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Terrestrial vertebrates in modified landscapes in northeastern Mindanao, Philippines

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Abstract

Dinagat Islands hold most of the mineral deposits in the Philippines and have been among the largest mining contributors in the country since 1939. Aside from a massive mining industry, logging is also intensive in this group of islands potentially imperiling its remaining biodiversity. This study primarily aims to determine the species composition of terrestrial vertebrates (amphibians, reptiles, birds, mammals) in two study areas categorized as modified habitats (mining area and logging area) in the Dinagat Islands. These wildlife species are important bio-indicators as they show sensitivity of the species to anthropogenic disturbances. Suitable field survey methods were conducted for the taxa established and a quantitative analysis was performed to determine the diversity and similarity of the species between the study areas. A total of 65 species were identified in the two study areas: 33 species were exclusively identified in the mining area, 49 species were exclusively identified in the logging area, and 17 species were found in both study areas. It should be noted that among the 65 species, 41 species are either endemic to Mindanao and/or the Philippines, and two species were endemic to Dinagat Islands. This study also recorded the newly described coral snake endemic to the island, *Calliophis salitan* Brown, Smart, Leviton and Smith. This study indicates that although Dinagat Islands is modified by anthropogenic activities, the terrestrial vertebrate species are thriving. Intensive survey in other modified habitats in Dinagat Islands is the next-step forward to take into account existing wildlife to improve conservation decisions, planning and management on the islands.

Key words: Anthropogenic disturbances, amphibians, birds, Dinagat Islands, logging, mammals, mining, reptiles

Introduction

Mining and logging have been among the major causes of biodiversity loss in tropical East Asia, including the Philippines (Catibog-Sinha and Heaney, 2006; Corlett, 2019). Though these activities undeniably imperil the biodiversity, there are laws regulating these activities in the Philippines as they contribute substantial revenue to the country's Gross Domestic Product (GDP), and provide direct and indirect opportunities for local communities (Miranda et al., 2003; Forest Management Bureau, 2013).

The Philippines is among the countries in the world that are rapidly losing their forest habitats (Chakravarty et al., 2012; Corlett, 2019), from 17 million hectares in 1934 to three million hectares in 2003, an approximately 82%

decline, mainly due to logging and mining activities (Lasco et al., 2001; Chakravarty et al., 2012). Additionally, a total of 529,675 hectares has been removed from the Philippines' forested areas from 2001–2012, with a 2.69% annual deforestation rate (Apan et al., 2017). About 93% of the primary forest cover in the Philippines has been removed, one of the tragic cases of deforestation in the Southeast Asian region (Hughes, 2017).

Dinagat Islands is one of the key conservation sites in the Philippines. It is, however, in serious need for protection against the negative environmental impacts of mining and logging activities (Haribon Foundation, 2004; Lillo et al., 2019). The Presidential Proclamation No. 391 of 1939 declared Dinagat Islands as a mineral reserve, due to its rich metallic and non-metallic mineral resources (Nakagawa and Franco, 1995), which encouraged mining applicants to explore, utilize, and quarry large areas of Dinagat Islands. As of the latest information, there are 19 mining companies with approved Mineral Production Sharing Agreements (MPSA) operating in Dinagat Islands extracting silver, nickel, copper, chromite, limestone, and silica (Lillo and Fernando, 2017). Logging was at its peak in the island in the 1960s to 1970s, further reducing the remaining forests (Haribon Foundation, 2004).

Dinagat Islands is part of the Greater Mindanao Faunal Region which represents a large number of endemic species (Heaney and Rabor, 1982); but, the island itself is considered a distinct sub-centre of species endemism, with a great number of endemic species in a small land area (Haribon Foundation, 2004). With a land area of approximately 80,212 hectares, Dinagat Islands has a high level of endemism for both plants and animal species compared to larger islands in the country (Heaney and Rabor, 1982; Ross and Lazell, 1990; Haribon Foundation, 2004; Villanueva, 2010; Řeháková et al., 2015; Sanguila et al., 2016; Brown et al., 2018; Lillo et al., 2019). Notable species that are endemic to Dinagat Islands are *Madhuca lanceolate* (Plantae: Sapotaceae), *Gomphandra dinagatensis* (Plantae: Stemonuraceae), *Risiocnemis calceata* (Animalia: Odonata, Hämäläinen), *Podogymnura aureospinula* Heaney and Morgan (Animalia: Mammalia), and the newly described coralsnake *Calliophis salitan* Brown, Smart, Leviton and Smith (Animalia: Reptilia).

Surveys in Dinagat Islands has been focused in the protected areas of Mts. Kambinliw and Redondo, which are recognized both as an Important Bird Area and Key Biodiversity Area (Mallari et al., 2000; Ambal et al., 2012); however, to our knowledge, no surveys have been conducted in areas which are heavily modified by logging and mining. Although a number of biodiversity surveys have been conducted by mining companies to comply with the Environmental Impact Assessment (EIA) requirement, the data of these surveys remain inaccessible to the public or are considered as gray literatures. Thus, this study was initiated, to determine the species composition of terrestrial vertebrate fauna (amphibians, reptiles, birds, and mammals) in a mining area and logging area in Dinagat Islands. We also intend to provide information on the ecological values (i.e., species richness, relative abundance, distribution range, endemicity and conservation status) of the terrestrial vertebrate fauna in the two modified areas in order to have a scientifically-backed management recommendations for the conservation of terrestrial species in the island.

Material and Methods

Study area and general habitat assessment

We surveyed two locations in Basilisa, Dinagat Islands (Fig. 1). The first location is Mt. Arayat (logging area: Arayat thereafter). Arayat (10º07'29.94" N, 125º37'0.96" E; 500 m a.s.l.) is a mountain located between the municipalities of Basilisa and Libjo in Dinagat Islands with an elevation of less than 500 m above sea level, under the jurisdiction of Barangay Rita Glenda. It is a secondary lowland forest situated on the lateritic terrain of the area dominated by *Antidesma bunius*, *Artocarpus blancoi*, *Macaranga tanarius*, *Parashorea malaanonan*, and *Xanthostemon verdugonianus*. Some parts of the mountain are still believed to be untouched and protected because it is considered as a local community watershed; however, the majority of the region was heavily logged for hard-wood timber.

