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Cover: Mauve Stinger *Pelagia noctiluca* by Swaathi Na. Medium used is soft pastels and gelly roll.

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ARTICLE

Inventory and abundance of non-volant mammals and birds in the unprotected regions of the Mount Apo Range, Philippines

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Abstract: Wildlife, such as non-volant mammals and birds, play a vital role in the maintenance of ecosystem health. They are considered ecological engineers that influence forest vegetation. However, due to deforestation, habitat loss, and human persecution, its population status has declined over the years. This study aimed to conduct a species inventory and assess the relative abundance of non-volant mammals and birds in the unprotected regions of the Mt. Apo Range, Philippines, through camera trapping methods. Furthermore, the anthropogenic threats observed in the study areas were also documented. A total of 1,106 camera trap days were carried out in 2016 and another 500 days in 2020. Based on 260 independent sequences for both the 2016 and 2020 surveys, 12 species were identified, consisting of eight non-volant mammals and four birds. Among the identified species are the Endangered Philippine Brown Deer *Rusa marianna* & Philippine Long-tailed Macaque *Macaca fascicularis philippensis* and the Vulnerable Giant Scops-owl *Otus gurneyi* & the Philippine Warty Pig *Sus philippensis*. Video evidence of the Philippine Warty Pig *Sus philippensis* performing an important ecological role as an ecological engineer in the Philippine tropical forests were also captured for the first time. Another 61 independent sequences of unidentified rodents were detected in the camera traps, requiring further species monitoring techniques. Conservation must be strengthened beyond the protected landscapes of the Mt. Apo Range through community-based forest governance. This will ensure that the forest vertebrates are protected and conserved from further anthropogenic pressures.

Keywords: Forest vertebrates, species inventory, relative abundance, Mt. Apo Range, Philippines.

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INTRODUCTION

Forest health has always been linked with rich biodiversity. Vertebrate species are known to be ecologically important, playing various roles in the environment (Zhang et al. 2018, 2020; Carreira et al. 2020). Mammals regulate prey populations, facilitate seed dispersal and pollination, shape vegetation patterns, and act as bioindicators of ecosystem health (Lacher et al. 2019). On the other hand, avian species are important pollinators, scavengers, predators, seed dispersers, and ecosystem engineers (Filho & Faria 2017; Villegas et al. 2022b).

Unfortunately, the ever-increasing environmental degradation led to the rapid decline of vertebrate populations, including non-volant mammals and avian species. Several members of these taxa face extinction risks due to human persecution and narrowed geographic ranges (Ripple et al. 2017). Some of the largest mammals in Philippine forests, including Philippine Brown Deer *Rusa marianna* and Philippine Warty Pig *Sus philippensis* are now Endangered and Vulnerable, respectively (Biodiversity Management Bureau – Department of Environment and Natural Resources 2020; Ong & Richardson 2008). Just recently, the previously categorized "Near-Threatened" Philippine Long-tailed Macaques *Macaca fascicularis philippensis* is now "Endangered" in view of the continued deforestation, hunting, and trapping, among others (Hansen et al. 2022). Also, although some mammals common in Mindanao forests such as the Philippine Tree Squirrel *Sundasciurus philippinensis*, Large Mindanao Forest Rat *Bullimus bagobus*, Common Philippine Forest Rat *Rattus everetti*, Mindanao Treeshrew *Urogale everetti*, and Palm Civet *Paradoxurus hermaphroditus* are categorized as "Least Concern", many of its local sub-populations are actually undergoing declines (Heaney 1993; Ibanez et al. 2004; Roxas et al. 2005; Balete et al. 2006; Tanalgo 2015). Additionally, the population of bird species, such as the Vulnerable Giant Scops-owl *Otus gurneyi* and Mindanao Bleeding-heart *Gallicolumba crinigera* was observed to be declining due to anthropogenic pressures (BirdLife International 2017).

