month in their cage, so they have a reserve whenever they crave them. In Majayjay, they hang the snails for two days (Fig. 6). Residents of

Dolores and Tayabas use the term “*tinatabag*” to describe removing dirt inside the snail’s body by not feeding them for a day.



**Fig. 6.** Snail hunting practices of the local community of Majayjay, Laguna (a,d) Dolores, Quezon (b,c). Shells of *Ryssota otaheitana* (*bayuko*) and *Helicostyla rufogaster* (*bayukong tulis*) were incised using a large single-edged knife (*bolo*) and were hooked on top of each other using a rope



**Fig. 7.** (a) Domestication of *Ryssota otaheitana* by feeding them with chayote (*Sechium edule*). Photo taken at the backyard in one of the households in the local community of Dolores, Quezon; (b) *Ryssota otaheitana* (*bayuko*) grilled for consumption in Majayjay, Laguna

There are several reasons why the locals collect *bayuko* from the forest. For one, it serves as a viand for the whole family and is a customary food during birthdays. Additionally, it is also used as an appetizer (*pulutan*) during drinking sessions of men. Some individuals find hunting *bayuko* a hobby and an alternative to their usual food.

The number of adult *bayuko* that the locals gather from the forest differs depending on the slope, period and season. In Dolores, five individuals can gather up to 70 *bayuko* for one hour. Hunting *bayuko* does not have a definite date or time; it usually depends on the hunters' mood or needs. On rare occasions, there is a demand for *bayuko* from the town proper (*bayan*), which prompts hunters to spend several hours collecting snails.

However, there were cases where they just gathered only a few depending also on the hunting season. Individual *bayuko* costs ₱5.00 (USD 0.10) and selling them is only observed in Dolores and not on other slopes or areas. In Tayabas, hunters can gather 20 pieces of *bayuko* in two hours of hand-searching, which is the target number for personal consumption. However, they can gather up to 80-100 pieces overnight, since snails are nocturnal. Similarly, in Lucban, a maximum of 20 *bayuko* is gathered for personal consumption, but 100 pieces can be gathered overnight or during the rainy season, from June to November. In Majayjay, three to four people can collect 46-50 pieces of *bayuko* in five to six hours, which is then shared equally among the hunters.

#### *Consumption of snails, storage and cooking methods*

The locals on the four slopes of Mount Banahaw consume *Ryssota otaheitana*, also known as *bayuko*. Only adult snails are typically collected since, according to the respondents, adults have more flesh to be eaten, and they let the juveniles grow and mature in the forest. This practice has been passed down from their forefathers through generations. Locals believe that *R. otaheitana* is the only safe and edible macro land snail to consume and this traditional knowledge is prevalent on all slopes. This practice has given them the idea that there are other macro land snails that should not be eaten, including *Lissachatina fulica*, *Helicostyla mirabilis*, *Helicostyla rufogaster* and *Helicostyla woodiana* (Fig. 2b-e). However, in Majayjay, a few *Helicostyla rufogaster* were hunted and consumed (Figs. 2d, 6a and d). It is worth noting that tourists have been reported to consume *Helicostyla woodiana*, *Helicostyla rufogaster* and *Lissachatina fulica* in the area, but not the locals.

Residents have several usual practices for preparing and cooking *bayuko*. The first step is to boil the snail with its shell for 30 minutes until the flesh becomes soft. Once done, the shell can be easily separated from the flesh. The snail will then be rinsed in running water to remove any mucus, visceral organs and other impurities. The rest of the methods include sautéing the snail with spices like garlic and onions or coating it with chicken breading mix, depending on the recipe they plan to cook. Locals cook the snails as their main dish in several ways, similar to how they cook other meat sources. Here are some of the dishes that they commonly make with *bayuko*:

- *Adobong bayuko sa toyo* (Marinated and cooked *bayuko* in soy sauce and vinegar);
- *Adobong bayuko sa gata* (Marinated and cooked *bayuko* in coconut milk);
- *Sisig na bayuko* (Grilled in skewers, cut into pieces and mixed with garlic, onions, ginger, chili peppers and chicken liver);
- *Inihaw na bayuko* (Grilled *bayuko*) (Fig. 8);
- *Bopis na bayuko* (Sautéed in garlic, onions, carrots, ginger, chili peppers and simmered in vinegar);
- *Kinilaw na bayuko* (Eating raw *bayuko*, cured with calamansi or vinegar, spiced with chili peppers);
- *Pirinitong bayuko* (fried *bayuko*);
- *Kinamatisan na bayuko* (Sautéed *bayuko* in tomatoes);

- *Afritadang bayuko* (Meat stew; fried *bayuko* in tomato sauce with carrots, potatoes and bell peppers);
- *Kalderetang bayuko* (Meat stew with liver spread);
- *Bistek na bayuko sa toyo* (Marinated and cooked *bayuko* in soy sauce).

The respondents have cited several reasons why they eat *bayuko* as their primary source of protein. Firstly, it is an exotic food item that is both free and relatively cheap, as compared to more traditional meat sources such as beef, pork and chicken. Moreover, it is readily available in the forest and many people find its taste similar to chicken gizzard, making it quite delicious. The locals also attest to the nutritional value compared to pork meat. They claim that land snail contains no fat (Majajjay), no cholesterol (Tayabas) and are clean and full of nutrients (Dolores) since it is sourced directly from the forests and vegetable farms.

The importance of land snails, especially *R. otaheitana* (*bayuko*), as a free food source for locals who lack resources to buy food, cannot be overstated. Poverty has been a driving force for the community to hunt snails in the forest. A similar scenario happens in North Cebu where people hunt and consume *H. daphnis* as a food source [28]. Humans have been consuming land snails since ancient times and this practice continues to the present day. In West Africa and West Europe, markets were supplied with land snails. Edible land snails, such as *Archatina* sp. and *Archachatina* sp. become culinary delicacies in Nigeria and an important single source of protein in the diet of rural communities. The high demand for edible land snails has also created a lucrative business through snail farming [68].

The participants of FGDs and KII mentioned that snails are a cost-effective source of protein. The nutritional value of snails is noteworthy, with the shell composed of calcium carbonate and the flesh being 70% made up of water and 60-70% protein on a dry basis. Giant land snails have low cholesterol levels and are rich in lysine. Some publications in Africa have focused on assessing the amino acid concentration of land snails consumed in Nigeria, confirming that the protein content in snails is composed of essential amino acids and sulfur-containing amino acids [69].

An individual *bayuko* costs ₱5.00 (USD 0.10), while the well-known edible snail, *Helix escargot*, is sold for between USD 0.50 to 1 per individual. The hunters have mentioned that the cost is relatively low compared to the energy and effort they exert in hunting the snail inside the forest. When computing the economic value of the snail, it is essential to consider the impact of their absence on the food chain, food web, chemical and nutrient cycling, as well as their interactions with other organisms in the forest ecosystem. This valuation of natural resources requires a thorough analysis [28]. It is alarming to note that the decline in the snail population is mainly due to anthropogenic activities such as deforestation, slash-and-burn agricultural practices, hunting, poaching and overexploitation of snails [70].

In terms of the hunting practices of the locals on land snails on Mount Banahaw, it can still be considered sustainable for several reasons. First, majority of the hunting was done during the rainy season when there is an abundance of *bayuko* in the forest. Second, only adult snails were hunted and not juveniles. Finally, the locals have been asked what they plan to do when they can no longer hunt adult *bayuko*, indicating a consideration for the long-term sustainability of their hunting practices. During the discussion, the participants answered that it is impossible to happen since the protected area is large enough and only a few areas are open for hunting to prevent significant impacts on the *bayuko* population. Furthermore, locals mentioned that there are designated areas where harvesting of *bayuko* is prohibited and these areas are believed to have a lot of *bayuko* growing and reproducing. According to the key informant in Lucban, the community is aware of the prohibition against extracting resources from the forest. As a result, farmers usually hunt *bayuko* in the lowland areas, specifically on vegetable farms rather than within the restricted areas of the protected forest.

