

Morpho-anatomical Characterization and Phylogenetic Position of Two Newly Discovered Rhynchomys Species (R. Labo & R. Mingan) in Luzon Island Philippines and their Conservation Status

Vivien Anne Aquino, Ellona Andrea Hernandez, Enrico Garcia
Bachelor of Arts in Biology

ABSTRACT

One of the known species of the Old-World rats that can be found in the Philippines is the Rhynchomys or shrew like-rats. The genus Rhynchomys has four species which are R. isarogensis, R. soricoides, R. banahao, and R. tapulao. Recently, there are two newly discovered species in the genus, R. labo and R. mingan. Thus, this study assesses Rhynchomys species including the two newly discovered species that were found in the Luzon Island, Philippines. The IUCN Red List was used by the researchers in order to evaluate the conservation status of the species. A bibliographical approach was also used to identify and compare their morphoanatomy. By comparing and analyzing the morphoanatomical characteristics of the six species and based on previous study of four Rhynchomys' phylogeny, the phylogenetic position of R. labo and R. mingan were able to determine. The assessment of their conservation status was R. banahao listed as Least Concern, R. isarogensis under Vulnerable, R. soricoides listed as Near Threatened, R. tapulao is in Data Deficient, and R. labo and R. mingan are still Not Evaluated. As the researchers described the body, head, forefeet, hind feet, and tail of all Rhynchomys species, they have identified that R. labo is closely related to R. isarogensis and R. mingan is to R. soricoides. The findings of this study will provide additional references for future researchers making studies about rats, specifically in the genus Rhynchomys. This could also be the first study to provide an updated geographic distribution and morphoanatomical phylogenetic tree of all six Rhynchomys species.

Keywords: *Rhynchomys, conservation status, morphoanatomy, phylogeny*

INTRODUCTION

Rodents are one of the most diverse mammals with approximately 2000 species which includes almost half of the mammalian species. The species richness of this order results to a succession of divergence and one example of this is the subfamily Murinae or the Old-World mice and rats (Michaux et al., 2017). The diversification was increased by having endemic taxa on some archipelago and islands including Philippines. One of the known species of the Old-World rats that can be found in the Philippines is the Rhynchomys or shrew like-rats. This rat species is characterized by an exceptionally long rostrum, slim mandible bearing thin, reduced molars, lower incisors like a saber, and a complement of other characters which reflect their behavior and diet (Heaney et al., 2017).

The genus Rhynchomys has four species: Rhynchomys isarogensis, Rhynchomys soricoides, Rhynchomys banahao, and Rhynchomys tapulao. They are named after which location they were discovered in various places in the Islands of Philippines where they originally originated. Recently, according to the study of Filipino and American scientists, there are two newly discovered species in this genus, the Rhynchomys labo and Rhynchomys mingan. These two newly found species differ from the four other species of the genus Rhynchomys in terms of its color, body size and proportion, features of their skull and dentition (Rickart et al., 2019). They

all have their own distinct characteristics which are further discussed by the researchers in this study. Furthermore, researchers found 56 new species of different mammal animals, of which 52 species can only be found in Luzon Island including shrew-like rats (Heaney et al., 2016). It significantly shows that Philippines particularly Luzon Island has a great concentration of unique mammals. It proves that the island of Luzon has incredible biodiversity and there might be many other endemic species that are poorly known just like *Rhynchomys* species. However, aside from the richness of the country's biodiversity, the threats to the habitats of endemic species also need consideration and attention.

The researchers conducted this study to assess the species of the genus *Rhynchomys* including the two newly discovered species that were found in the islands of Luzon, Philippines. The study also aims to identify the conservation status of all *Rhynchomys* species. This could be the first study to provide a morphoanatomical phylogenetic tree of all six *Rhynchomys* species. Comparing their morphoanatomy and determining the phylogenetic tree of this genus helps to have further knowledge and clearer understanding of the differences of the species. The findings of this study will provide additional references for future researchers making studies about rats, specifically in the genus *Rhynchomys*.

