LAND MALACOFAUNAL SURVEYS IN NORTHERN LUZON, PHILIPPINES: STATUS AND CHALLENGES

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ABSTRACT

Island snail diversity is truly amazing for archipelagic country such as Philippines with the prospect of high level of endemicity. The Northern Luzon alone encompasses the two largest mountain chains with different geologic origins, the Central Cordillera and the Sierra Madre. The mountains are mostly made up of mixture of limestone and volcanic materials. To gauge as to how many of the land snails have been reported in Northern Luzon, we surveyed accessible secondary sources. The most comprehensive listing of Philippine land snails was reported by Faustino in 1930 comprising of 1,294 species of which 709 (or more than 50%) are recorded from Luzon. Other relevant sources of information include the work of Springsteen and Leobrera in 1986 on Shells of the Philippines and Gray's Collection of the Cyclophoridae from the British Museum in 1850. We compared these listings with the collections that we have accumulated from several opportunistic field surveys. We then generated a spatial distribution map based on the available geographic references. We suspect that the collated data is an underrepresentation of the actual land snail diversity in the island. Some of the challenges that we have identified based on our actual field experience in Northern Luzon are as follows: 1) security concerns related to insurgency; 2) bureaucracy in obtaining required permits; 3) rugged terrains and unsafe trails going to the forests; 4) lack of taxonomic experts and field based researchers, 5) few funding opportunities for taxonomic researches; 6) issues on the publishability of taxonomic work; and, 7) lack of computer databases, inventories, and information networks for the collection and collation of information. It takes a lot of courage, passion, and determination to do malacology in the most remote regions where silent snails are awaiting to be discovered.

Keywords: malacofauna, Northern Luzon, Philippines, survey, biodiversity

INTRODUCTION

Heaney et al. (2016) considers Luzon as one of the most geologically active and complex part of the world, with the Philippine fault lying in Northern Luzon's two largest mountain chains, the Central Cordillera and the Northern Sierra Madre. These two mountain ranges are therefore composed primarily of the remnants of ancient and recent volcanic eruptions. Sierra Madre extends to the south of the Philippine Fault along the eastern edge of Luzon constituting the Southern Sierra Madre. The mountains are made up of mixture of limestone and volcanic materials (Heaney et al. 2016), substrate known to be favored by land malacofauna (Graveland and van der Wal 1996).

Land snails play an important role as macro-decomposers responsible for recycling of dead plant matter and animal wastes in forest ecosystems. The shells of dead snails contribute to concentration of soil calcium. They also serve as food for many animals such as ants, amphibians, reptiles, birds, and mammals including humans. Native species are habitat-specific and are most vulnerable to habitat degradation. Despite the elegant beauty and color of Philippine land snails, there are still very few who are studying them as compared to their marine counterparts. In a literature survey, only 11 malacological studies were conducted so far in Northern Luzon with just three works being published (Baoanan and Obanan, 2009; Cabauatan et al. 2014; Pall-Gergely et al. 2017). The rest were report from UPLB Museum of Natural History (2018) and undergraduate theses from University of the Philippines Baguio (Guerrero and Pamplona 2009; Perez and Sampang 2009; Bayating et al. 2012; Cruz and Sevilla 2012; Lazaro and Montiflor, 2012; Sotalbo and Romero 2013; Batle et al. 2017).

In this paper, we hope to: 1) provide list of land snails collected from literature and field surveys in selected sites of Northern Luzon; 2) generate a spatial distribution map of collected specimens; 3) assess the status of land snails so far documented in Northern Luzon based on IUCN Red List; and 4) identify the challenges that limits researches on land snails.