In addition, according to key informants in Dolores, as specified in Republic Act 9847, anything coming from the forest, especially wildlife, should have a permit or clearance from the Protected Area Management Board (PAMB). Those who violate the Republic Act may face fines and the severity of the penalty will be determined by a judge. The penalty can range from ₱500 to 500,000 (USD 8816.71), and the offender may be imprisoned.

However, due to the large, protected area, there are numerous entry points and limited manpower, making it challenging for the government to manage the area effectively. To address this issue, stakeholders, especially the Department of Environment and Natural Resources (DENR), in partnership with local government units, should create ordinances and programs aimed at regulating or preventing snail hunting activities. These initiatives should take into consideration the biological requirements, life cycle and habitat protection of land snails, especially the famous *Ryssota otaheitana*. For example, there should be a limit on the number of snails that can be hunted and the strict implementation of R.A. 9847 should be enforced. Anyone caught violating these regulations should be subjected to strict fines or sanctions.

#### ***Forest value of Mount Banahaw***

The forest is highly valued by the communities living along the four slopes because it provides various ecosystem services that are integral to their everyday lives. The forest serves as a primary source of all the resources that they need, including essential provisioning services such as food sources like *bayuko*, crops like sweet potato and livelihood opportunities; however, forest lands are converted to agricultural lands for tilling and vegetable farming. Mount Banahaw is also known to be a watershed. It is a source of water for both domestic, commercial and agricultural purposes. According to the elders, Mount Banahaw is called *Vulcan de agua* because its crater in Sariaya, Quezon expelled water and rocks during its last eruption in 1843 [72].

The respondents also mentioned the importance of regulating services that forests can offer, such as climate control. Forests provide fresh air and cool weather since more trees mean more carbon dioxide absorption, which is essential nowadays because of climate change. Additionally, having more trees helps prevent erosion and landslides and they serve as windshields against storms and typhoons.

According to the respondents, Mount Banahaw provides cultural ecosystem services such as recreational and spiritual services. It serves as a popular tourist destination, providing opportunities for relaxation and connecting with nature. It is also a place where mountaineers usually go for a hike. Additionally, the Dolores side of the mountain is known to be a pilgrimage site for different religious groups. Lastly, Mount Banahaw provides supporting services since the forest serves as a habitat for numerous organisms, including land snails.

#### ***Activities in Mount Banahaw***

A timeline analysis was constructed based on the interviews with key informants and responses from focus group discussions. Land use changes on the mountain occurred between the 1960s and 1990s, including slash-and-burn farming, wildlife hunting and poaching. These activities were very rampant on all the slopes from 1960s to the 1980s but stopped from the 1990s until the year 2000.

Activities vary across the slopes of Mount Banahaw. In Dolores, pilgrimage and hiking are popular, especially during the Lenten season or Holy Week. In Majayjay, Bukal Falls, located at the foot of Mount Banahaw, has become a popular ecotourism site since it was publicly opened in 2016, attracting many tourists. Lastly, hiking and mountain climbing are popular on the Tayabas side of Mount Banahaw.

#### ***Efforts of Stakeholders to protect and conserve Mount Banahaw***

In Lucban, the local government unit put an end to slash-and-burn farming that was stopped in the 1990s. As a result, a portion of Mount Banahaw was declared under the protection of the Forest and Conservation Unit of Southern Luzon State University (SLSU).

In Tayabas, treasure hunting was stopped by the DENR and the local community. In 1984, the *Luntiang Alyansa ng Bundok Banahaw* (LABB) was established. Members of this organization have undergone training from different universities and experts in forest management, protection and ecosystem conservation. The LABB organization is now called *Tapat Kalikasan*. Since the early 2000s, students, government employees and non-government organizations have been conducting tree planting activities, particularly in Dolores (Figure 8a), Tayabas and Lucban.