The second location was Edera Mining Site Parcel 2B Pit 9 (mining area: Edera hereafter). Edera (10º06'29.52" N, 125º33'38.34" E; 250 m a.s.l.) is a chromite-nickel mining managed by the AAM-PHIL Natural Resources Exploration and Development Corp located in Sitio Sandayong, Barangay, Edera has an elevation of less than 250 m above sea level with fruit trees (i.e. *Artocarpus heterophyllus*, *Cocos nucifera*, and *Mangifera indica*) planted at the edges of the slopes. The area was given an Environmental Compliance Certificate in 2009, and started operation and extraction of resources in 2011. Currently, it is on preparation for the decommissioning or closure stage.

Prior to the surveys, we initially coordinated with the local government unit to execute a site reconnaissance to select the best location to conduct the survey. The selection of study areas is primarily based on the observed degree of disturbance in the area. General habitat descriptions for each of the sampling areas were also undertaken prior to the start of the actual field surveys. We used a GPS device to record the coordinates, an LCD temperature-humidity meter to record the temperature and humidity, and a light meter to determine light intensity and habitat openness.

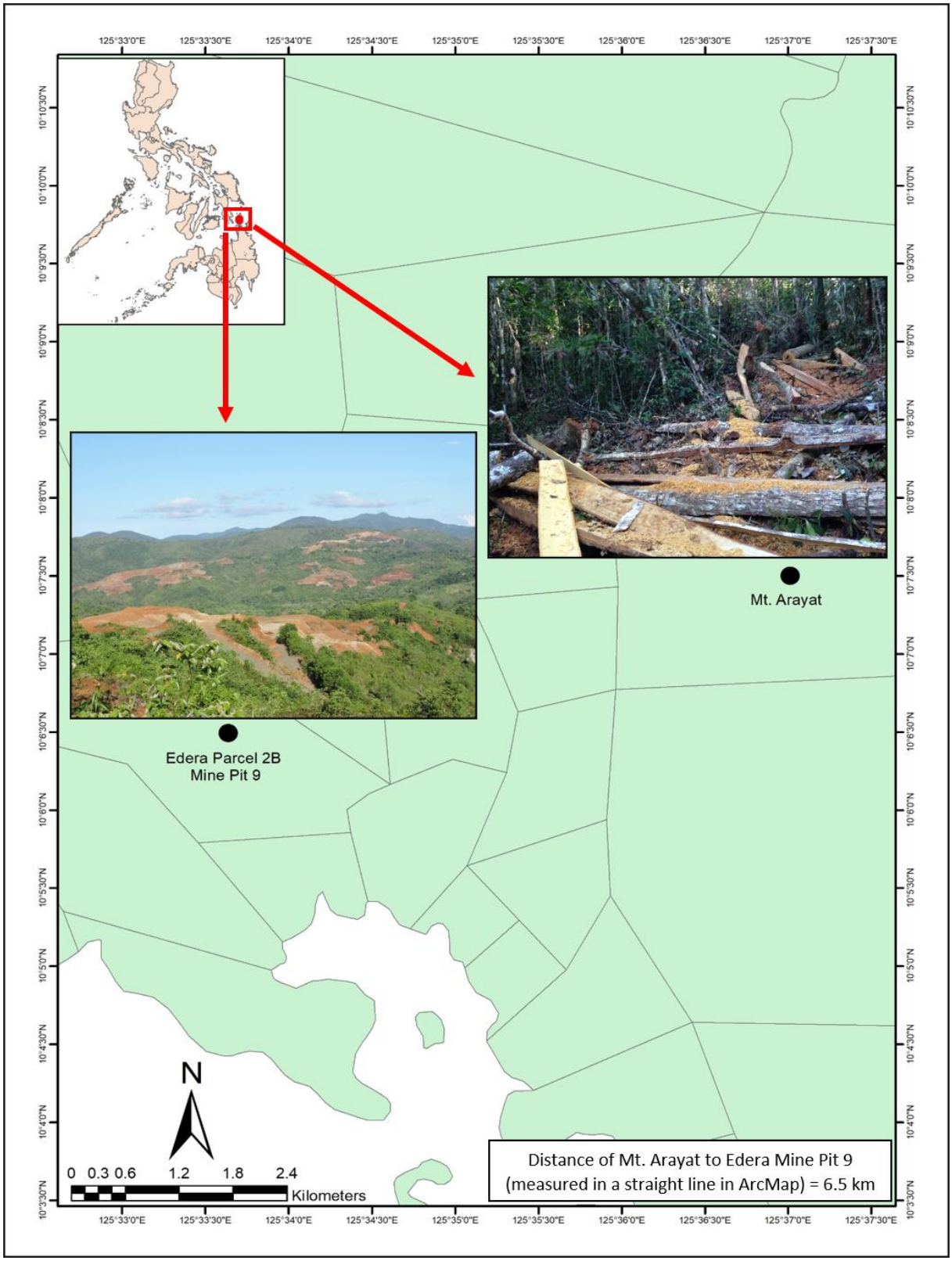


Figure 1: Location of the study areas in Dinagat Islands (Mindanao: Philippines) and corresponding photos of the modification observed in the areas. Map created using the Free and Open Source QGIS.

Species survey

The species surveys encompassed four groups of vertebrate species including amphibians, reptiles, birds, and mammals. Identification of captured and/or observed individual species were ascertained through the aid of published books, field guides and diagnostic keys by Alcala (1986), Alcala and Brown (1998), Ingle and Heaney (1992), Heaney et al. (1998), Kennedy et al. (2000), and

Sanguila et al. (2016), among the few to mention. Due to limited financial resources, we only conducted a rapid assessment where each study area was surveyed for three days and two nights, between the months of April and May in 2017, which is dry season in the country.

Amphibians and reptiles were recorded mainly through strip transect sampling and opportunistic catching. The surveys were conducted twice a day between 0700 to 0900 and 1500 to 1700, where amphibians and reptiles usually bask. We also checked suspected microhabitats like rotten logs, streams, and leaf litters, for possible presence of amphibians and reptiles. In addition, we employed pitfall traps and drift fence in strategic locations for three days and two nights to capture the ground-dwelling and leaf-thriving species.