METHODOLOGY

Biodiversity datasets on land snails covering the landscapes in Northern Luzon were initially gathered from libraries and research offices of universities, national government agencies, and local government units. Materials available via internet were accessed using search engines with open access including Open Science Directory (http://www.opensciencedirectory.net/), Public Library Science (http://www.plos.org/), and Google Scholar (http://scholar.google.com.ph/). The collated data were supplemented with the collections accumulated by the first author (ZGB) from opportunistic field samplings including the recent expeditions funded by the Commission on Higher Education Discovery Applied Research and Extension Trans/Inter-Disciplinary Opportunities (CHED- DARE TO) Grant-in-Aid. Standard methods in malacological survey were employed such as timed-search in an approximately 10 x 10m microhabitats where the snails can be most likely found such as in rotten logs, loose litter, understory vegetation, underside of leaves, and trunks of trees covered with mosses.

Previous studies with reported geographic coordinates and past and recent collections of the authors were included in the summary table (Table 1) and used as basis for the map lay-outing in QGIS. The geographical locations were determined either with the use of GPS

(GARMIN Montana 680) or smart phone installed with Geocam and GPS Status free applications. The position format was standardized into decimal degree format.

After collecting the data (spatial and attribute data) from the secondary sources and from the field, these were exported to Microsoft Excel then subsequently imported to the QGIS formatting for the creation of the map showing the collection sites of land snails (Figs. 1 and 2). Available photos from secondary sources were included in the plates (with permission from authors). Collected shells and encountered live specimens from the field were photographed with CANON DLSR camera and smart phone with Geocam and GPS Status Applications to easily obtain the georeference and altittude of collection sites. Samples of microsnails were brought to the University of the Philippines Baguio laboratory for documentation using a split camera (EC 300 Model) attached to a stereozoom and a computer system. These photographs were presented into several Plates (Plates I-VI). The height and diameter of shell were measured with Vernier caliper. Identification was done using various taxonomic materials (Bartsch 1909, 1913, 1918a,b,c, 1919, 1938, 1942, 1946; Springsteen and Leobrera 1986; Tan et al. 2012) and available data bases such as Global Biodiversity Information Facility (GBIF 2019), Worldwide Mollusc Species Data Base (Galli 2016), iNaturalist Research-grade Observations (iNaturalist.org 2019), and MolluscaBase (2019). Classification was based on the latest revision by Bouchet et al. (2017).

RESULTS AND DISCUSSION

The work of Faustino (1930) is the oldest available literature on Philippine land snails. He listed a total of 1,294 land snails of which 769 or more than 50% are from Luzon. Filtering through the datasets, 95 or 7.3% of the listed species are found strictly in Northern Luzon area because some entries would generally indicate Luzon. Gray's compilation of Nomenclature of Molluscous Animals and Shells in the Collection of the British Museum for Cyclophoridae (Gray 1850) and the series of publications of Bartsch (1909, 1913, 1918a,b,c, 1919, 1938, 1942, 1946) significantly contribute to our understanding of Philippine land malacofauna.

Two new species of a new diplommatinid genus were recently described and reported inhabiting Cagayan Province which is northeastern part of Luzon Island: the *Luzonocoptis antenna* Páll-Gergely & Hunyadi, sp. n. [17°49.967'N, 121°56.042'E] and *L. angulata* Páll-Gergely & Hunyadi, sp. n. [18°4.477'N, 121°44.128'E] (Páll-Gergely et al. 2017). Five species of land snails were recorded on selected caves of the Northern Sierra Madre Natural Park that include *Achatina fulica, Helicostyla rollei, Cyclophorus apendiculatus, Helicostyla sp.,* and *Hemitrichiella setigera* (Cabauatan et al. 2014). Pictures of snails and geographical coordinates of the collection sites were not provided in their study. The unpublished literatures were not included but it is worthwhile to mention that the preliminary malacological assessment of selected caves at Sta Teresita, Cagayan had interesting finds of 8 macrosnails and several unidentified microsnails (UPLB Museum of Natural History 2018). Other studies with available shell collections for cross-validation were included in the following summary list.

