Online ISSN: 2588-3526

Journal of Wildlife and Biodiversity

Volume 7(3): 80-95 (2023) (http://www.wildlife-biodiversity.com/)

Research Article

A detailed assessment of threats to tarsiers and its habitat: A case of Tarsiers *Carlito syrichta* (Linnaeus, 1758) in Hindang, Leyte

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Received: 19 July 2022 / Revised: 01 October 2022 / Accepted: 29 October 2022/ Published online: 09 November 2022. Ministry of Sciences, Research, and Technology, Arak University, Iran.

How to cite: Torrefiel, J.T. et al. (2023). A detailed assessment of threats to tarsiers and its habitat: The case of a forest fragment-confined population of Philippine *Tarsiers Carlito syrichta* (Linnaeus, 1758) in Hindang, Leyte. Journal of Wildlife and Biodiversity, 7(3), 80-95. **DOI**: https://doi.org/10.5281/zenodo.7308755

Abstract

The Philippine tarsier *Carlito syrichta* (Linnaeus, 1758) is considered a specially protected flagship species in the Philippines. However, the species is threatened due to natural disasters and human activities. Little is known about the ecology and existing threats of tarsier populations in some islands in the Philippines, particularly in Samar, Dinagat, Biliran, and Leyte. In this study, we report the existence of a population of tarsiers utilizing a karst forest patch in Hindang, Leyte, and characterize the habitat of the species after a super typhoon. Using field-based observations, camera traps, and Focus Group Discussions (FGDs) with the stakeholders, we generated baseline data on tarsiers in Mt. Bontoc, their habitats, and the existing and possible future threats. Results revealed that tarsiers were present in forested areas dominated by small-sized trees having a mean diameter at breast height (DBH) of 2.5 centimeters and a mean height of 5.0 meters. These trees are harvested for firewood. Recorded threats to the population and its habitat include incidental captures of the animal, typhoons, forest fires, and the presence of exotic animals. FGDs revealed

high concerns of the stakeholders for the protection and conservation of the species and the inclusion of the tarsiers for local management and tourism strategies in the future. The study highlights the significance of field visits and community participation to assess the local threats to tarsiers for future actions in terms of biodiversity conservation in fragmented habitats.
Keywords: Fragmentation, Karst forest, Leyte island, Tarsier, threat

Introduction

The Philippine tarsier *Carlito syrichta* or *Tarsius syrichta* (Linnaeus, 1758) is a non-human primate endemic to the Mindanao Faunal Region, with representative populations from the islands of Samar, Leyte, Bohol, Biliran, Basilan, Maripipi, Dinagat, and the Greater Mindanao (Shekelle, 2020). Despite being considered a specially protected flagship species (Proclamation No. 1030, 1997), the species is under the *Other Threatened* S*pecies* (OTS) category in the updated national list of threatened terrestrial Philippine fauna (Department of Environment and Natural Resources, 2019), due to hunting, forest fragmentation, and climate change (Gursky et al., 2017; Shekelle, 2020). The habitats of Philippine tarsiers include mixed secondary forests, agricultural lands, and forests near human habitations (Dagosto et al., 2001; Neri-Arboleda et al., 2002; Gursky et al., 2011). They have been reported to occupy even a small karst forest fragment (Bejar et al., 2020) suggesting the importance of small fragmented environments to tarsier. Most ecological and habitat studies on Philippine tarsiers were conducted in Bohol (Gamalo et al., 2021) which have been instrumental in the development of conservation and management strategies, particularly in the tarsier sanctuaries of the island. This highlights the importance of conducting field-based and ecological studies from other regions considering that populations of tarsiers in some islands are genetically different from the Bohol population (Brown et al., 2014).