The bird transect survey was conducted by walking through existing trails (e.g., approximately 1.5 to 2.0 km) within the study areas at a pace of 250 m/15 minutes (method modified from Bibby et al., 1998). Bird species were identified visually and if possible, birds call recognition. If feeding flocks were encountered in the transect line, more observation time was given to ascertain identities of individual birds. The transect walks was performed for three days between 0600 to 0900 and 1500 to 1700, where birds are most active. The species and number of individual birds seen and/or heard were recorded. In addition to the transect walk method, four 12 m mist-nets (standard length used for surveys) were set to capture nocturnal and cryptic bird species (method modified from Bibby et al., 1998). The mist nets were left open for 24 hours for three days and two nights. Mist nets were checked for possible netted individuals every two hours from 0600 to 1600.

We utilized the same mist-nets for birds to capture bats (volant mammals). Mist-nets were left overnight for three nights and were checked early in the morning. For non-volant mammals (i.e., rodents, shrews, primates), fabricated cage traps were used to capture and record the species existing in the area. Fifty fabricated cage traps baited with roasted coconut mixed with peanut butter were set and positioned 5 m apart along possible runways, near burrow entrances, beside tree buttresses, root tangles, rotten logs, and other areas suspected to possibly capture these species.

A profile of species recorded in the two study areas were created by taking note on their residency status, general population trend, conservation status from the latest IUCN (2021) assessment and Philippine RA 9147 DAO-2005, and if they are generalist or specialist species.

Upon capture, photographs of the individuals were taken and released to aid in confirmatory identification of the species. A maximum of five individuals for each species in each survey sites as indicated in the Gratuitous Permit given by DENR Region XII (R13-2016-005). All voucher specimens were deposited in the Philippine National Museum – National Museum of Natural History (PNM-NMNH).

Data analysis

The Shannon-Weiner Diversity Index (H' and Hmax) (Magurran, 1988) was generated using the species richness and relative abundance information. The species dominance (D) and evenness (e) in the area were also computed (Magurran, 1988). To demonstrate if there is an overall difference in the diversity between Arayat and Edera, we computed the Kruskal-Wallis H test. All analyses were made using Paleontological Statistics 4.02 (PAST) Software Package for Education and Data Analysis (Hammer et al., 2001).

Results and Discussion

General profile of terrestrial vertebrates recorded in Arayat and Edera

A total of 65 species was identified in the both study areas surveyed in Dinagat Islands, of which eight are amphibians (12.3%), seven are reptiles (10.8%), 35 are birds (53.9%), and 15 are mammals (23.1%) (see Table 1 for the details of the species). Table 1 shows the number of species recorded for each group in each study area. Of the 65 species, 17 species (26.2%) are similar in the two study areas. In addition to the species richness, we recorded a total of 138 individuals in Arayat and 293 individuals in Edera. Few notable species were photographed and shown in Fig. 2.

We recorded 41 endemic species (63%) among the 65 total species recorded in this study (Fig. 3). There are three amphibians, four reptiles, 16 birds, and seven mammals or a total of 30 species that are endemic to the Philippine archipelago (73.2%). A total of nine species (22%) are endemic to the Greater Mindanao Faunal region, which includes two amphibians, one reptile, four birds, and two mammals. Two species (4.9%) endemic to Dinagat Islands were recorded: the Dinagat Islands Banded Coral Snake (*Calliophis salitan*) and Dinagat Gymnure (*Podogymnura aureospinula*). No introduced or invasive species were observed in the study areas during the survey.

Most species (31 out of 65= 47.7%) recorded have a stable population status based on the IUCN (2021). However, a large number (n= 21) is also decreasing (32.4%). There are two species (3.1%) that are believed to have an increasing number despite the disturbances: the Mindanao Flying Lizard (*Draco cyanopterus* Peters) and the Yellow-vented Bulbul (*Pycnonotus goiavier* Scopoli), based on the IUCN (2021).

Table 1: Number of species recorded in the two study areas: Mt. Arayat and Edera Mining Sites in Dinagat Islands, Mindanao, Philippines.

Taxon	Heavily logged area (Arayat)	Mining area (Edera)
Amphibians	8	2
Reptiles	7	0
Birds	23	24
Mammals	11	7
Total	49	33