Class Gastropoda
- Subclass Prosobranchia
  - Order Architaenioglossa
    - Family Cyclophoridae Gray, 1847 [November]
      - *Cyclophorus ibyatensis* Pfeiffer 1854 (Plate I, Fig. 1)
      - *Cyclophorus turgidus* Pfeiffer, 1851 (Plate I, Fig. 2)
      - *Cyclophorus fernandezi* Hidalgo, 1890 (Plate I, Fig. 3)
      - *Cyclophorus woodianus* Lea, 1862 (Plate I, Fig. 4)
      - *Cyclotus mucronatus* (Plate I, Fig. 5)
      - *Leptopoma atricapillum* Sowerby, 1843 (Plate VI, Fig. 2)
      - *Leptopoma caroli* Dohrn, 1862 (Plate I, Fig. 6)
      - *Leptopoma helicoides* Grateloup, 1840 (Plate I, Fig. 7)
      - *Leptopoma nitidum* Sowerby, 1843 (Plate VI, Fig. 3)
      - *Leptopoma vitreum* Draparnaud, 1801 (Plate I, Fig. 8)
      - *Platyrhaphe plebeja* (Plate I, Fig. 9)
      - *Pterocyclos amabilis* Fulton, 1905 (Plate I, Fig. 10)
- Subclass Pulmonata
  - Order Stylommatophora
    - Family Achatinidae Swainson, 1840
      - *Lamellaxis gracilis* (Plate II, Fig. 1)
      - *Subulina octona* (Plate II, Fig. 2)
    - Family Ariophantidae Godwin-Austen, 1888
      - *Macrochlamys sp.* (Plate II, Fig. 3, Plate VI, Fig. 1)
    - Family Bradybaeninae Pilsbry, 1934 [17 April]
      - *Bradybaena similaris* (Ferussac, 1822) (Plate III, Fig. 1)
        - (=*Helix similaris* Férrusac, 1822)
        - (=*Helix similaris* Rang, 1831)
    - Family Camaenidae Pilsbry, 1895
      - *Calocochlia luzonica fumosa* Kobelt, 1908 (Plate III, Fig. 2)
      - *Calocochlia roissyana* Ferussac, 1821 (Plate III, Fig. 3)
      - *Chloraea virgo* Broderip, 1841 (Plate III, Fig. 4,Plate VI, Fig. 4)
      - *Cochlostyla carinata* Lea, 1840 (Plate III, Fig. 5)
      - *Eulota mighelsiana* Pfeiffer, 1846 (Plate III, Fig. 6)
      - *Helicostyla dubiosa* (Plate III, Fig. 7, Plate VI, Fig. 6)
        - (=*Calocochlea dubiosa*)
      - *Helicostyla festiva (*Donovan, 1825) (Plate III, Fig. 8)
        - *(=Calocochlia festiva)*
        - *(=Helix festiva)*
      - *Helicostyla leai* Pfeiffer, 1892 (Plate III, Fig. 9)
        - (=*Eudoxus leai*)
      - *Helicostyla leucophaea* Sowerby, 1841(Plate III, Fig. 10)
      - *Helicostyla lignaria* Pfeiffer, 1891 (Plate III, Fig. 11, Plate VI, Fig. 7)
      - *Helicostyla pithogaster* (Plate III, Fig. 12)
      - *Hypselostyla sp.* (Plate VI, Fig. 5)
      - *Obba listeri batanensis* Bartsch (Plate III, Fig. 13)
    - Family Chronidae Thiele, 1931
      - *Hemiglypta connectens* (Plate IV, Fig. 1)
    - Family Euconulidae Baker, 1928
      - *Kaliella sp.* (Plate IV, Fig. 2)

Family Gastrocoptidae Pilbry, 1918 (=Hypselostomatinae Zilch, 1959; =Aulacospirinae Zilch, 1959)
Gastrocopta sp. (Plate VI, Fig. 8)
Hypselostoma latispira Thomas & Auffenberg (Plate IV, Fig. 3)
Family Helicarionidae Bourguignat, 1877
Lepidotricihia segitera (Sowerby, 1898) (Plate V, Fig. 1)
Nanina azpeitiae (Hidalgo) (Plate V, Fig. 2)
Nanina globulus (Mollendorf) (Plate V, Fig. 3)
Nanina lucidella (Peiffer) (Plate V, Fig. 4)
Ryssota sp. (Plate V, Fig. 5)
Ryssota sagittifera batanica Bartsch, 1938 (Plate VI, Fig. 9)
Vitrinoconus sinaitensis (Peiffer) (Plate V, Fig. 6)
Family Helicinidae Férussac, 1822 (13 April)
Geophorus agglutinans Sowerby, 1842(Plate IV, Fig. 4)
Family Pupillidae Turton, 1831
Pupilla sp. (Plate IV, Fig. 5)
Family Trochomorphidae Möllendorf, 1890 (= Geotrochinae Schileyko, 2002)
Trochomorpha gracilis (Plate IV, Fig. 6)
Trochomorpha metcalfei (Plate IV, Fig. 7)