Review of Literature

Genus Rhynchomys

Rhynchomys, a genus of unusual old-world rats in the family Muridae, can be found only on Luzon Island in the Philippines. As of year 2007, there are four known species of Genus *Rhynchomys* that are all endemic to Island of Luzon: *R. soricooides* (1895) from Central Cordillera Mountain; *R. isarogensis* (1981) from Mt. Isarog in Bicol Peninsula; *R. banahaw* (2007) from Mt. Banahaw in South Central Luzon; and *R. Tapulao* (2007) from Mt. Tapulao in Zambales Mountain. However, in 2019, the study led by Eric Rickart revealed two additional species of *Rhynchomys*'s which were *R. labo* from Mt. Labo in Bicol Peninsula and *R. mingan* from Mt. Mingan in Central Sierra Madre (Rickart et al., 2019).

Morphologically, *Rhynchomys* has a long rostrum, long, slender mouth with thin, saber-like lower incisors, hugely reduced molars, and a variety of other characteristics that indicate a specialized behavior and diet. Further, it was stated as different or most distinctive among other *Chrotomyne* genera (Rickart et al., 2019).

Conservation Status and Concern

The International Union for Conservation of Nature (IUCN) Red List gives information and assesses the trends, status, and threats to distinct species to update and catalyze action for biodiversity management. It has progressed from a subjective list of endangered species produced by a group of experts to a scientifically robust, carefully applied evaluation of extinction risk and threat state of species that is based on quantitative categories and criteria (Betts et al., 2020). Thus, this helps to assess the current status of the *Rhynchomys* species.

Based on (Rickart et al., 2019), there are four more species: *Apomys microdon* Hollister, *Rattus everetti*, *Crocidura grayi* Dobson, and *Suncus murinus*, where *R. labo* occurs which is in the northern slope of Mt. Labo. Among these species, *R. labo* was documented as the most abundant or next to the most abundant native species. Furthermore, in the areas where *R. mingan* was found, it was the second or third most abundant species of small mammal, specifically in mossy forests.

However, according to Lawrence R. Heaney, the species of *Rhynchomys* are not abundant and restricted to montane habitats. These habitats are not under the threat of agriculture or logging, but the mining in Zambales, the number of hikers in mountains, and religious pilgrims in Mt. Banahaw cause a reason to be concern (Heaney et al., 2016). Additionally, indirect risks from geothermal development and mining operations, as well as direct threats from overexploitation of forest resources, all sections of highland habitat, especially the supporting endemic species, require conservation. In this region of regular typhoons, protecting these sites would have significant socioeconomic benefits in terms of sustaining critical watershed processes (Rickart et al., 2019).

The nonappearance of *Batomys* from other mountains in Luzon area seems enigmatic, yet *Batomys uragon* now joins *Archboldomys luzonensis*, *Chrotomys gonzalesi*, and *Rhynchomys isarogensis* as species which are endemic either entirely to Mt. Isarog or to Mt. Isarog and nearby mountains on the Bicol Peninsula. It also suggests that humans played a role in the extinction of old murine rodent (Balete et al., 2015).

Morphoanatomical Approach

Researchers examined the external and craniodental features of available specimens throughout the Luzon area (Rickart et al., 2019; Heaney et al., 2016). *Rhynchomys* is the most distinctive of the *Chrotomyini* genera. They revealed that *Rhynchomys* is characterized by an extremely long rostrum, slender mandibles, reduced molars, and a suite of other characters that reflect specialized diet and behavior.

Rickart, et al. (2016), conduct a study about the mammals of Mt. Amuyao in the Central Cordillera of northern Luzon Island, Philippines. They used 15 native species (14 rodents and 1 insectivore), and two species of non-native rodents. All the native species are endemic to the Philippines, eight being restricted to the Cordillera. Their study revealed greater species richness and faunal heterogeneity within the Central Cordillera than previously suspected.