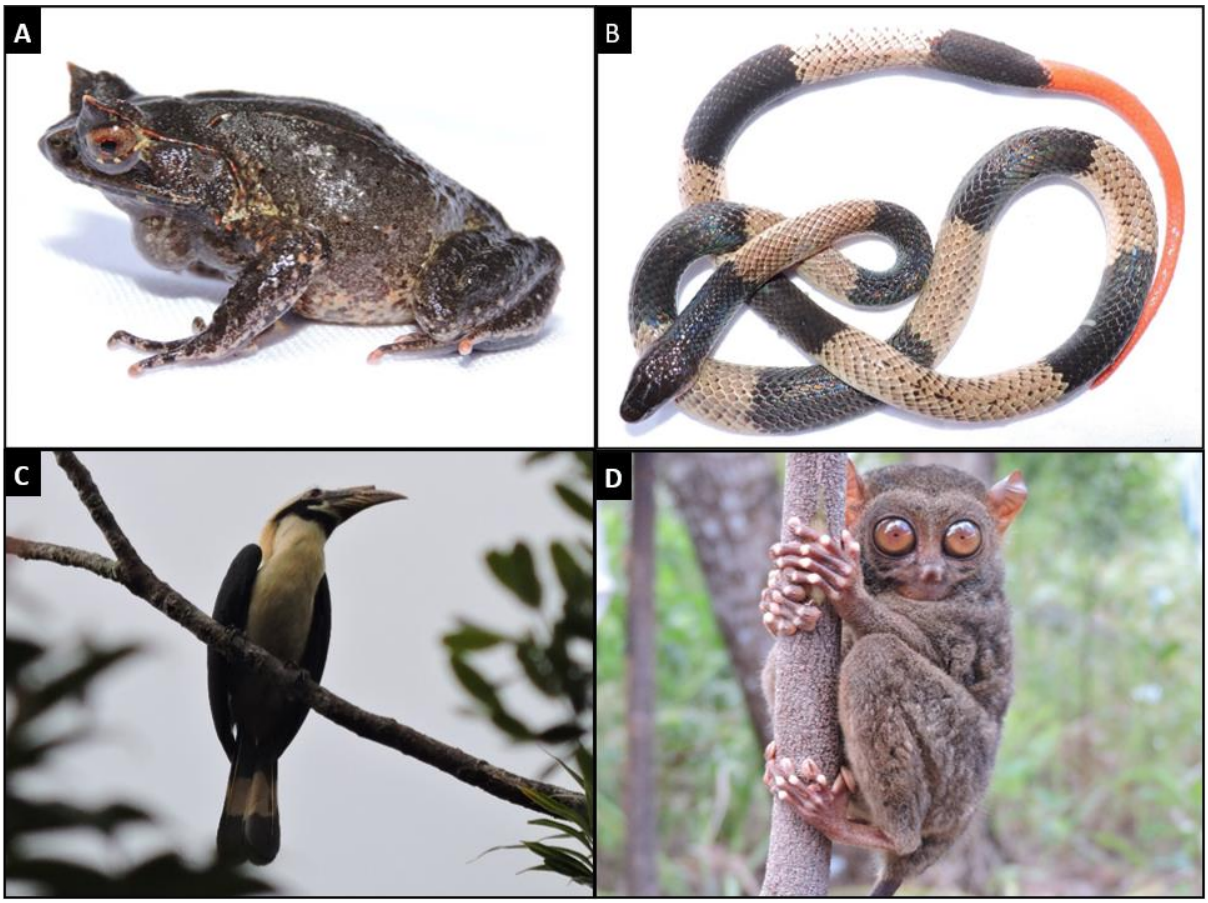
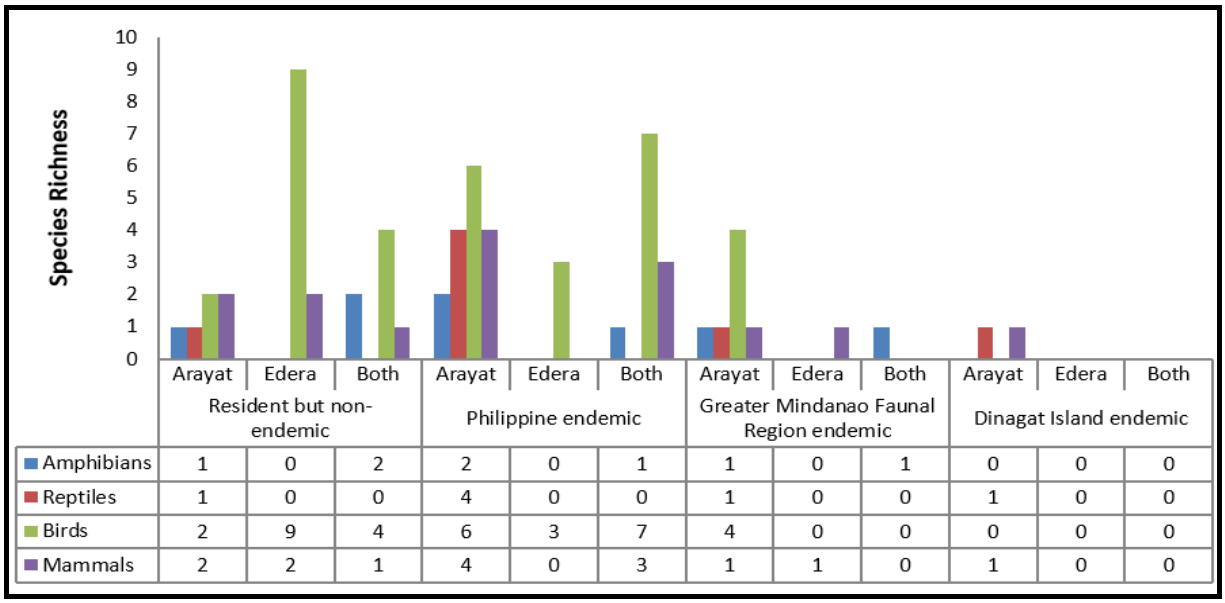


Figure 2: Some of the species recorded in Dinagat Islands during the survey: (A) Mindanao Horned-frog (*Megophrys stejnegeri* Taylor), (B) Dinagat Islands Banded Coral Snake (*Calliophis salitan*), (C) Mindanao Hornbill (*Penelopides affinis* Tweeddale), (D) Philippine Tarsier (*Tarsius syrichta* Linnaeus). Photos captured on-site during the survey by MNRMQ.



	Resident but non-endemic			Philippine endemic			Greater Mindanao Faunal Region endemic			Dinagat Island endemic		
	Arayat	Edera	Both	Arayat	Edera	Both	Arayat	Edera	Both	Arayat	Edera	Both
Amphibians	1	0	2	2	0	1	1	0	1	0	0	0
Reptiles	1	0	0	4	0	0	1	0	0	1	0	0
Birds	2	9	4	6	3	7	4	0	0	0	0	0
Mammals	2	2	1	4	0	3	1	1	0	1	0	0

Figure 3: Residency status of the species recorded in the study areas in Dinagat Islands, Mindanao, Philippines.

Based on the IUCN (2021) conservation status of the species, most of the species (n= 52) are classified as Least Concern (LC) (80%). There are 10 species classified as threatened in different extents: six species (9.2%) classified as near-threatened (NT), two are vulnerable (V), and two are endangered (E): the Mindanao hornbill *Penelopedes affinis* and Dinagat gymnure *Podogymnura aureospinula*. There are two species (3.1%) which were not assessed yet and has no data in the IUCN database (NE): Dinagat Islands Banded Coralsnake *Calliophis salitan* and the skink *Sphenomorphus variegatus* Peters.