There are total of 44 documented species distributed into twelve families. Twelve species of prosobranchs belong to the single Family Cyclophororidae. The rest of the species are pulmonate stylommatophorans of the families Achatinidae, Ariophantidae, Bradybaeninae, Camaenidae, Chronidae, Euconulidae, Gastrocoptidae, Helicarionidae, Helicinidae, Pupillidae, and Trochomorphidae.

Majority of the snails obtained in the field belong to the Family Cyclophoridae and Camaeinidae. Cyclophoridae Gray, 1847 is reportedly synonymous to Alycaeidae Blanford, 1864 as the latter appeared in seven checklist datasets in GBIF database (Alycaeidae in GBIF Secretariat 2017). The name Cyclophoridae is the accepted name by virtue of taxonomic publication priority.

The most represented Family is the Camaeinidae which includes the genus *Helicostyla* A.Férussac, 1821 (GBIF Secretariat 2017). *Helicostyla* (also referred to as *Cochlostyla*) is considered to be representing the Philippine land snails and is known to be concentrated in Luzon (Barnett 1982). However, its taxonomic classification has been problematic which may have led to erroneous listings. Springsteen and Leobrera (1986) previously reported that the family Camaenidae is almost morphologically indistinguishable from Family Bradybaenidae such that separation can be based on anatomical characterization. This confusion led to many cases of synonymy as in the case of *Bradybaena similaris* (Ferussac, 1822) being synonymous to *Helix similaris* Férussac, 1822 and *Helix similaris* Rang, 1831 (GBIF Secretariat 2017). The genus *Helicostyla* is likewise synonymized to *Cochlostyla* (Barnett 1982), *Calocochlea* (Barnett 1983), Calocochlia (Naturalis Biodiversity Center 2019), *Eudoxus* (Barnett 1983; GBIF 2017), *Halocochlea* Bartsch, 1932 (GBIF Secretariat 2017), *Heliscostyla* Clench & Archer, 1933 (GBIF Secretariat 2017), and *Helix* (Naturalis Biodiversity Center 2019). While the monophyly of these two families are still unresolved, they are united under the senior name Camaenidae but divided into two subfamilies Camaeninae, primarily from Asia, and Hadrinae from the Australian Region (Bouchet et al. 2017).

The Family Ariophantidae is only represented by *Macrochlamys* Gray, 1847 in this survey. This genus is apparently widely distributed but the identification at species level is difficult. Live snails have shiny shell, but the body comes in different colors from tan (observed at Benguet), dark gray (observed at Batanes), to black (observed at Magsinarao), to yellow (found at Mt. Kalawitan). Thus, accurate identification would require descriptions based on shell, animal colouration, radula, and genitalia (Pholyotha et al. 2018) thereby necessitating collection of several samples for anatomical studies.

The places and the respective geological coordinates where the snails were collected or documented are summarized in Table 1. From this spatial data, a map was created with the use of QGIS software as shown in Figures 1 and 2. Only representative species were used to plot the distribution sites.

Figure 1. Map showing the study sites for malacofaunal surveys in mainland of Northern Luzon.