On Leyte Island, the presence of tarsiers had been reported in previous accounts but its exact distribution is yet to be determined. Recorded populations in the region were at Mt. Pangasugan near the Visayas State University campus (Dagosto et al., 2001), forested habitat in Tacloban City (Gabieta, 2022), Silago, Southern Leyte (Cayubit, 2017), and in nearby islands such as Biliran (De la Cruz & Casas, 2015) and Samar (Brown et al., 2014; Obeña et al., 2021). Despite this, ecological studies and identification of threats to the tarsiers in the region, which are important in influencing the development of conservation measures and the proper implementation of management goals, are still limited.

During a behavioral and ecological survey of long-tailed macaques in a small forest fragment in the municipality of Hindang last August 2021, an unknown population of tarsier was serendipitously observed. In December 2021, super typhoon Rai (locally known as Odette) hit the Leyte province, including the municipality of Hindang. In this paper, we report the presence of a

tarsier population after super typhoon Rai and the threats to their habitat in Mt. Bontoc, Hindang Leyte.

As part of a larger initiative to understand the population viability of non-human primates in fragmented habitats, we assessed the present and possible future threats to the tarsiers and its forest fragment habitat. Using a relatively new approach to identifying causes and consequences of habitat fragmentation and habitat loss in non-human primates (Boonratana, 2020), coupled with different field-based survey techniques (e.g. field visits, camera traps, interviews with various stakeholders), the assessment can provide crucial information for the conservation of the target primate species. Although localized and with limited geographical scope, the study can be used for local conservation decisions which could impact the conservation of a species on a larger scale. Furthermore, from the identified threats, we also present implications for future conservation in the area, as well as recommendations for research and possible responses to mitigate population loss of tarsiers in the forest fragment.

Materials and methods

Study Site

The study was conducted in Mt. Bontoc (10.465123 N; 124.73697 E) in Hindang, Leyte (Figure 1). Situated within Barangay Bulacan, Barangay Bontoc, and Barangay San Vicente in Hindang, Mt. Bontoc has a total area of 0.78 square kilometers. The region has a Type IV climate, which means it receives evenly distributed rainfall throughout the year. Located within the area is Hindang Caves and Wild Monkeys, a nature park managed by the Local Government Unit (LGU) of Hindang for caves and macaque conservation and tourism.

Tarsier Documentation and Habitat Survey

During field visits for an ecological and behavioural study on long-tailed macaques, tarsiers were opportunistically documented on our first visit in August 2021 while documenting macaque behavior through direct observation and camera trapping. After the onslaught of super typhoon Rai, a second visit was conducted from January to February 2022 where a targeted camera trapping for tarsiers was performed. Three to four camera traps were strategically placed in areas where tarsiers were initially observed and on locations with possible sleeping sites based on literature and field guide suggestions/expertise. The safety of the researchers (e.g., substrate, slope, and devastated locations due to typhoon) were also considered in choosing a spot. Camera traps were transferred to other locations following the same strategy every two days for 20 days. Coordinates were obtained from the location of the trees/saplings where tarsiers had been documented.