Based on the local Philippine RA 9147 DAO-2005 listing of endangered species, five species (7.7%) were classified as threatened in various degrees: one near-threatened: the Mindanao Fanged Frog *Limnonectes magnus* Stejneger; three species were listed as vulnerable: the Northern Rufous Hornbill *Bucerus hydrocorax* Linnaeus, Writhed Hornbill *Rhabdotorrhinus leucocephalus* Vieillot, and Little Slaty Flycatcher *Ficedula basilanica* Sharpe; and one endangered species: the Mindanao Hornbill *Penelopides affinis*, which are all endemic species. All the rest of the species (n= 60 or 92.3%) were not listed as endangered under Philippine RA 9147 DAO-2005.

A total of 47 generalist species (72.3%) and 17 specialist species (26.2%) were recorded. One species (1.5%), the Dinagat Islands Banded Coralsnake *Calliophis salitan*, is not specified as it has only been recognized recently.

In addition to the diversity indices, the species rarefaction is ploted to see the rarity of species in the two study areas (Fig. 4). It shows that the species curve in Edera is flattening, while species richness in Arayat is still increasing. Given more time to do the sampling, more species will be recorded in the Arayat study area. Although the importance of rapid biodiversity surveys should also not be overlooked as they address the lack of baseline biodiversity information (Tanalgo et al., 2019), especially in critical areas such as Arayat and Edera.

Diversity indices between disturbed landscapes

The computations made showed that Arayat (H'= 3.571) is relatively more diverse compared to the Edera (H'= 2.576), with more dominant species in the latter (Edera D= 0.122) compared to the former (Arayat D= 0.038), while species are more evenly distributed in Arayat (e= 0.726) than Edera (e= 0.399). The Glossy Swiftlet (*Collocalia esculenta* Linnaeus) and Large-billed Crow (*Corvus macrorhynchos* Wagler) dominated the two study areas; although, more individuals were recorded in Edera compared to Arayat. However, despite the noticeable differences in the computed diversity indices between the two study areas, Kruskal-Wallis test showed that there are no significant differences in the diversities between Arayat and Edera ($H[chi^2]$= 2.256; H_c[tie corrected]=2.418; p= 0.1199).

Impacts of logging to terrestrial vertebrates

Although heavily disturbed by logging, Arayat still collectively recorded 49 species, compared to the 33

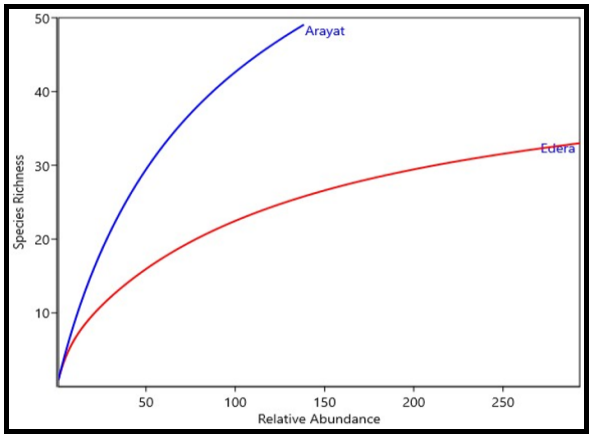


Figure 4: Rarefaction curve of species richness versus relative abundance in the study areas in Dinagat Islands generated using PAST 4.02.

species recorded in Edera (number including the 17 species (26.2%) common in both areas). Excluding the common species recorded in the two study areas, Arayat has exclusively recorded 32 species (49.2%) while Edera has exclusively recorded 16 species (24.6%).

Among the 49 species overall recorded in Arayat, there were 25 endemics that were recorded only in Arayat; in addition, there were 12 endemic species recorded in both Arayat and Edera, making a total of 37 endemic species, or 75.5% of the recorded species in Arayat are endemics. We regard that the presence of a locally protected watershed near the study area and Arayat being a secondary growth forest could have provided a suitable habitat to these highly specialist endemic species.

Logging in Arayat is an example of selective logging, where only specified species, type, and age are being harvested (Catibog-Sinha and Heaney, 2006), which has different practice compared to "legal" or permitted logging, "low impact" logging, and "illegal" logging for high-value timber (Hughes, 2017). Although, as observed and reported, even the selective logging in the island is still illegal as no permit is given to harvesters (Caballero, pers. comm.). The main reason for selective logging varies from locations, and in Dinagat Islands, it is for timber. Dinagat Islands is rich in hard-wood species such as *Xanthostemon verdugonianus* ("mangkono"), *Shorea astylosa* ("yakal"), *Shorea contorta* (white lauan), to name a few (Lillo et al., 2019), which are in-demand timber materials (Haribon Foundation, 2004).

Although a number of studies showed that logging greatly affects and change species composition and decrease the richness due to habitat changes; several studies have revealed that selective logging has limited effects across a range of taxa (Hill and Hamer, 2004; Berry et al., 2010; Edwards et al., 2010), which could be the reason why there are still important species thriving in Arayat despite being heavily logged. Nonetheless, if the selective logging

continues, the quality of the forest will worsen, causing fewer species to remain in the area and it can cause changes to the composition of species communities, instability in the trophic organizations, and flux in the complexities of the food web interactions in the long run (Cottingham et al., 2001; Wells et al., 2007; Sodhi et al., 2012; Edwards et al., 2014; Hughes, 2017).

Effects of mining to biodiversity

In 2013, AAM-PHIL conducted a survey for their Environmental Performance Report and Management Program (EPRMP), which included Edera but in a slightly different location. The previous survey has recorded a total of 66 species of terrestrial vertebrates from four sampling sites, of which there were 46 birds, 11 mammals, five amphibians, and four reptiles. Most of the notable species in the EPRMP report were also recorded in the current survey, like the Mindanao Fanged Frog *Limnonectes magnus*, Mindanao Tree shrew *Tupaia everetti* Thomas, Yellowish Bulbul *Hypsipetes everetti* Tweeddale, and Brown Tit-babbler *Macronus striaticeps* Sharpe. However, the previous survey (EPRMP, 2013) did not record a number of important species that we have recorded in this current survey, like Northern Rufous Hornbill *Buceros hydrocorax*, Philippine Pygmy Woodpecker *Dendrocopos maculatus* Scopoli, Mindanao Bullimus *Bullimus bagobus* Mearns, and Philippine Tarsier *Tarsius syrichta*, to name a few. These species are endemic, "specialists", and sensitive species, which are highly dependent on their habitat (Odum, 1971). The previous survey (EPRMP, 2013) recorded four reptiles; however, we did not record any reptile species in the mining site. Although, we have recorded a lower number of species in our current survey, with only 33 species compared to the 66 species previously recorded (EPRMP, 2013), we reckon that recording a number of endemic species makes the mining site still habitable, despite the modification that happened in the area. As of the moment, the mining site is in preparation for closure stage and no operations are being performed.