Moreover, in the study of Rowsey, et al. (2020), they analyze the mandibular morphology (as a proxy for dietary diversity) of lineages on three rodent clades: *Phloeomyini* and *Chrotomyini* (including the genus *Rhynchomys*) from Luzon Island, Philippines, and *Sahul Hydromyini*. They also demonstrate a phylogeny containing the three rodent clades, however, in their study only four species of *Rhynchomys* are included.

Furthermore, there is a study that identify three extinct species which belongs to genera *Batomys*, *Carpomys*, and *Crateromys*, that are distinguished from congeners by body size, distinctive dental and other morphological features, and occupancy of a habitat. This information adds to the species richness and morphological diversity of this endemic Philippine radiation of large folivores and show specifically that the lowland fauna of small mammals on Luzon was more diverse in the recent past than it is currently, and that Luzon recently supported some species of giant rodents (Ochoa et al., 2021).

Phylogeny

Nevertheless, most studies to date have focused on the evolution of multiple lineages. For instance, in the study Rowsey, Heaney, & Jansa (2018), they provide phylogenetic analyses of two clades of Philippine “Old Endemic” murine rodents—*Phloeomyini* and *Chrotomyini*. It shows that *Rhynchomys* species are closely related to the species of *Apomys* and *Soricomys*. It also reveals that *R. banahao* and *R. isarogensis* are closely related while *R. soricoides* and *R. tapulao* are more closely related.

In a study of Steppan & Schenk (2017), they combined new sequence data for more than 300 muroid rodent species with previously published sequences for up to five nuclear and one mitochondrial gene to generate the most widely and densely sampled hypothesis of evolutionary relationships across Muroidea. They used the results of their study to update muroid classification and highlight questions needing additional data. In Australia, the Hydromyini, a lineage of murine, consisted of two major clades, the Philippine endemic radiation of shrew mice, such as *Apomys*, *Archboldomys*, *Chrotomys*, *Rhynchomys*, and *Soricomys*, containing over 32 species in a small area. In this study they were able to collect and create a chronogram and phylogenetic tree consisting of 900 muroid rodent species.

Recent phylogenetic research and taxonomy assessments have almost resolved the evolutionary divides within the old-world rats and mice. Pagès et al. (2016) sequenced one mitochondrial and three nuclear genes from Southeast Asian keystone species from two arboreal divisions for the first time. Their discoveries have far-reaching consequences for the systematics of the Murinae, as well as the early evolution of mouse morphology and dental characteristics. Furthermore, it discloses that three tribes are regarded as dominant murines of Southeast Asian and Indo-Australian areas based on molecular phylogenetic data, one of which is the Hydromyini, which consists of 198 species native to the Philippines, including *Rhynchomys* species.