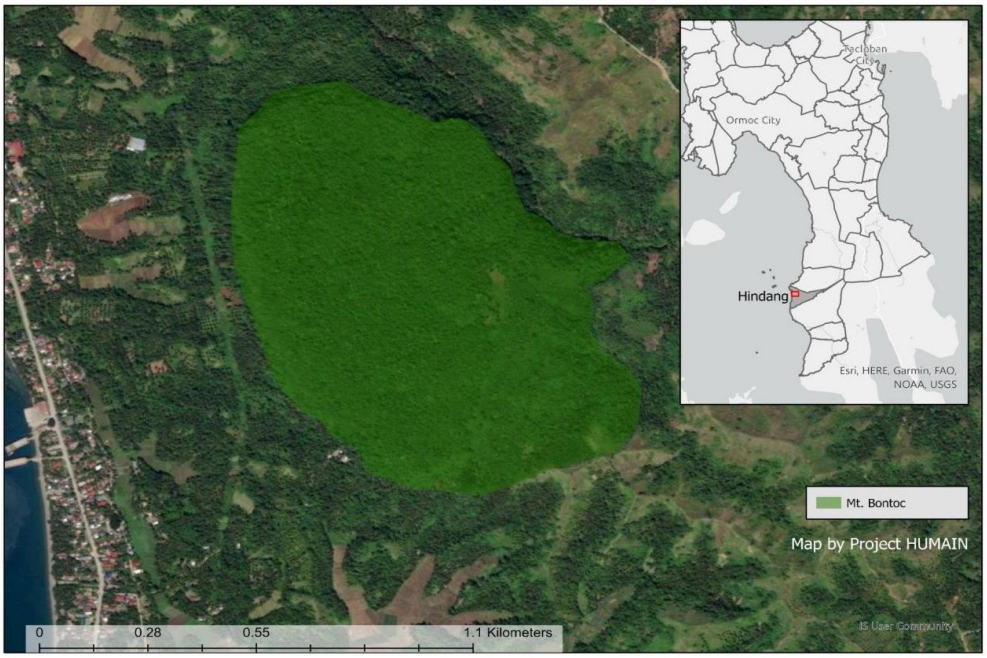

Figure 1. Map showing the location of Mt. Bontoc.

Habitat surveys were done by establishing a 5-meter radius around the tree/sapling where tarsiers were observed (Munds et al., 2013). Height and diameter at breast height (DBH) of all trees/saplings (>1 m height), and woody lianas inside the plot were measured (Munds et al., 2013; Bejar et al., 2020). A total of five plots were established and examined. Other data such as forest type, altitude, slope, substrate, and common plant species were also noted. A map was generated to show the locations of the sightings. This includes the sites where tarsiers were seen during the first and second visits and the most recent reports from locals. The map was created using ArcGIS Pro 9.1 and Esri's World Imagery was used as a base map providing high-resolution satellite imagery of the target location.

Stakeholders' Knowledge and Perception

Focus Group Discussions (FGDs) were conducted to assess the knowledge and perceptions of the stakeholders of Mt. Bontoc towards tarsiers. We used a semi-structured questionnaire in their local language, *Cebuano,* to independently assess the farmers directly utilizing the forest, local government officials from Barangay Bontoc and Barangay San Vicente, the park managers, and tourist guides. Respondents were asked to identify the animals present in the forest aside from long-tailed macaques, locate the sightings, if possible, and describe the diet, habitat, threats, existing laws, or local policies associated with tarsiers and other wildlife. Additionally, perceived benefits and plans for the conservation of tarsiers and the forest were also gathered. Prior to the FGDs, all respondents were asked to sign the consent form that explained the nature and objectives

of the study, the request for permission to record the data, and the use of this data with strict confidentiality.

Threat Assessment

Direct threats to the population of tarsiers in the forest fragment were assessed using the IUCN-CMP Unified Classifications of Direct Threats Version 3.2 (IUCN & CMP, 2012) used by Boonratana (2020). A threat was assessed in terms of their likelihood to threaten tarsiers and/or their habitats, cause fragmentation, exacerbate fragmentation, and threaten tarsiers and/or their habitats as a consequence of fragmentation based on the FGDs, researchers' observations, and literature. Moreover, the severity of a threat was then assigned based on the degree of its effect on the decline of the tarsier population, on their habitats, and the level of influence on fragmentation. A threat was considered high if it threatens the persistence of tarsiers, moderate if will likely threaten their persistence in the near future, and low if present but will not affect their persistence in the area (Boonratana, 2020).

Results

Tarsier sightings

A total of five tarsiers were opportunistically observed before super typhoon Rai last August 2021. One pair of tarsiers and two independent individuals were sighted between 5:00 PM to 6:00 PM. Another individual was recorded in a camera trap, preying on an insect. Calls of the tarsiers were also heard during the survey. After super typhoon Rai from January to February 2022, six individuals were observed: two were directly sighted and four were documented through camera trapping (Fig. 2). However, we were not able to confirm if these individuals are different from each other.

Figure 2. Tarsier sightings in Mt. Bontoc through (A) direct sightings and (B) camera trapping.