Mount Apo Range is an important Key Biodiversity Area (KBA) in the Philippines. Large portion of the KBA is within the 64,000 hectare (ha) Mt Apo Natural Park - a protected area under the country's National Integrated Protected Areas System (NIPAS) Act. As such, it has been the subject of several biodiversity conservation initiatives. However, a significant portion of secondary and natural forests of the mountain range are left unprotected and, thus, receive fewer conservation initiatives. More importantly, at least three ancient nesting sites of the IUCN Critically-Endangered Philippine Eagle *Pithecophaga jefferyi* were documented in these unprotected areas (Abaño et al. 2015; Sutton et al. 2023). This called for intensive forest governance and conservation programs beyond the protected landscapes.

The present study documents the non-volant mammals and bird species in the non-NIPAS unprotected areas of the Mount Apo Range. This aims to enhance baseline data of wildlife populations outside the protected zone to pursue community-based wildlife protection. Several sites were surveyed through camera trapping techniques in Davao, Magpet, and Arakan (Table 1). This is a preliminary study on the inventory and abundance of non-volant mammals and birds in these areas, which are critical to guide policymakers, implementers, and environmental advocates in the region to pursue the much-needed conservation of these taxa.

MATERIALS AND METHODS

Study Area

Figure 1 shows the study area in the unprotected regions of the Mt. Apo Range, southern Mindanao, Philippines. Mount Apo Natural Park, a portion of the range consisting of 64,000 ha, has been declared a protected landscape under the National Protected Areas System through Republic Act No. 9237. It was also included in the UN List of National Parks and Equivalent Reserves and acknowledged as an ASEAN Heritage Site. Species surveys were conducted in areas in Davao City, Arakan, and Magpet in 2016. Another expedition was completed in 2020 in Davao City.

Camera Trapping

Camera trapping has been widely used in wildlife monitoring. It is a non-invasive monitoring tool employed for many forest vertebrates such as the Philippine Pangolin *Manis culionensis*, Philippine Warty Pig *Sus philippensis*, and deer *Rusa* spp. (Ingram et al. 2019; Willcox et al. 2019; Villegas et al. 2022a,b; Ali et al. 2020). Kays et al. (2011) reported that camera trapping is ideally used when direct observation methods are difficult or costly. It is less laborious and yields robust data, which is particularly useful for obtaining baseline data for important conservation decisions.