Conceptual Framework

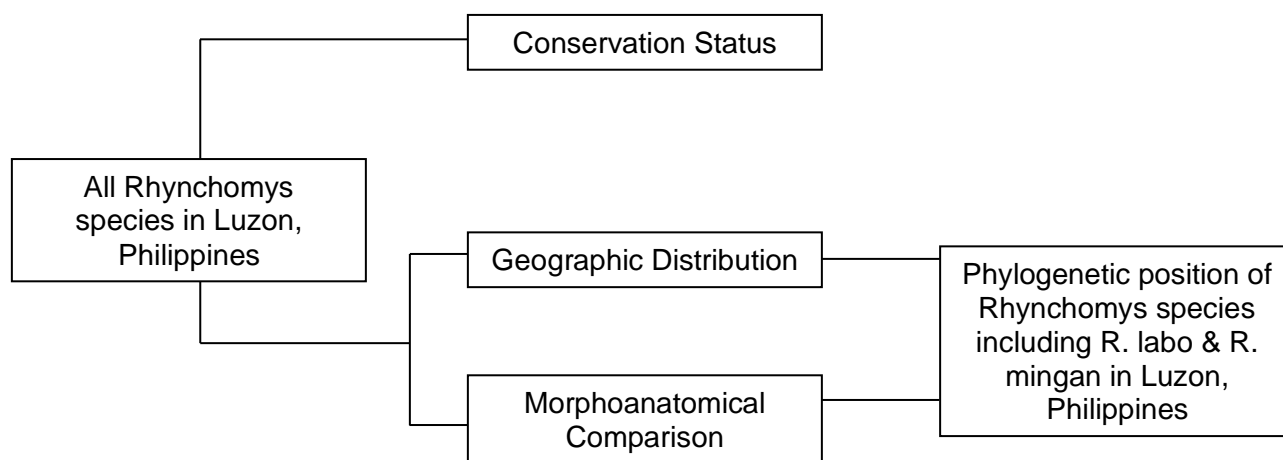


Figure 1. Conceptual framework of the Study

Figure 1 presents the conceptual framework of the study. It shows the process that researchers need to meet the objective of the study. It will start from identifying all *Rhynchomys* species in Luzon, Philippines then assessing its conservation status and geographic distribution, as well as comparing the morphoanatomy of all *Rhynchomys* species. The updated geographic distribution map and morphoanatomical comparison in tabular forms will then be used for determining the phylogenetic position of two newly discovered species, *R. labo* and *R. mingan*, with the old world endemic *Rhynchomys* species.

Objectives of the Study

Generally, the objective of this study is to provide a phylogenetic tree of *Rhynchomys* species including two newly discovered species, *Rhynchomys labo* and *Rhynchomys mingan*.

The study specifically aims to assess the conservation status of *Rhynchomys* species in the Philippine biodiversity. The researchers also aim to provide an updated geographic distribution including six *Rhynchomys* species. Additionally, the researchers aim to compare the morphoanatomy of all *Rhynchomys* species and to determine the phylogenetic position of *Rhynchomys labo* and *Rhynchomys mingan* with the old world endemic *Rhynchomys* species in the Philippines.

METHODOLOGY

This study used qualitative methodology. The researchers utilized a descriptive research design. In research studies, descriptive research design aims to describe a problem or situation which involves obtaining deep information about the subject of the study (Sahin, 2021).

A Bibliographic approach was used in order to identify the endemic species of *Rhynchomys* and to compare the morphoanatomy of all these species. The comparison of its morphoanatomy was presented in tabular forms. Data was also gathered through bibliographical approaches to different articles and journals.

In addition to that, the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (iucnredlist.org) was used as a basis to evaluate the conservation status of all *Rhynchomys* species.

The construction of the phylogenetic tree was done by comparing and analyzing the different morpho-anatomical characteristics of six *Rhynchomys* species in Luzon, Philippines which were published by Rickart et al., 2019; Rickart et al., 2016; Rowsey et al., 2020; Rowsey et al., 2018; Michaux et al., 2007. With this, the phylogenetic position of *Rhynchomys labo* and *Rhynchomys mingan* with other *Rhynchomys* species in terms of its morphoanatomical characteristics were able to be assessed.

RESULTS AND DISCUSSIONS

Conservation Status

The species *Rhynchomys isarogensis* was found in Mount Isarog in Camarines Sur. Based on the IUCN Red List that was assessed also by (Kennerly, 2019), it is under “Vulnerable” (VU) species. It was described as a more common species than *Archbold luzonensis* and *Chrotomys gonzalezi* that dwells in Mt. Isarog. The population of *R. isarogensis* seems secure and unchanging, however, if logging in mossy and montane forest starts again, it would be a big threat to the species. Before, Mt. Isarog National Park was logged specifically in the lower montane forest part. Although it has already stopped, the fact that it has been a place of logging operations, is a threat to happen again in the future.