Mining in Edera for nickel and chromite ore is an example of a strip mining or surface mining, where a large tract of land is removed leading to the removal of the entire surface flora to collect the topsoil for mineral processing (Attuquayefio et al., 2017). It is practiced by most mining companies in the entire island (Haribon Foundation, 2004). Surface mining is an invasive method that results to a barren landscape, displacing the terrestrial fauna species naturally living in the area (Hilson, 2002). In addition to the displacement of terrestrial fauna, contamination of water bodies in the mining area and its downstream caused by the heavy sandy ores and high sediment load affects aquatic organisms (Villanueva, 2010; Brosse et al., 2011).

It is difficult to say that the absence of several species recorded in the previous survey is an effect of the mining activities from 2013 to present; however, several studies highlighted that surface mining, like the one in Edera, has negative impact on the species richness and abundance of birds (Haribon Foundation, 2004), small mammals (Attuquayefio et al., 2017; Tanalgo et al., 2017), and aquatic animals (Villanueva, 2010; Wantzen and Mol, 2013), which also includes amphibians and reptiles. Surface mining poses a serious threat to forest resources and rich biodiversity (Hilson, 2002; Schueler et al., 2011; Attuquayefio et al., 2017); however, it may not be the top driver of environmental change, but it can exert pressure on biodiversity by altering habitats (Murguia et al., 2016).

Conclusion

The current study showed that despite being heavily modified by illegal logging and mining, a number of endemic and "specialist" species are still thriving. The relatively high endemism record and records of island endemic species coupled with expanding anthropogenic threats makes the Dinagat Islands an important habitat that requires urgent conservation action.

Dinagat Islands was identified as an "extremely and highly-critical terrestrial conservation priority" by the 2001 Philippine Biodiversity Conservation Priority-setting Program (PBCPP) by the Department of Environment and Natural Resources (DENR) and different conservation groups, such as the Haribon Foundation. Illegal logging and mining are among the main drivers that causes pressure to the biodiversity and ecological stability of the forests in island (Haribon Foundation, 2004). On a large-scale scenario, logging and mining, along with agricultural expansion, causes habitat alterations which decrease the population and species richness of an area, and thus, affecting the available resources (Pimm and Raven, 2000; Sala et al., 2000; Krauss et al., 2010; Cardinale et al., 2012; Attuquayefio et al., 2017). However, the local government is still divided on how to deal with the conflicts on protecting the biodiversity in Dinagat Islands while providing livelihood to the people, especially those who depend largely on logging and mining operations (Caballero, pers. comm.).

For mining companies, one concrete action plan that can be carried out to resolve the problem caused by mining operations to biodiversity is the one stipulated in the Republic Act 7942 (also known as Mining Act of 1995) and further specified in DENR Administrative Order No. 96-40 of 1996 where the mining company is required to have a 10-year post-mining action plan upon closing of the operations in the area. Post-land development activities, such as land restoration, re-seeding, and re-vegetation, have always been suggested by previous studies related to habitat alterations; however, poor monitoring and strategies are among the challenges of this initiative (da Silva Dias et al., 2017).

We recommend for the maximum cooperation between the mining companies and local government unit to follow-up the post-development programs suggested by the mining company in their action plans.

Compared to mining activities, illegal logging could be more difficult to monitor as concessionaires are often difficult to identify and trace. Though there are national policies on managing illegal logging activities (i.e. National Integrated Protected Areas System Act or RA 7586), we suggest to strengthen the community-based (barangay level) initiatives, for example, close monitoring of logging concessions and mandating intensive forest protection, to prevent continuous logging activities.

Intensive surveys in understudied areas, for example, inside and outside the protected areas and other heavily modified areas in Dinagat Islands, is a next-step forward to take into account of existing wildlife that would improve conservation decisions, planning and management in the island.

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Conflict of interest

The authors declare that there are no conflicting issues related to this research article.

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Appendix 1: List and information of all species recorded by this study in the two study areas (Mt. Arayat and Edera Mining Site Parcel 2B Pit 9) surveyed in Dinagat Islands, Mindanao, Philippines.