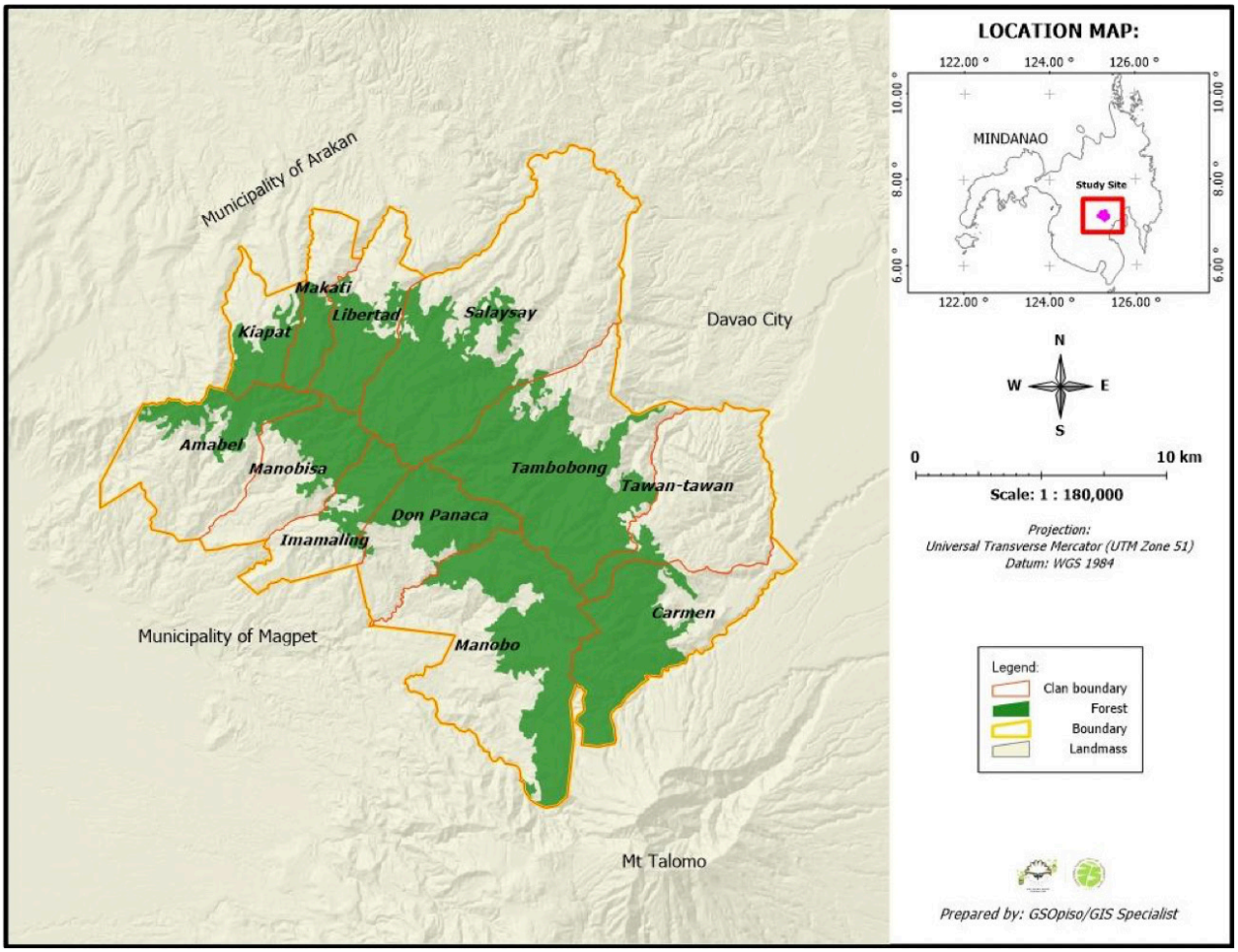

Figure 1. Study Areas within the Mount Apo Range, Philippines. (Cartographer: Guiller Opiso).

In 2016, four HCO Scoutguard SG560C camera traps were used. The cameras have a highly-sensitive passive infra-red (PIR) motion sensor that can take high-quality photos up to 8 megapixels and with a detection range of up to 25 m (82 ft). The same cameras were used in 2020, with additional six Bushnell Trophy Cam HD aggressor no-glow trail camera traps. This type also has a high PIR motion sensor, 48-LED no-glow flash, high-resolution stills, and takes up to 20 megapixels of high-definition video. These camera traps were set to capture three consecutive photos followed by a 30-second video upon detection of any movement in its range.

For the first round of the survey in 2016, a total of 79 camera stations were established in the study areas. In the Davao area, eight camera stations were installed along the 2-km transect line in Brgys. Salaysay, Tambobong, and Tawan-Tawan while 12 camera stations along 3-km transect line in Brgy. Carmen. All camera traps were left for 14 days; thus, a total of 36 camera stations and 504 camera trap days were done in Davao. In the Arakan area, eight camera stations were established along a 2-km transect line in each barangay (Brgy. Libertad, Kiapat, and Macati). These camera traps were also left for 14 days; thus, a total of 24 camera trap stations and 336 camera trap days were done in the Arakan area. Lastly, 19 camera stations were established along a 4.5-km transect in the Magpet area (Brgy. Don Panaca and Manobo) for a total of 266 camera trap days. The camera traps installed in all areas had an interval of 250 m away from the next camera trap

Table 1. Summary of the geo-coordinates and the range elevation in the sampling areas.