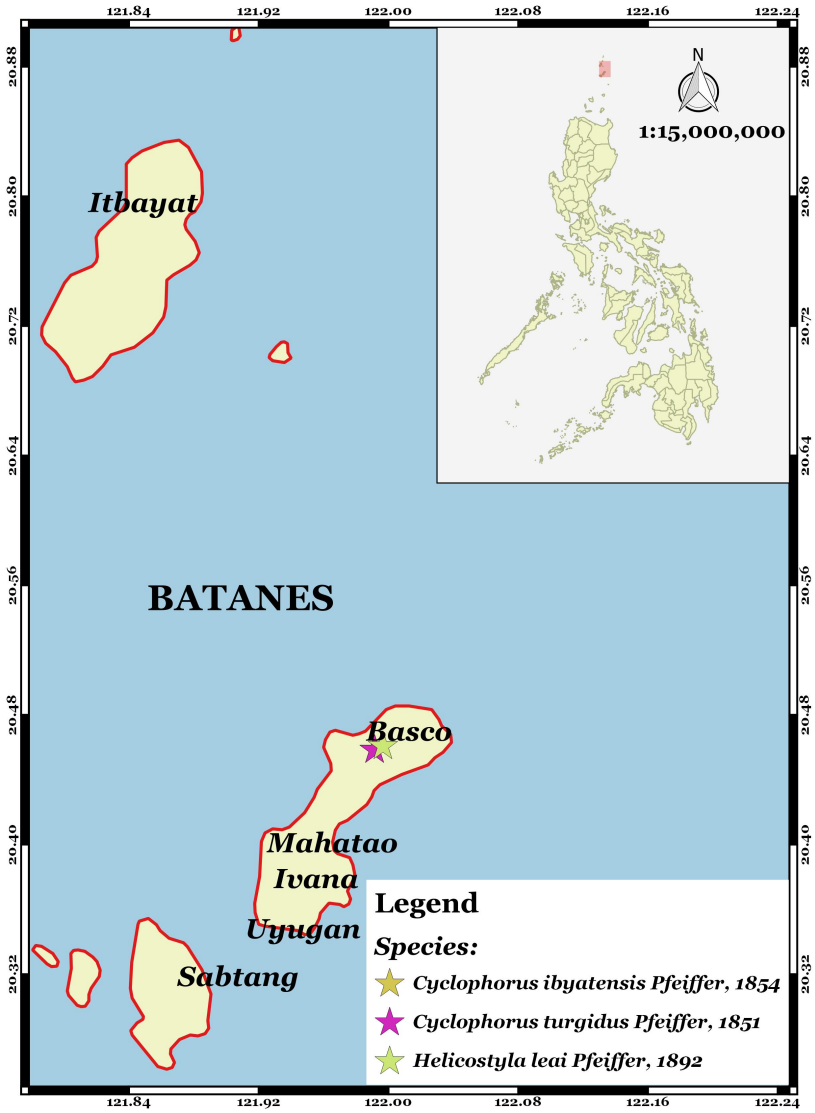

Figure 2. Map showing the study sites for malacofaunal surveys in Batanes group of Islands.

It is evident from Table 1 and in the two figures presented here that malacofaunal surveys are limited to certain provinces. For Batanes, studies were only conducted in Batan Island. The probable reasons for these observations will be discussed later in this paper.

Status of Documented Snails Based on IUCN Red List:

Of the 470 land snails included in the global Red List Category, 75 (16%) are already extinct, 74 (15.7%) are critically endangered, 62 (13.2%) are endangered, a large number of 121 (25.75) are vulnerable, 42 (8.9%) are near threatened, only 16 (3.4%) are of least concern, and 80 (17%) are data deficient (IUCN 2019).

For the genus *Cyclophorus*, *C. horridulum* is declared extinct while two others are endangered: *Cyclophorus sp.nov.* "cave" and *Cyclophorus sp. nov*. "Periomphalic furrow". An unidentified species of *Platyrhaphe sp. nov. 1* in Vietnam is assessed to be Vulnerable in the IUCN Red List due to decreasing population trend and limited distribution on rocky areas of inland cliffs and mountain peaks (Vermeulen 2016). There is only one individual of juvenile

Platyrhaphe plebeja documented in this study. This was found on the litter near the Magsinarao cave.