Rhynchomys soricoides was documented from Mount Data in Benguet Province, Balbalasang in Kalinga Province, Mount Pulag, and Mount Amuyao. In the IUCN Red List, it was listed under “Near Threatened” (NT) that was assessed by (Balete et al., 2017). The species is common in Balbalasang National Park but is uncommon in Mt. Amuyao. *R. soricoides* perhaps is in significant decline at a rate lower than 30% in the span of ten years due to the disruption of its habitats. Some of the forest areas were being converted to farms and some parts of the Cordillera were still in restoration caused by the burning of forest. Since the species occurs in parts of forest with wet leaf litter as they consume earthworms, they are mainly disturbed with the burning as the leaf litter dries, which causes a reduction of their food source.



Figure 2. Conservation status of all Rhynchomys species

Furthermore, *Rhynchomys banahao* was known from Mount Banahaw in Quezon Province. According to the IUCN Red List that was assessed by (Kennerly, 2017), it was in the list of “Least Concern” (LC) species. *R. banahao* exists only in a limited scope of Mt. Banahaw, but it is abundant since the area is not in any threat and is protected. It is distinguished as an uncommon species in montane forests where several *Syzygium* (Myrtaceae), *Podocarpus* (Podocarpaceae), and *Lithocarpus* (Fagaceae) can be found. There is not much conservation action needed for this as the species range is within Mt. Banahaw and San Cristobal National Park, which is being properly managed.

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As of the year 2016, *Rhynchomys tapulao* is listed as “Data Deficient” (DD) in the IUCN Red List that was assessed by (Kennerly, 2017b). There is only a little information on its habitat, ecology, distribution, and abundance which made it listed under Data Deficient species. *R. tapulao* was found in Mount Tapulao in Zambales Province. Agriculture or logging is not the concern for the montane forest in Zambales but the mining plans. The place has been a location for mining before and it might occur once again. Also, the mountain has no specified protected zones which needs an action to conserve the living species in the area.

The two newly discovered *Rhynchomys* species, *R. labo* and *R. mingan*, are under the list of “Not Evaluated” (NE) in the IUCN Red List. It has been categorized as NE as the species has not yet been assessed. According to (Bland et al., 2015), if the assessor did not register a criterion for a species, then this will stay as Not Evaluated (NE).

Morphoanatomy of Rhynchomys Species

Table 1. Description of body of all Rhynchomys species

| Body | <i>R. banahao</i> | <i>R. isarogensis</i> | <i>R. soricoideus</i> | <i>R. tapulao</i> | <i>R. labo</i> | <i>R. mingan</i> |
|----------------|--|--------------------------------------|--|---|--|---|
| Dorsal fur | Dense; tricolored: basal is dark gray, distal is pale golden brown with black tips | Thick and short; soft brown in color | Short, dense, and soft; blackish brown in color | Medium golden-brown in color; tricolored in its individual hair: the basal is medium gray and the distal is pale brown and has black tips | Dense and dark brown overall color; individual dorsal hairs are tricolored: basal is medium gray, distal is golden brown with black tips | Short and dark grayish brown in color |
| Ventral fur | Medium gray with white tips | White with short gray in bases | Pale, silver-gray but some have pure white patches | All white | White with a mix of light gray on the chin, throat, and inner thighs | Medium gray with highlights of yellowish brown with white patches |
| Weight (grams) | 121.5 g (female) and 152.5 g (male) | 121.5 g (female) and 124.2 g (male) | 166.2 g (female) and 173.1 g (male) | 155 g (female) and 134.5 g (male) | 163.1 g (female) and 155.3 g (male) | 162.7 g (female) and 161.4 g (male) |