Sampling areas	Coordinates	Elevation range (m)
Arakan	7.1973°N, 125.2404°E; 7.1828°N, 125.1790°E	1,200–1,500
Davao	7.1255°N, 125.3159°E; 7.1281°N, 125.3182°E	1,448–1,709
Magpet	7.1727°N, 125.2037°E ; 7.1447°N, 125.2453°E	1,150–1,500

and were attached to a tree 1.5 m above the ground. Overall, a total of 1,106 camera trap survey days were conducted to monitor the mammals and bird species in these areas.

In the second set of surveys in 2020, a total of 40 camera stations (Brgy. Carmen, Salaysay, Tambobong, and Tawan-Tawan) in Davao City were installed. A 2.5-km transect line was established in the forested areas of each barangay. Ten camera traps were left within the transect line for 12.5 days (125 camera trap days) before they were moved to the next barangay. Each camera was set at least 250 m away from another camera and approximately 1.5 m above the ground attached to a tree. Overall, 500 camera trap days were completed in all four stations in the 2020 survey.

Image and video sequences were downloaded and stored in a computer hard drive, in an external hard drive and a backup at the Google drive. Each image sequence with captured species are properly marked and labeled including the species, group size, date, time, and location (Kays et al. 2011) to show frequency of detection of each species and the temporal distribution of activity. The image sequence was also rated dependent or independent following Data et al. (2008); independent sequence are a) consecutive photographs of different individuals of the same or different species, b) consecutive photographs/videos of individuals of the same species taken more than 0.5 h apart, and c) non-consecutive photos of individuals of the same species.

Relative Abundance Index (RAI)

Relative Abundance Index is the most widely used index for camera-trapping data. In this study, RAI is the ratio between non-volant mammals and birds detection based on the photographic capture rates from camera trap surveys and the entire trapping days. To get the RAI, the total number of independent sequences detected is divided by the total trapping days and then multiplied by 100 (Jenks et al. 2011). Image sequences were rated or classified as dependent or independent following Tanwar et al. (2021). Only the independent sequences were used to compute the RAI.

Ethics

This study is based on a community-solicited project for efficient forest governance within the surveyed culturally-protected landscapes. It is part of the continuing project led by the Philippine Eagle Foundation in partnership with the local indigenous communities. The Obu Manuvu tribal leaders and elders signed Resolution No. 1, s. 2019, permitting the investigators to gather data in the study sites. Community rituals were also conducted before the fieldwork according to the tradition of the indigenous community.

RESULTS AND DISCUSSION

Species Composition

The survey conducted in the Davao, Arakan, and Magpet areas of Mt. Apo Range in 2016 reached a total of 1,106 camera trapping days, whereas surveys conducted in 2020 in Davao area yielded a total of 500 camera trapping days, for a total of 1,606 camera trapping days. From these surveys, 12 different forest vertebrate species were detected, of which eight species are non-volant mammals, while four species are forest birds (Table 2). The non-volant mammals include the Philippine Brown Deer, Philippine Warty Pig, Philippine long-tailed macaque, Common Palm Civet *Paradoxurus hermaphroditus*, Mindanao Tree Shrew *Urogale everetti*, Philippine Pygmy Squirrel, Philippine Forest Rat *Rattus everetti*, and Mindanao Bullimus *Bullimus bagobus* (Image 1). On the other hand, the avian species documented were the Giant Scops-owl, Bagobo babbler *Leonardina woodi*, Wild Jungle Fowl *Gallus gallus*, and Crested Goshawk *Accipiter trivirgatus*.

Non-Volant Mammals

Non-volant mammals from the 2020 survey recorded 61 individuals (independent sequences) representing six species (and some unidentified species of probably the same genus *Bullimus* and *Rattus*). The same species were observed in the 2016 surveys, which recorded 199 individuals (independent sequences) representing eight species, including *R. marianna*, *S. philippensis*, *M. fascicularis philippinensis*, *P. hermaphroditus*, *U. everetti*, *E. concinnu*, *R. everetti*, and *B. bagobus*. Among these, 7 out of 8 species are endemic in the Philippines (Table 3). The endemic *R. marianna* was recently categorized by the Department of Environment and Natural Resources Administrative Order (DAO) No. 2019 (2019) as endangered, while *S. philippensis* is Vulnerable. The endemic *M. fascicularis philippinensis* was also recently categorized from Vulnerable to Endangered by Hansen et al. (2022), while the remaining three endemic species *U. everetti*, *E. concinnus*, and *R. everetti* were categorized as Least Concern. Finally, the southeastern Asian endemic *P. hermaphroditus* was also categorized as Least Concern (Duckworth et al. 2016).