No	Species Name	Common Name*	Family	Conservation Status		Generalist/ Specialist Species	Residency Status	General Population Status based on IUCN (2020)	Recording Methods	Recorded in Arayat and/or Edera study area/s
				IUCN (2020)	RA 9147					
Amphibians (n=8)										
1	*Platymantis dorsalis* (Duméril)	Dumeril's Wrinkled Ground Frog	Ceratobatrachidae	Least Concern	Not Listed	Generalist	Philippine endemic	Decreasing	Opportunistic	Arayat
2	*Platymantis corrugatus* (Duméril)	Litter Frog	Ceratobatrachidae	Least Concern	Not Listed	Generalist	Philippine endemic	Stable	Opportunistic	Arayat
3	*Limnonectes magnus*	Mindanao Fanged Frog	Dicroglossidae	Near-threatened	Near-threatened	Generalist	Greater Mindanao Faunal Region endemic	Decreasing	Opportunistic	Arayat and Edera
4	*Occidozyga laevis* (Günther)	Puddle Frog	Dicroglossidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Opportunistic	Arayat
5	*Megophrys stejnegeri*	Mindanao Horned Frog	Megophryidae	Least Concern	Not Listed	Specialist	Greater Mindanao Faunal Region endemic	Unknown	Opportunistic	Arayat
6	*Kalophrynus sinensis* (Peters)	Mindanao Sticky Frog	Microhylidae	Least Concern	Not Listed	Specialist	Greater Mindanao Faunal Region endemic	Not Assessed	Opportunistic	Arayat
7	*Pulchrana grandocula* (Taylor)	Big Eyed Frog	Ranidae	Least Concern	Not Listed	Generalist	Philippine endemic	Stable	Opportunistic	Arayat and Edera
8	*Staurois natator* (Günther)	Mindanao Splash Frog	Ranidae	Least Concern	Not Listed	Specialist	Greater Mindanao Faunal Region endemic	Decreasing	Opportunistic	Arayat
Reptiles (n= 7)										
9	*Draco cyanopterus*	Mindanao Flying Lizard	Agamidae	Least Concern	Not Listed	Generalist	Greater Mindanao Faunal Region endemic	Increasing	Opportunistic	Arayat
10	*Calliophis salitan*	Dinagat Islands Banded Coralsnake	Elapidae	Not Assessed	Not Listed	Data Deficient	Dinagat Islands endemic	Not Assessed	Opportunistic	Arayat
11	*Cyrtodactylus mamanwa* (Welton et al.)	Philippine Bent-Toed Gecko	Gekkonidae	Least Concern	Not Listed	Generalist	Philippine endemic	Not Assessed	Opportunistic	Arayat
12	*Tropidophorus davaoensis* (Bacon)	Skink	Scincidae	Least Concern	Not Listed	Generalist	Philippine endemic	Decreasing	Pit fall trap	Arayat
13	*Tropidophorus misaminius* (Stejneger)	Skink	Scincidae	Least Concern	Not Listed	Generalist	Philippine endemic	Stable	Opportunistic	Arayat
14	*Sphenomorphus variegatus*	Skink	Scincidae	Not Assessed	Not Listed	Generalist	Resident, but non-endemic	Not Assessed	Pit fall trap	Arayat
15	*Pinoyscincus jagori jagori* (Peters)	Jagor's skink	Scincidae	Least Concern	Not Listed	Generalist	Philippine endemic	Not Assessed	Opportunistic	Arayat

Appendix 1: (Continued)

No	Species Name	Common Name*	Family	Conservation Status		Generalist/ Specialist Species	Residency Status	General Population Status based on IUCN (2020)	Recording Methods	Recorded in Arayat and/or Edera study area/s
				IUCN (2020)	RA 9147					
				Birds (n= 35)						
16	*Haliastur indus* (Boddaert)	Brahminy Kite	Accipitridae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Decreasing	Transect	Edera
17	*Todiramphus chloris* (Boddaert)	Collared Kingfisher	Alcedinidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Decreasing	Transect	Edera
18	*Aerodramus vanikorensis* (Quoy and Gaimard)	Island Swiftlet	Apodidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Edera
19	*Collocalia esculenta*	Glossy Swiftlet	Apodidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Arayat and Edera
20	*Collocalia troglodytes* (Gray)	Pygmy Swiftlet	Apodidae	Least Concern	Not Listed	Generalist	Philippine endemic	Decreasing	Transect	Edera
21	*Artamus leucorynchus* (Linnaeus)	White-breasted Woodswallow	Artamidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Edera
22	*Buceros hydrocorax*	Northern Rufous Hornbill	Bucerotidae	Vulnerable	Vulnerable	Specialist	Philippine endemic	Decreasing	Transect	Arayat and Edera
23	*Penelopides affinis*	Mindanao Hornbill	Bucerotidae	Endangered	Endangered	Specialist	Greater Mindanao Faunal Region endemic	Decreasing	Transect	Arayat
24	*Rhabdotorrhinus leucocephalus*	Writhed Hornbill	Bucerotidae	Near-Threatened	Vulnerable	Specialist	Greater Mindanao Faunal Region endemic	Decreasing	Transect	Arayat
25	*Orthotomus nigriceps* (Tweeddale)	Black-headed Tailorbird	Cisticolidae	Least Concern	Not Listed	Specialist	Greater Mindanao Faunal Region endemic	Stable	Mist-net	Arayat
26	*Geopelia striata* (Linnaeus)	Zebra Dove	Columbidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Edera
27	*Treron vernans* (Linnaeus)	Pink-necked Green Pigeon	Columbidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Arayat
28	*Corvus macrorhynchos*	Large-billed Crow	Corvidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Arayat and Edera
29	*Centropus viridis* (Scopoli)	Philippine coucal	Cuculidae	Least Concern	Not Listed	Generalist	Philippine endemic	Stable	Transect	Arayat and Edera
30	*Dicaeum austral* (Hermann)	Red-keeled Flowerpecker	Dicaeidae	Least Concern	Not Listed	Specialist	Philippine endemic	Stable	Transect	Arayat and Edera
31	*Dicaeum hypoleucum* (Sharpe)	Buzzing Flowerpecker	Dicaeidae	Least Concern	Not Listed	Specialist	Philippine endemic	Decreasing	Mist-net/transect	Arayat
32	*Prionochilus olivaceus* (Tweeddale)	Olive-backed Flowerpecker	Dicaeidae	Least Concern	Not Listed	Specialist	Philippine endemic	Stable	Mist-net/transect	Arayat and Edera

Appendix 1: (Continued)