Table 2. Description of head of all *Rhynchomys* species

| Head | <i>R. banahao</i> | <i>R. isarogensis</i> | <i>R. soricoides</i> | <i>R. tapulao</i> | <i>R. labo</i> | <i>R. mingan</i> |
|----------------------------------|--|---|--|--|--|---|
| Eye | Finely edged and black in eyelids' color with pale gray eye ring | Small eyes | Fairly small eyes | Finely edged and black in eyelids' color | Thinly lined in black color and has pale eye ring | Narrow and has pale eye ring |
| Mouth | Unpigmented lips | Long, pointed, small mouth and unpigmented lips | Small mouth and unpigmented lips | Unpigmented lips | Unpigmented lips | Unpigmented lips |
| Mystacial vibrissae | Long and darker than other <i>Rhynchomys</i> | Long | Long | Longer than other <i>Rhynchomys</i> but paler | Longest as <i>R. mingan</i> than other <i>Rhynchomys</i> | Thickest and longest as <i>R. labo</i> |
| Ear color | Darker than others covered with short black hairs | Paler than other <i>Rhynchomys</i> | Dark gray covered with short black hairs | Medium gray in color with short and black hairs on outer and inner surface | Dark gray covered with short and black hairs | Grayish brown covered with short and pale hairs |
| Ear size from notch (millimeter) | 23-24 mm (female) and 25 mm (male) | 22.2 mm (female) and 22 mm (male) | 24.2 mm (female) and 24.8 mm (male) | 24 mm (female) and 25 mm (male) | 21.3 mm (female) and 21.4 mm (male) | 22.3 mm (female) and (male) |

Table 3. Description of forefeet of all Rhynchomys species

| Forefeet | <i>R. banahao</i> | <i>R. isarogensis</i> | <i>R. soricoides</i> | <i>R. tapulao</i> | <i>R. labo</i> | <i>R. mingan</i> |
|----------------|--------------------------------------|-----------------------------|--|-----------------------------------|----------------------------|--|
| Dorsal | Dark gray with short dark gray hairs | Unpigmented with white hair | Unpigmented with white hair | Unpigmented with short white hair | Unpigmented even the hairs | Unpigmented with short dark brown hair |
| Palmar Surface | Pale with short white hair | Naked and unpigmented | Unpigmented with whitish or flesh-colored hair | Unpigmented | Naked and unpigmented | Unpigmented |

Table 4. Description of hind feet of all Rhynchomys species

| Hind feet | <i>R. banahao</i> | <i>R. isarogensis</i> | <i>R. soricoides</i> | <i>R. tapulao</i> | <i>R. labo</i> | <i>R. mingan</i> |
|-----------------------------|--|--|---|---|--|--|
| Hind feet size (millimeter) | 39.5 mm (male) | 38.0 mm (female) and 38.4 mm (male) | 41.5 mm (female) and male) | 40 mm (female) and 39 mm (male) | 36.5 mm (female) and 37.0 mm (male) | 39.9 mm (female) and 40.0 mm (male) |
| Dorsal | Dark gray with short and dark gray hairs | Unpigmented with short dark brown and gray colored hairs | Unpigmented with short dark brown and medium gray hairs | Unpigmented with short white hair | Unpigmented with short dark brown and pale colored hairs | Unpigmented with short dark brown and pale colored hairs |
| Plantar Surface | Dark gray and naked; pale gray | Naked and unpigmented with gracile claws | Naked and unpigmented with dark gray in | Naked and gray colored; small and unpigmented | Naked and unpigmented with dark gray in | Naked and unpigmented with medium gray in |

| | pads | | some part | d pads | some part | some part |
|---|---|--|---------------------------------------|--|---|--|
| Table 5. Description of tail of all Rhynchomys species | | | | | | |
| Tail | <i>R. banahao</i> | <i>R. isarogensis</i> | <i>R. soricoides</i> | <i>R. tapulao</i> | <i>R. labo</i> | <i>R. mingan</i> |
| Tail size (millimeter) | 123.5 mm (female) and 129 mm (male) | 115.3 mm (female) and 119.7 mm (male) | 146.4 mm (female) and 146.7 mm (male) | 120 mm (female) and 127 mm (male) | 103.6 mm (female) and 105.9 mm (male) | 126.0 mm (female) and 126.6 mm (male) |
| Tail color | Black with an extremely short unpigmented tip | Brown in dorsal; unpigmented in ventral but brown strip in midventral to tip | Dark dorsally and paler ventrally | Medium gray covered with short white and gray hairs dorsally; Ventrally, paler gray in basal and the rest is unpigmented | Dark dorsally and slightly paler ventrally with unpigmented tip | Dark brownish gray dorsally and paler ventrally with darker gray strip in the mid-ventral to the tip |
| Tail Scale Rings (centimeter) | 18-19 cm (female) and (male) | 20-21 cm (female) and 20 cm (male) | 14–18 cm (female) and 15–18 cm (male) | 20 cm (female) and (male) | 18–20 cm (female) and 17–19 cm (male) | 15–17 cm (female) and (male) |