Sus philippensis was the most abundant species

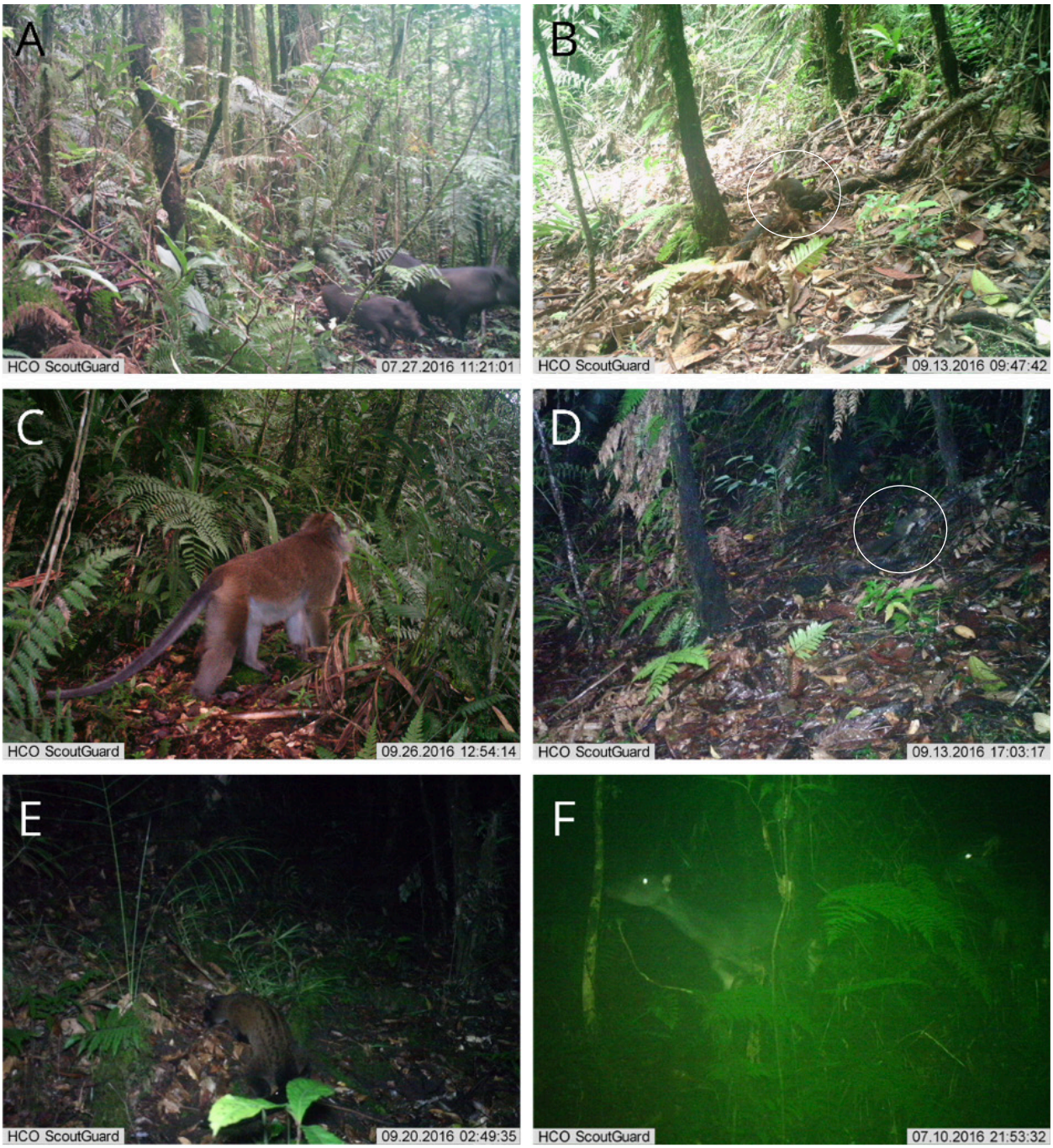

Image 1. Documented species in the Mount Apo Range: a—*Sus philippensis* Nehring, 1886 | b—*Urogale everetti* (Thomas, 1892) | c—*Macaca fascicularis philippinensis* (I. Geoffroy, 1843) | d—*Exilisciurus concinnus* (Thomas, 1888) | e—*Paradoxurus hermaphroditus* (Pallas, 1777) | f—*Rusa marianna* (Desmarest, 1822). © DOrSU, PEF, USAID, UNDP, GEF.

from the 2020 survey in the four barangays of the Davao area (10 individuals, RAI = 2.0). Similarly, it also had the highest number of individual counts from the 2016 survey in the Davao Area (15 individuals) and Arakan (18 individuals). Meanwhile, the *M. fascicularis philippinensis* was the most abundant species in Magpet Area (14 individuals) during the 2016 survey. The number of photographed individuals of the other five species from the 2020 survey ranged from one to nine (Table 3). In the 2016 survey, *M. fascicularis philippinensis* (RAI = 2.71), *P. hermaphroditus* (RAI = 2.26), and *U. everetti* (RAI = 2.35) have an almost similar number of individuals with 30, 25, and 26 captured individuals, respectively. The remaining four species

Table 2. Relative abundance index (RAI) of non-volant mammal and bird species in Mount Apo Range, Philippines (2016).