No	Species Name	Common Name*	Family	Conservation Status		Generalist/ Specialist Species	Residency Status	General Population Status based on IUCN (2020)	Recording Methods	Recorded in Arayat and/or Edera study area/s
				IUCN (2020)	RA 9147					
33	*Irena cyanogastra* (Vigors)	Philippine Fairy-bluebird	Irenidae	Near Threatened	Not Listed	Specialist	Philippine endemic	Decreasing	Mist-net/transect	Arayat
34	*Hypothymis helenae* (Steere)	Short-crested Monarch	Monarchidae	Near Threatened	Not Listed	Generalist	Philippine endemic	Decreasing	Transect	Arayat
35	*Ficedula basilanica*	Little Slaty Flycatcher	Muscicapidae	Vulnerable	Vulnerable	Specialist	Greater Mindanao Faunal Region endemic	Decreasing	Transect	Arayat
36	*Cyornis ruficauda* (Sharpe)	Rufous-headed Jungle Flycatcher	Muscicapidae	Least Concern	Not Listed	Specialist	Resident, but non-endemic	Decreasing	Transect	Arayat
37	*Rhipidura javanica* (Sparrman)	Sunda Pied Fantail	Muscicapidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Mist-net	Edera
38	*Saxicola caprata* (Linnaeus)	Pied Bush-chat	Muscicapidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Edera
39	*Cinnyris jugularis* (Linnaeus)	Olive-backed Sunbird	Nectariinidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Arayat and Edera
40	*Leptocoma sperata* (Linnaeus)	Purple-throated Sunbird	Nectariinidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Stable	Transect	Arayat and Edera
41	*Sittiparus semilarvatus* (Salvadori)	White-fronted Tit	Paridae	Near Threatened	Not Listed	Generalist	Philippine endemic	Decreasing	Transect	Edera
42	*Dendrocopos maculatus*	Philippine Pygmy Woodpecker	Picidae	Least Concern	Not Listed	Generalist	Philippine endemic	Stable	Transect	Edera
43	*Passer montanus* (Linnaeus)	Eurasian Tree Sparrow	Ploceidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Decreasing	Transect	Edera
44	*Loriculus philippensis* (Müller)	Philippine Hanging Parrot	Psittacidae	Least Concern	Not Listed	Specialist	Philippine endemic	Decreasing	Transect	Arayat
45	*Hypsipetes everetti*	Yellowish Bulbul	Pycnonotidae	Least Concern	Not Listed	Specialist	Philippine endemic	Stable	Mist-net/transect	Arayat and Edera
46	*Hypsipetes philippinus* (Forster)	Philippine Bulbul	Pycnonotidae	Least Concern	Not Listed	Generalist	Philippine endemic	Stable	Transect	Arayat
47	*Pycnonotus goiavier* (Scopoli)	Yellow-vented Bulbul	Pycnonotidae	Least Concern	Not Listed	Generalist	Resident, but non-endemic	Increasing	Mist-net/transect	Edera
48	*Pycnonotus urosticus* (Salvadori)	Yellow-wattled Bulbul	Pycnonotidae	Least Concern	Not Listed	Generalist	Philippine endemic	Stable	Mist-net/transect	Arayat and Edera
49	*Sarcops calvus* (Linnaeus)	Coleto	Sturnidae	Least Concern	Not Listed	Generalist	Philippine endemic	Unknown	Transect	Arayat
50	*Macronus striaticeps*	Brown Tit-babbler	Timaliidae	Least Concern	Not Listed	Generalist	Philippine endemic	Decreasing	Mist-net/transect	Arayat and Edera

Appendix 1: (Continued)

No	Species Name	Common Name*	Family	Conservation Status		Generalist/ Specialist Species	Residency Status	General Population Status based on IUCN (2020)	Recording Methods	Recorded in Arayat and/or Edera study area/s
				IUCN (2020)	RA 9147					
Mammals (n= 15)										
51	*Podogymura aureospinula*	Dinagat Gymnure	Erinaceidae	Endangered	Not Listed	Generalist	Dinagat Endemic	Decreasing	Cage trap	Arayat
52	*Hipposideros diadema* (Geoffroy)	Diadem Leaf-nosed Bat	Hipposideridae	Least Concern	Not Listed	Generalist	Resident but non-endemic	Unknown	Mist-net	Arayat
53	*Bullimus bagobus*	Mindanao Bullimus	Muridae	Least Concern	Not Listed	Specialist	Philippine Endemic	Stable	Cage trap	Arayat and Edera
54	*Rattus everetti* (Günther)	Philippine Forest Rat	Muridae	Least Concern	Not Listed	Generalist	Philippine Endemic	Stable	Cage trap	Arayat
55	*Eonycteris spelaea* (Dobson)	Dawn bat	Pteropodidae	Least Concern	Not Listed	Generalist	Resident but non-endemic	Unknown	Mist-net	Arayat
56	*Ptenochirus minor* (Yoshiyuki)	Lesser Musky Fruit Bat	Pteropodidae	Least Concern	Not Listed	Specialist	Greater Mindanao Faunal Region endemic	Stable	Mist-net	Arayat
57	*Haplonycteris fischeri* (Lawrence)	Philippine Pygmy Fruit Bat	Pteropodidae	Least Concern	Not Listed	Generalist	Philippine Endemic	Stable	Mist-net	Arayat
58	*Ptenochirus jagori* (Peters)	Greater Musky Fruit Bat	Pteropodidae	Least Concern	Not Listed	Generalist	Philippine Endemic	Stable	Mist-net	Arayat and Edera
59	*Harpyionycteris whiteheadi* (Thomas)	Harpy Fruit Bat	Pteropodidae	Least Concern	Not Listed	Generalist	Philippine Endemic	Stable	Mist-net	Arayat
60	*Macroglossus minimus* (Geoffroy)	Dagger-toothed Long-nosed Fruit Bat	Pteropodidae	Least Concern	Not Listed	Generalist	Resident but non-endemic	Stable	Mist-net	Arayat and Edera
61	*Cynopterus brachyotis* (Müller)	Lesser Dog-faced Fruit Bat	Pteropodidae	Least Concern	Not Listed	Generalist	Resident but non-endemic	Unknown	Mist-net	Edera
62	*Rousettus amplexicaudatus* (Geoffroy)	Geoffroy's Rousette	Pteropodidae	Least Concern	Not Listed	Generalist	Resident but non-endemic	Unknown	Mist-net	Edera
63	*Rhinolophus virgo* (Andersen)	Yellow-faced Horseshoe Bat	Rhinolophidae	Least Concern	Not Listed	Generalist	Philippine Endemic	Stable	Mist-net	Arayat
64	*Tarsius syrichta*	Philippine Tarsier	Tarsiidae	Near-threatened	Not Listed	Generalist	Philippine Endemic	Decreasing	Mist-net	Arayat and Edera
65	*Tupaia everetti*	Mindanao Treeshrew	Tupaiidae	Least Concern	Not Listed	Generalist	Greater Mindanao Faunal Region endemic	Stable	Cage trap	Edera

* = Common names are provided when available