Geographic Distribution and Phylogenetic Position

To create a of phylogeny of Rhynchomys species including two newly discovered species, the researcher based the arrangement in respect to the study of (Rowsey et al., 2018; Rowsey et al.,2020) wherein the phylogenetic position of four Rhynchomys (*R. banahao*, *R. isarogensis*, *R. soricoides*, and *R. tapulao*) was based on DNA sequence data. It is used in the phylogram and

Maximum clade credibility tree of BEAST 2 analysis (Supplementary material). The Figure 3 shows short branch lengths which indicates a recent diversification of *Rhynchomys* species. The phylogeny includes bars at nodes which means there is 95% highest posterior density interval of node ages. In addition, dots at nodes implies ≥ 0.95 posterior probability which are based on (Rowsey et al.,2020). A study reveals that there was a high bootstrap support measured from 90 to 100% for sister relationship of *R. soricoides* and *R. tapulao* however there was a weak support equivalent to $< 75\%$ for sister relationship between *R. isarogensis* and *R. banahao* (Rickart et al., 2019).

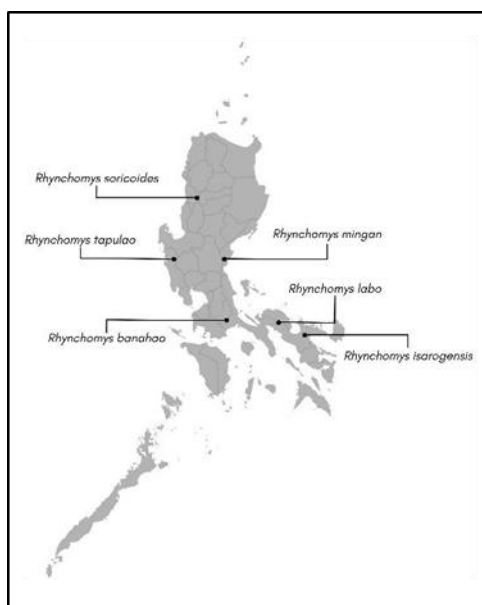


Figure 3. Geographic distribution of *Rhynchomys* species in Luzon Island Philippines

The two *Rhynchomys* species, *R. labo* and *R. mingan*, were positioned according to the analysis of their morphoanatomical data and their geographic region. In table 1, *R. labo*, *R. soricoides*, and *R. mingan* has similar dorsal fur which are slightly darker than *R. tapulao* and *R. isarogensis*, and paler than *R. banahao*. For their ventral fur, *R. labo* and *R. tapulao*, while *R. mingan* and *R. soricoides* are similar. Among other *Rhynchomys*. *R. labo* and *R. mingan* have the longest mystacial vibrissae as indicated in Table 2. The ear color of *R. labo*, *R. mingan*, and *R. tapulao* are similar in which it is darker than *R. isarogensis* and paler in *R. banahao*. All *Rhynchomys*' dorsal and palmar surface of their forefeet are unpigmented except for *R. banahao* which is described in Table 3. Similar to the dorsal of hind feet in table 4, all are unpigmented except for *R. banahao*. The five *Rhynchomys* have unpigmented plantar surface and only the *R. banahao* has pigmented one, but all of them have naked plantar surface. Moreover, table 5 showed that *R. banahao* and *R. labo*, then *R. soricoides* and *R. mingan* have similar tail color. This morphological data and analysis are supported by the study of Rickart and his colleague about two new species of shrew-rats also known as *Rhynchomys*. The findings of the study also