Species	Common name	Independent sequences			Total	Trap-days	RAI
		Davao	Arakan	Magpet			
Mammals							
Bullimus bagobus Mearns, 1905	Mindanao Bullimus	1	0	0	1	1,106	**0.09**
Exilisciurus concinnus (Thomas, 1888)	Philippine Pygmy Squirrel	3	1	0	4	1,106	**0.36**
Macaca fascicularis philippinensis (I. Geoffroy, 1843)	Philippine Long-tailed Macaque	13	3	14	30	1,106	**2.71**
Paradoxurus hermaphroditus (Pallas, 1777)	Asian Palm Civet	11	11	3	25	1,106	**2.26**
Rusa marianna (Desmarest, 1822)	Philippine Brown Deer	5	6	2	13	1,106	**1.18**
Rattus everetti (Günther 1879)	Philippine Forest Rat	2	10	0	12	1,106	**1.08**
Sus philippensis Nehring, 1886	Philippine Warty Pig	15	18	4	37	1,106	**3.35**
Urogale everetti (Thomas, 1892)	Mindanao Treeshrew	4	17	5	26	1,106	**2.35**
Unidentified Rodent		18	9	13	40	1,106	**3.62**
Birds							
Accipiter trivirgatus (Temminck, 1824)	Crested Goshawk	0	1	0	1	1,106	**0.09**
Gallus gallus (Linnaeus, 1758)	Red junglefowl	0	1	0	1	1,106	**0.09**
Leonardina woodi (Mearns, 1905)	Bagobo babbler	0	1	5	6	1,106	**0.54**
Otus gurneyi (Tweeddale, 1879)	Giant Scops-owl	0	3	0	3	1,106	**0.27**

Table 3. Relative abundance index (RAI) of non-volant mammal species in Davao area of Mount Apo Range, Philippines (2020).