These sightings confirm the survival of the tarsiers after the super typhoon but the viability of their population is unknown.

Habitat Characteristics

A total of 612 stem samples were measured. The majority of the samples in all of the plots were small-sized having a mean DBH of 2.5 cm and a mean height of 5.0 m, of which 90.36% had DBH ≤ 5.00 cm and 58.82% had heights ≤ 5.0 m (Table 1).

Table 1. Size distribution of individual samples measured in terms of DBH and height in plots with confirmed tarsier sightings

Parameter	Distribution	Percentage
DBH		
<1.00 cm	135	22.06
1.00–2.50 cm	277	45.26
2.51–5.00 cm	141	23.04
5.01–7.50 cm	32	5.23
7.51–10.00 cm	10	1.63
>10.00 cm	17	2.78
Total	612	100
Height		
1.0–2.5 m	175	28.59
2.6–5.0 m	185	30.23
5.1–7.5 m	128	20.92
7.6–10.0 m	45	7.35
>10.00 m	79	12.91
Total	612	100

The tarsier habitat in Mt. Bontoc is classified as a forest over limestone (Figure 3). In the Philippines, it is a type of forest formation dominated by karst outcrops, often with white cliffs, ridges, and caves. The area has an altitude of 25 m to 290 m and is made of a regenerating secondary forest with many small-sized trees. The ground is covered with a thick layer of leaf litter and roots. The accessibility of the area was difficult because of its rugged terrain with steep slopes and cliff regions. Common flora in the area includes *Abroma augusta* L., *Arytera littoralis* Blume, *Alstonia scholaris* (L.) R.Br., *Caryota rumphiana* C.Mart., *Ficus* spp., *Gnetum gnemon* L., *Securinega flexuosa* (Müll.Arg.) Müll.Arg., and *Vitex parviflora* Juss. The understory is occupied by smaller trees, shrubs, climbing bamboo, palms, vines, lianas, and saplings. Epiphytes, orchids, and ferns were also observed.

Figure 3. The tarsier habitat in Mt. Bontoc A) A karst formation is typical of the area, B) The abundant small-sized trees of the habitat.

Threats to the tarsier population

Seventeen threats were observed and reported in the area. From these 17 threats, eight were assessed to directly affect tarsiers, one identified as high, and others as low or medium. Of the eleven threats that caused and/or exacerbated fragmentation, two were assessed as serious threats, four as a medium, and four as low. Eleven of the threats identified are possibly a consequence of fragmentation or habitat destruction (Table 2).

The direct threats to tarsiers include incidental hunting for pets, sometimes with dogs, as reported by some respondents. Excessive noises can sometimes be heard in the area during the harvesting of wood by loggers. Moreover, forest fires and typhoons have also been reported by the respondents to cause large devastation in the forest potentially resulting in habitat loss and death of the animals. These could also cause an open canopy allowing excessive light to penetrate the forest. Other threats, such as the presence of houses near the forests, farms, and recreational areas in the forest, would likely threaten the species in the future, possibly by exacerbating habitat loss.

Table 2. Threat analysis on tarsier and its habitat in Mt. Bontoc, Hindang, Leyte using the IUCN-CMP Unified Classifications of Direct Threats Version 3.2 (IUCN & CMP, 2012) used by Boonratana (2020).

Threats to Biodiversity	Threatens Primates	Threatens Primate Habitats	Causes Fragmentation*	Exacerbates Fragmentation*	Threatens Primate & Primate Habitats as a Consequence of Fragmentation*	Remarks
Housing & Urban Areas	NO	Possible	Possible	Possible	Possible	direct observation; possible expansion of houses
Tourism & Recreation Areas	NO	YES (M)	YES (M)	YES (M)	YES (M)	direct observation; tourism area (caves, zipline, and macaques)
Small-holder Farming	NO	YES (M)	YES (M)	YES (M)	YES (M)	direct observation; cacao, coconut, banana and other root crops plantation beside the forest