For the styllomatophorans, *Macrochlamys sp. nov*. "White, umbilicate" is endangered. Two species of *Helicostyla* are least concern. These are *H. velata* and *H. collodes* while data is deficient for *H. zebuensis. Kaliella hongkongensis* and *K.aldabra* are declared as vulnerable and endangered, respectively. Two species of Gastrocopta are already extinct, namely *G. chichijimana* and *G. ogasawarana* while *G. boninensis* is vulnerable. Another two species of *Hypselostoma*, i.e. *H. perigyra* and *H. megaphonum*, are vulnerable with *H. elephas* being critically endangered. Lastly, the population of *Pupilla muscorum* is reported to be declining but is still of least concern.

None of the reported species on our list appeared in the IUCN Red List indicating that no studies have been done so far to assess the state of malacofaunal populations in Northern Philippines.

Challenges limiting malacological studies in Northern Luzon

Generally, there is dearth of malacofaunal studies in the Philippines as previously reported by Barnett (1983) and Ramos et al. (2017). The collated data is apparently an underrepresentation of the actual land snail diversity in the Northern Luzon islands considering that new discoveries (Páll-Gergely et al. 2017) are adding to the list. It is also possible that some of the species have gone to extinction without being noticed since very few are monitoring the malacofaunal diversity.

Some of the challenges that we have identified based on our actual field experience in Northern Luzon are as follows:

Security concerns related to insurgency

It is a sad fact that while national parks and wildlife reserves are haven of diverse organisms, these are also the frequent target of the insurgents due to its strategic geographical isolation (Upreti 2009). This is the case for the provinces of Abra and Apayao with security issues concerning guerilla fronts (NEDA 2017). There was a recent armed conflict between the Regional Mobile Force Battalion of the Police Regional Office – Cordillera and alleged members of the New People's Army last March 29, 2019 which led to the suspension of all activities in mountain province (Cawis April 5, 2019), including Mt. Kalawitan which is one of our research sites. This prompted us to move our scheduled field activities. On the other hand, armed conflicts in protected areas can also be seen as beneficial because it drives people away from the area preventing landscape degradation (Santiapillae and Wijeyamohan 2003).

Bureaucracy in obtaining required permits

Since the passage of Protected Area Legislations including the National Integrated Protected Areas System (NIPAS) and the creation of Protected Area Management Board (PAMB (Restificar et al. 2006), securing permits was indeed cumbersome both in terms of time and resources based on our experience. This discourages researchers to do biodiversity studies in the protected areas where many species remain undocumented.

Rugged terrains and unsafe trails going to the forests

Conducting biodiversity surveys in the rugged terrains of the Cordillera Mountain Ranges can be very challenging as they are steep and mighty high. The access to safe transportation can also be difficult as in the case of going to Palanan, Isabela which can only be accessed by small planes.

Other limitations

The lack of taxonomic experts and field based researchers (Barret 1983), few funding opportunities for taxonomic researches, issues on the publishability of taxonomic works (Drew 2011; Costelo et al., 2013), and lack of computer databases, inventories, and information networks for the collection and collation of information (Ramos et al., 2017) are limitations that generally apply to biodiversity studies. Although some publishing companies are already open for data base publications (Specht et al. 2018), taxonomists will still have to train on how to do this with the help of experts on bioinformatics.

CONCLUSION AND RECOMMENDATIONS

Malacofaunal studies is lacking in Northern Luzon with only three published work out of the 11 materials being accessed. An inventory of 44 species were listed and cross-validated belonging to a prosobranch family of Cyclophoridae and the rest are all pulmonates of the families Achatinidae, Ariophantidae, Bradybaeninae, Camaenidae, Chronidae, Euconulidae, Gastrocoptidae, Helicarionidae, Helicinidae, Pupillidae, and Trochomorphidae. The malacofaunal surveys are apparently limited to areas that are accessible to the researchers. This, together with other challenges being identified, have to be addressed to better address the state of malacofaunal diversity not only in Northern Luzon but to the entire country. There is a need to strategically collate all the available information, both published and unpublished, and systematically deposit in data bases that can be accessed globally.

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