		Independent sequences				Total	Trap-days	RAI
Species	Common name	Tambobong	Salaysay	Tawan-tawan	Carmen			
Mammals								
Exilisciurus concinnus (Thomas, 1888)	Philippine Pygmy Squirrel	2	0	1	1	4	500	**0.8**
Macaca fascicularis philippinensis (I. Geoffroy, 1843)	Philippine Long-tailed Macaque	0	4	1	0	5	500	**1.0**
Paradoxurus hermaphroditus (Pallas, 1777)	Asian Palm Civet	0	4	2	3	9	500	**1.8**
Rusa marianna (Desmarest, 1822)	Philippine Brown Deer	0	1	1	1	3	500	**0.6**
Sus philippensis Nehring, 1886	Philippine Warty Pig	4	6	0	0	10	500	**2.0**
Urogale everetti (Thomas, 1892)	Mindanao Treeshrew	2	1	2	4	9	500	**1.8**
Unidentified rodent		1	6	4	9	21	500	**4.2**

have an individual count ranging from 1 to 13 (Table 3). Both surveys recorded 21 individual sequences (2020) and 40 individual sequences (2016) of rodents that cannot be identified at the genus and species level.

Birds

The camera traps also recorded interesting bird behavior during the survey in 2016, particularly in Magpet and Arakan areas, while none was observed in Davao City both in the 2016 and 2020 surveys. Four species of birds were recorded, initially identified as the two endemic *O. gurneyi*, and *L. woodi*. The other two are the non-endemic *G. gallus* and *A. trivirgatus*. Among these, the *O. gurney* was categorized as Vulnerable (BirdLife International 2017), while the three remaining species were categorized as Least Concern (Table 3).

The Giant Scops-owl *O. gurneyi* and Crested Goshawk *A. trivirgatus* were recorded in a puddle of water occupied previously by *S. philippensis*. Most of the behavior recorded was during daytime and nighttime. *O. gurneyi* and *A. trivirgatus* were captured bathing in the same puddle. It was observed and recorded that more rainfall occurred at night, forming a wet patch. This only shows the importance of resource availability, including rich soil, abundant moisture, many trees, and regular inputs of nutrients and biological materials from the

Table 4. Distribution and conservation status of non-volant mammal and bird species in Mount Apo Range, Philippines.

Species	Common name	Geographic range	Site distribution	Conservation	References
Mammals					
Exilisciurus concinnus	Philippine Pygmy Squirrel	Endemic	Davao, Arakan	Least Concern	IUCN, 2016
Bullimus bagobus	Mindanao Bullimus	Endemic	Davao	Least Concern	IUCN, 2016
Macaca fascicularis philippinensis	Philippine Long-tailed Macaque	Endemic	Davao, Arakan, Magpet	Endangered	IUCN, 2022
Paradoxurus hermaphroditus	Common Palm Civet	Southeast Asia	Davao, Arakan, Magpet	Least Concern	IUCN, 2016
Rusa marianna	Philippine Brown Deer	Endemic (introduced in Guam)	Davao, Arakan, Magpet	Endangered	DENR DAO 2019-09
Sus philippensis	Philippine Warty Pig	Endemic	Davao, Arakan, Magpet	Vulnerable	DENR DAO 2019-09
Urogale everetti	Mindanao Tree shrew	Endemic	Davao, Arakan, Magpet	Least Concern	IUCN, 2019
Rattus everetti	Philippine Forest Rat	Endemic	Davao, Arakan	Least Concern	IUCN, 2016
Birds					
Accipiter trivirgatus	Crested Goshawk	Resident	Arakan	Least Concern	IUCN, 2016
Gallus gallus	Red Junglefowl	Resident	Arakan	Least Concern	IUCN, 2016
Leonardina woodi	Bagobo Babbler	Endemic	Arakan, Magpet	Least Concern	IUCN, 2016
Otus gurneyi	Giant Scops-owl	Endemic	Arakan	Vulnerable	IUCN, 2017

forest. These parameters are essential for avian species, especially those understory key species (Klapproth & Johnson 2009; Mohagan et al. 2015).

The most abundant species of bird based on captured individual sequences was the endemic *L. woodi* (six individuals, RAI = 0.54), followed by the vulnerable *O. gurneyi* (three individuals, RAI = 0.27), and then the non-endemic *G. gallus* and *A. trivirgatus* (one individual, RAI = 0.09) (Table 3). Regarding species richness, the Arakan area of the Mt. Apo range had the highest species account (four species), followed by the Magpet area (one species), while none was observed in the Davao area.