Small-holder Plantations	NO	YES (M)	YES (M)	YES (M)	YES (M)	reported by respondents; ipil-ipil for firewood
Incidental effects (species being assessed is not the target)	YES (L)	NO	NO	NO	NO	reported by respondents; incidentally caught
Unintentional effects: subsistence/small scale	NO	YES (H)	YES (H)	NO	YES (H)	reported by respondents; unintentionally caught
Work & Other Activities	NO	NO	NO	YES (L)	NO	direct observation; forest trails used by farmers
Increase in Fire Frequency/ Intensity	YES (M)	YES (M)	YES (M)	NO	YES (M)	reported by our field guide
Invasive Non-Native / Alien Plants & Animals	YES (L)	NO	NO	NO	NO	reported to accidentally hunt tarsier; presence of dogs through camera traps
Pathogens & Microbes	Possible	NO	NO	NO	NO	possible transmission from the observed domesticated animals
Viral/Prion-induced Diseases	Possible	NO	NO	NO	NO	possible transmission from the observed domesticated animals
Light Pollution	YES (M)	NO	NO	NO	YES (M)	direct observation; open canopy because of typhoon
Noise Pollution	YES (L)	NO	NO	NO	YES (L)	direct observation; noises from visitors and other activities near the area
Earthquakes / Tsunamis	NO	YES (L)	YES (L)	NO	YES (L)	Leyte is frequently hit by earthquakes
Avalanches / Landslides	NO	YES (L)	YES (L)	NO	YES (L)	Direct observation
Droughts	NO	YES (L)	NO	YES (L)	YES (L)	during summer season
Storms & Flooding	YES (H)	YES (H)	YES (H)	YES (H)	YES (H)	direct observation (e.g., Super typhoon Rai)

*Please note that we are using the Fragmentation definition that implies a combination of fragmentation per se and habitat loss combined
L – low, M – Moderate, H – High

Local knowledge and future plans

Results of the FGDs revealed that some farmer respondents from Barangay San Vicente were already aware of the presence of tarsiers in Mt. Bontoc, while farmer respondents from Bontoc are unaware. Local government officials, tourist guides, and park managers were aware of tarsiers in the forest. Some of the respondents added that they heard of tarsiers' presence through their neighbors. Interestingly, few respondents experienced sighting of tarsiers long ago (around year 2000) at farms (Figure 4), and even reported having one as a pet but died due to starvation.

The respondents identified insects as the main component of the tarsier's diet. Other officials claimed that tarsiers consume charcoal. Consequently, they added that predators of tarsiers include civet cats, birds-of-prey (e.g., owls, serpent eagles), monitor lizards, macaques, snakes (e.g., python), and dogs. Reported threats to tarsiers and their habitat include logging for firewood, clearing of trails, small-scale plantations, hunting by exotic animals such as dogs, and incidental captures.

The park managers and officials expressed strong support for the inclusion of tarsiers as a tourist attraction in addition to long-tailed macaques and even proposed the establishment of a tarsier sanctuary. However, farmers were unsure about the roles of tarsiers to the community through tourism as they expressed concerns about the greater cost of tourism activities to their livelihood than the benefits it would bring to their livelihood. However, they expressed the strong importance of the tarsiers' role in balancing the ecosystem when asked about the roles of tarsiers in the forest. Likewise, the participants have also called for strong efforts to conserve tarsiers in the area.