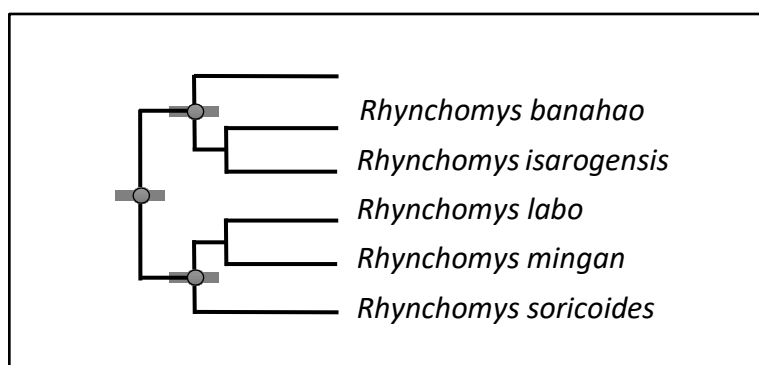
suggest relationship between *Rhynchomys mangan* and *Rhynchomys soricoides*, and between *Rhynchomys labo* and *Rhynchomys isarogensis* (Rickart et al., 2019).

Figure 4. Phylogenetic position of *Rhynchomys* species

CONCLUSIONS

The study successfully assessed the conservation status of six *Rhynchomys* species. The researchers found out that based on IUCN Red List *R. isarogensis* is under “Vulnerable,” *R. soricoides* is “Near Threatened”, *R. banahao* is “Least Concern”, *R. tapulao* status is “Data Deficient”, and both *R. labo* and *R. mangan* have a status of “Not Evaluated”.

Out of all the six *Rhynchomys*, *R. soricoides* has the heaviest weight in both male and female. In contrast, *R. banahao* and *R. isarogensis* have the lightest weight for female and *R. isarogensis* for male. For their ear size, female *R. soricoides* and male *R. banahao* and *R. tapulao*



has the longest ear. While *R. labo* has the shortest ear size in both female and male. Moreover, *R. soricoides* have the longest hindfeet and *R. labo* has the shortest for both male and female. Similar for the tail, *R. soricoides* has the longest and *R. labo* has the shortest size for both male and female. For their tail scales, female *R. isarogensis* and male *R. isarogensis* and *R. tapulao* has the largest scales. Female *R. soricoides* and male *R. mangan* has the thinnest tail scales.

The study revealed the similarities as well as the differences in main body parts of all the *Rhynchomys* species in the Philippines. This helped to identify the phylogenetic position of the two newly found *Rhynchomys* species where *R. labo* is closely related to *R. isarogensis* and *R. mangan* is closely related to *R. soricoides*.

Rhynchomys species are endemic to the Philippines; proves that the island of Luzon has incredible biodiversity and there might be many other endemic species that are poorly known just like *Rhynchomys* species. However, aside from the richness of the country’s biodiversity, the threats to the habitats of endemic species also need consideration and attention.

Recommendations

Further research on *Rhynchomys* species is necessary. A species of *Rhynchomys* is under the list of Data Deficient and two are still Not Evaluated in the IUCN Red List which means that it needs additional information to be enough for its status to be assessed. Also, the conservation status of the species was out of date. Therefore, an update on the data is necessary.

Additionally, the molecular sequence of all *Rhynchomys* species must be in GenBank. It will be more accessible and measurable for researchers to construct a phylogenetic relationship of the six *Rhynchomys* species if all the data sequences are available in the site.

For future researchers, it is recommended to create more study focusing on the endemic species in the Philippines. As we believe there are other endemic species that are poorly known besides *Rhynchomys*. Moreover, the researchers recommend producing related study on phylogeny of *Rhynchomys* that includes the two newly discovered, *R. labo* and *R. mingan*, together with other rats that can be found in Luzon Island, Philippines.

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