**Familiarity and awareness of Environmental laws and regulations**

Regarding familiarity and awareness of environmental laws and regulations, only the key informants had knowledge of R.A. 7586 (National Integrated Protected Areas System/ NIPAS Act of 1992) and R.A. 9147 (Wildlife Resources Conservation and Protection Act of 2002). However, respondents from the FGDs were knowledgeable about R.A. 9847 (Mount Banahaw-San Cristobal Protected Landscape/ MBSCPL) and the environmental laws and regulations within their community, such as no littering and waste segregation (Fig. 8b and c). Information education campaigns on environmental laws and regulations were conducted as well as posters of DENR were posted in different areas of Mount Banahaw to inform the locals, visitors and tourists about the rules and regulations in the protected area (Fig. 8c and d).



**Fig. 8.** Information education campaign found on the pilgrimage and camping site of Mount Banahaw de Dolores (a); Environmental rules and regulations in barangay-level (b), municipal-level found on the pilgrimage and camping site of Mount Banahaw de Dolores (c); and Environmental rules and regulation found on the foot of Mount Banahaw de Tayabas (d)

Based on the responses of the locals regarding the ecosystem services provided by the forest, emphasis was given to the consequences of habitat degradation and land use change in the protected area, especially on land snails, due to their economic importance to the locals. Results from KIIs and FGDs revealed that slash-and-burn farming was prevalent from the 1960s up to the 1990s. Efforts from various stakeholders, such as local government units (LGUs), a state university (SLSU) and the Department of Environment and Natural Resources (DENR), led to the cessation of this activity [39-43].

The timeline analysis also showed the importance of collaborative efforts of the LGUs, DENR, barangays and local communities in the strict implementation of the policies, rules and regulations for protecting the mountain from habitat degradation. Based on the FGD results, the local communities perceived the laws imposed by DENR as having a positive impact on the environment. The entire protected landscape was regenerating and being reforested, indicating good governance from the LGUs and local communities in implementing the moratorium and limiting the number of people entering the protected area. The forest, the habitat of land snails, was protected by laws such as R.A. 9847 and 63,038 hectares have already been reforested in Mount Banahaw [44].

## Conclusions

LEK (Local Ecological Knowledge) is a community-based conservation effort aimed at the sustainable management of natural resources in Mount Banahaw. The locals have extensive knowledge of macro land snails, especially those with economic importance such as *Ryssota otaheitana*. However, they were previously unaware of the existence of micro land snails due to their small size and some mistook juvenile specimens of the bigger species. The LEK initiative has documented the local consumption of land snails such as *R. otaheitana* (commonly known as *bayuko*), as a food source. Additionally, LEK efforts have focused on understanding the ecological roles, habitats and biological requirements of land snails, which coincide with published literature on the subject.

Despite hunting for *bayuko* for local consumption, respondents have suggested that there is a sustainable way to utilize this species. The community only hunts mature snails, leaving the juveniles and sub-adults to reach maturity. Furthermore, they only consume adult *R. otaheitana* and consider other macro land snails inedible. This knowledge has been passed down by their forefathers to the succeeding generations. Snail hunting was only practiced during rainy season when *bayuko* is abundant. Hunters only hunt in accessible areas of the mountain and believe that there are still many unexplored areas where land snails can still grow and reproduce. Thus, sustainable hunting of this species was noted in all slopes.

In terms of conservation strategies, the moratorium implemented since 2004 has resulted in successful reforestation. The combined efforts of the local government units (LGUs), Department of Environment and Natural Resources (DENR) and the community have been instrumental in achieving successful commitment towards environment conservation. However, there should be a community effort to conservation of land snails in the protected area. Strict monitoring and management of land snails should be implemented and ordinances, regulations and laws should be initiated and mandated by the LGUs in coordination with DENR to regulate land snail consumption and utilization. Moreover, it is recommended to conduct information education campaigns and control or eradicate invasive species of land snails in collaboration with local malacologists.

Therefore, this research highlights the importance of understanding Local Ecological Knowledge (LEK) and underscores its importance in developing rules, policies, regulations and laws that promote sustainable utilization and conservation of land snails in a tropical forest setting.

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