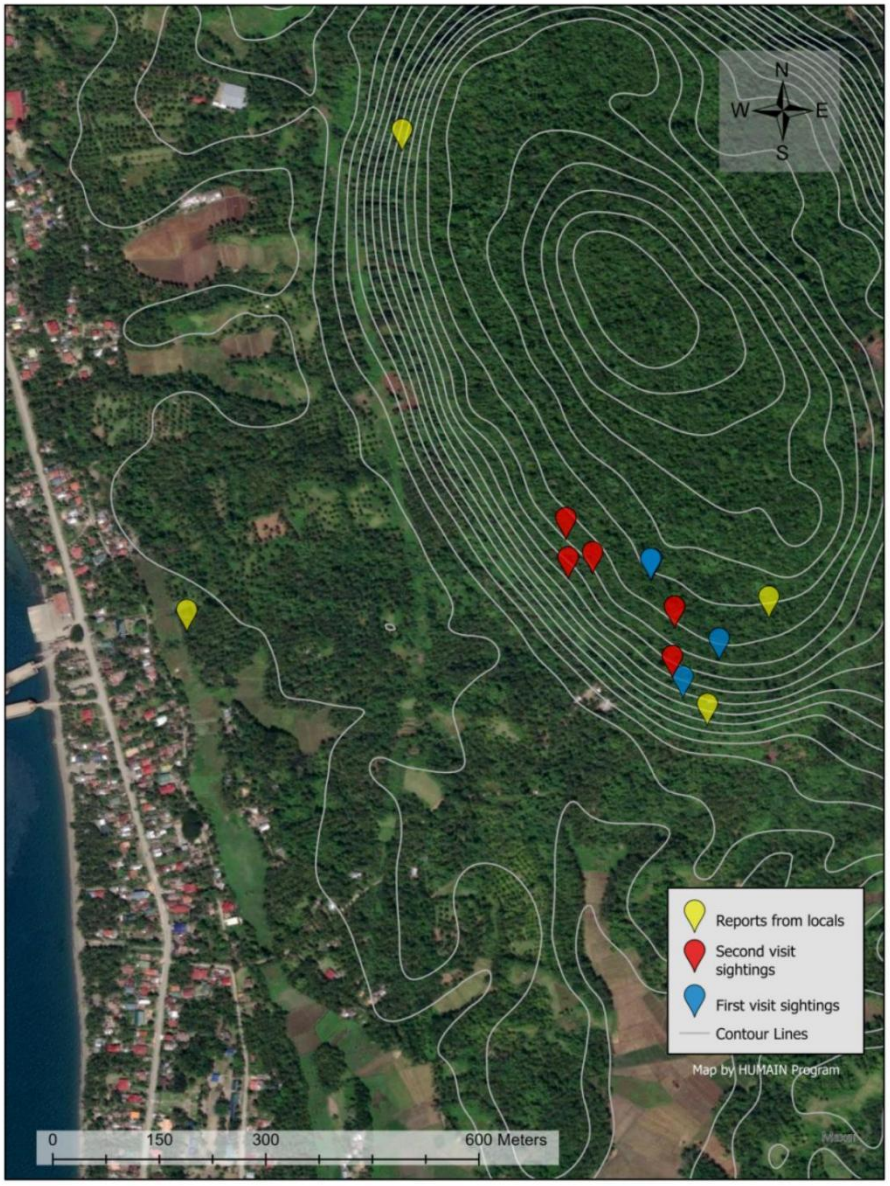

Figure 4. Map showing tarsier sightings in the area from the field visits and local reports.

Discussion

Tarsiers in Mt. Bontoc, Hindang

Direct sightings and camera trapping revealed that Philippine tarsiers (*Carlito syrichta*) are present in Mt. Bontoc, Hindang, Leyte, confirming the claims of some locals that the species is present in the area. Our observations were restricted inside the forest fragment. Nonetheless, these supplement past sightings by the locals in the vicinity, highlighting the importance of citizen science and local community knowledge in providing occurrence, distributional reports, and ecological information on non-human primates (Mohd Rameli et al., 2020; Wojciechowski et al., 2021), especially on species with secretive and cryptic habits (Adamík et al., 2019) like tarsiers.

In addition to sightings, the respondents also reported insects as part of the tarsiers' diet. They have also reported natural predators of tarsiers in the area such as snakes, owls, and monitor lizards. Specifically, *Varanus salvator* has been reported to hunt tarsiers in Bohol (Řeháková-Petrů et al., 2012), as well as bird and snake hunting *Tarsius spectrum* in Sulawesi (Gursky, 1998; Gursky, 2002). This report highlights the importance of key respondents such as farmers and other people engaged in income-generation activities in the field, e.g., park managers and guides, in providing information on tarsiers (Wojciechowski et al., 2021), thus they are crucial during conservation and management plans for the species.

Habitat Characteristics

Mt. Bontoc, being a secondary forest dominated by small-sized trees, provides a favourable environment for tarsiers (Neri-Arboleda et al., 2002; Merker et al., 2005; Gursky et al., 2011; Munds et al., 2013; Arrijani & Rizki, 2020; Bejar et al., 2020). The slim branches of small trees may provide a more secure grip for tarsiers when foraging for their prey. Moreover, the presence of woody lianas in the area may add to more efficient locomotion when foraging and/or protecting themselves from their predators (Bejar et al., 2020), and possibly typhoons.

Previous data on forest habitats of tarsiers in the Philippines include large continuous forests (Rickart et al., 1993; Dagosto & Gebo, 1997; Gursky et al., 2011; Neri-Arboleda, et al., 2002). This present study confirms the findings of Bejar et al. (2020) that small forest fragments with favorable habitat characteristics can still harbor tarsier populations. This also highlights the importance of forests over limestone as a habitat for tarsiers on Leyte Island.

Threats to tarsiers and their habitat

Despite the targeted effort to find tarsiers during the second visit, only six individuals were detected. This is a relatively similar number of opportunistically detected individuals during the first visit with five individuals even without the targeted effort. This observation was expected as

the super typhoon Rai significantly devastated the forest in December 2021. Although we were not able to quantify the effect of the super typhoon on the tarsier population and their habitat in Mt. Bontoc, typhoons have been reported to affect populations and sightings of tarsiers in Bohol. For instance, super typhoon Haiyan was documented to decrease significantly the density of tarsiers in a 2014 assessment in Corella, Bohol (Gursky et al., 2017). From the same report, tarsier habitats were also severely affected, i.e., the average reduction of trees was 50% of the vegetation plots after the typhoons. Moreover, the recent super typhoon Rai was also reported to cause a reduction of sighted tarsiers in a conservation area on the same island (Severo, 2021).

Together with these reports, our observations suggest that severe storms can negatively affect tarsier populations through habitat destruction. As the increase of ocean temperature continues due to global warming, further amplified by localized environmental degradation, more intense typhoons are expected to make landfall in the Philippines (Holden & Marshall, 2018). A large unintentional forest fire was also reported to cause habitat destruction in Mt. Bontoc. Karst forests are known to be in very dry surface conditions with the majority of the water supply running underground (De Waele et al., 2011). This makes it susceptible to forest fires, particularly during a season with extreme temperatures intensified by a changing climate producing warmer dry seasons (Flannigan et al., 2006). These threats could critically affect forest habitats and could also reduce prey items of tarsiers.

Other threats to tarsier habitats in the area are wood harvesting and logging for firewood. These activities cut potential sleeping and foraging sites, and induce anxiety by emitting excessive noises from the use of chainsaws (Merker & Muhlenberg, 2000). According to the locals, wood harvesting is also sometimes coupled with incidental captures of tarsiers in the forest possibly for sale or for pets (Wojciechowski et al., 2021). Tarsiers are known to be traded illegally although most of the reports are local trades (Shekelle, 2020). However, a report from 2016 (Mayuga, 2016) showed that international trade might be an underreported threat to Philippine tarsiers.

Domesticated animals such as dogs and cats were also present in the area. Our camera traps revealed that dogs can penetrate the forest. Dogs are used in some areas to hunt tarsiers (Aure & Escabi-Ruiz, 2005; Dagosto et al., 2001), however, to our knowledge, there is still no confirmed incident of predation of dogs on Philippine tarsiers. Feral cats, however, were reported to be the cause of death of many tarsiers in the Philippine Tarsier Sanctuary in Bohol (Aure & Escabi-Ruiz, 2005). Furthermore, a recent study in Bohol suggests that cats were among the most reported animals to prey on tarsiers (Wojciechowski et al., 2021). In 2020, a Mindanao tarsier was preyed and killed by a pet cat in Davao City (Causon, 2020). Thus, it is important to mitigate the impacts

of these animals on wildlife by incorporating conservation awareness and educational programmes for pet owners.

Conservation Implications and Future Directions

Although more studies are needed to develop an effective conservation strategy for Philippine tarsiers in its known geographical range, this report showed that a localized assessment can provide significant information in broadening the understanding of the distribution, habitat, and threats to this threatened flagship species.

The existence of tarsiers in Mt. Bontoc highlights the importance of conservation and preservation of forest fragments (Bejar et al., 2020). The present and future threats to wildlife and its habitats in the area signal immediate action, especially since the forest is relatively isolated and is partly a tourism spot. Forest fragmentation observed in the area can significantly reduce habitable areas and increase local extinction risks for this isolated population. Its isolation makes this tarsier population highly vulnerable to habitat changes that come with fragment characteristics, species-specific responses, and rapid human population growth (Matthews et al., 2014; Boonratana, 2020). The conservation and possible expansion of the remaining natural forest fragments should be prioritized since it can sustain and enhance the tarsier population in Leyte.

Considering that tarsiers in the area may become an additional tourist attraction, an educational drive is also important in expanding appreciation outside the financial values of the wildlife (Wojciechowski et al., 2021). Hopefully, this contributes to more sustainable conservation in the long term. Moreover, training of tourist guides in the area can help in mitigating harmful tourism practices on tarsiers, such as handling and taking pictures with the animal which sometimes can trigger demands for pet trade. It is highly recommended that more targeted studies on tarsiers be conducted in Mt. Bontoc. These may include population surveys and monitoring, home range determination, tracking studies, behavioral studies, and extensive habitat surveys, particularly on the characterization of preferred sleeping sites. We also recommend that these future studies involve the local community (e.g., guides, and field assistants). Activities that initiate the sharing of knowledge with the locals can hopefully encourage a change in attitudes towards the forest and the animals and ultimately increase the local support for continuous conservation even after the research project.

Conclusion

This paper adds to the scant and sporadic literature on Philippine tarsiers in Leyte Island, providing information on its distribution, existing habitats, ecology, and threats. Here, we demonstrate the community knowledge of the locals and its importance in identifying the threats to the tarsiers and

their habitat in Mt. Bontoc. The presence of Philippine tarsiers in a small, fragmented, and isolated karst forest before and even after a super typhoon also highlights the viability of an isolated environment as a suitable habitat for this cryptic and sensitive species. Considering this, it is imperative to protect small forest fragments which have the potential in supporting tarsier populations. Furthermore, the information presented here opens new possibilities and future directions in terms of research (e.g. home range studies, camera trapping, citizen science approach) and conservation of tarsiers and their habitat.

Acknowledgments

We thank the respondents who participated in the Focus Group Discussions (FGDs) about wildlife in Mt. Bontoc. Special thanks are also given to the following individuals who provided valuable assistance in this study: Dr. Ramesh Boonratana, Simeon Gabriel F. Bejar, Hon. Betty A. Cabal, Dexter Sarcon, Gemma Bentulan, Adonis Berdos, Johnny Degamon, Cielo Baldo, Marlon Baldo, Ruel Gesulga, Mario Ceniza, Jessica Cavite, Miguelito Cabal, Marius Miraflor, Brix Bramida, Chenalin delos Santos, Armie Joshua, Rheo Ryan Balbuena, and Sharmene Esplago. Also, we are grateful to the National Research Council of the Philippines, the Department of Environment and Natural Resources VIII, the Municipality of Hindang, and Local Government Units of Barangay San Vicente and Barangay Bontoc for their support to the HUMAIN research team to conduct field visits in the area, and to VSU Geographic Information System Service Unit headed by Sir Pastor Garcia for the base map.

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