The number of detected bird species and their RAIs is relatively low compared to the other bird survey studies using the camera trap method. No published studies are available yet in the Philippines on bird surveys using the camera trap method, but several studies from nearby countries are available. Naing et al. (2015) documented 16 species of birds in the Hukaung Valley of Northern Myanmar using 403 camera traps for a total of 7,452 trap-nights, whereas Pla-ard et al. (2021) recorded 23 species of birds in the limestone habitats in Central Thailand using 40 camera traps over a period of two years. Possible reasons for the low species richness in this study could be the number of camera trap stations and camera trap days used. Kays et al. (2020) recommended that a total of 25 to 35 camera trap locations should be used per study area to monitor the diversity of wildlife within an area. Moreover, another factor could be the location of the camera trap. It is recommended to also place the camera trap at a distance of 2.5 to 5 m above the ground in order to capture birds at the mid-canopy or upper canopy of the trees (Meek et al. 2012; Pla-ard et al. 2021). Because the camera traps were placed close to the ground, it was biased towards capturing birds of the forest floor.

Distribution and Conservation Status

Of all the recorded mammals, *S. philippensis*, *M. fascicularis philippinensis*, *R. marianna*, *P. hermaphroditus*, and *U. everetti* were common since they were detected in all the study areas (Table 4). Unfortunately, some previously recorded mammal species on Mt. Apo, such as the Mindanao Flying Squirrel *Petinomys mindanensis* and the threatened Philippine Tarsier *Carlito syrichta* were not observed in this study. This could be because they inhabit other areas not covered in this study. On the other hand, the rarely encountered Mindanao Bullimus *Bullimus bagobus* was recorded only in the Davao area and was absent in both Arakan and Magpet areas. Overall, these endemic species and other flora and fauna made Mindanao the most important island in the Philippines, followed by Luzon and Palawan in terms of species richness and degree of endemicity (Lewis 1988).

S. philippensis was observed in all study areas and recorded the highest number of individuals. This could

be attributed to the camera trap locations within the forest interior with recorded human activities. It can be found in the forest's innermost or remote areas since it is sensitive to human disturbances. However, others have noted that it also tends to be active in areas with fewer anthropogenic disturbances (Podgorski et al. 2013; Johann et al. 2020; Villegas et al. 2022a,b). Moreover, it is also noted to roam in groups, searching for food (Relox et al. 2009). Warty pigs were observed roaming at night, but most were photographed during the day.

M. fascicularis philippinensis was the second most abundant species in the study areas. It is known to be distributed in anthropogenic and non-anthropogenic areas (Hansen et al. 2021). Long-tailed Macaques, due to their synanthropic nature, can inhabit diverse habitats, including deciduous forests, evergreen forests, savannah, mangroves, and beaches, from sea level up to 1900 m (Fooden 1995; Thierry 2007; Yanuar et al. 2009; Gumert et al. 2011a; Hansen et al. 2021). It can also consume various diets, including human foods (Sha & Hanya 2013; Hansen et al. 2021). On the other hand, *P. hermaphroditus* can be found in agricultural, lower, and upper montane forests from sea level up to at least 2,400 m. Accordingly, it is active mostly at night, feeding on a wide range of fruits, invertebrates, and vertebrates (Heaney et al. 2016). However, it was also observed during the daytime in this study.

The endemic and endangered *R. marianna* was also observed in all study areas in the 2016 survey but was rare during the 2020 survey in the Davao area. Most of the deer were documented grazing at night in the upper montane forest from 1000 m and higher.

However, footprints and fecal pellets were observed in the lower montane forest. Because they are highly sensitive to human presence, severely hunted, and limited in habitat, they are now found only in isolated forests (Oliver et al. 1992; Heaney et al. 1999, 2006).

The non-volant small mammals *U. everetti* and *R. everetti* were present in all study areas, while *B. bagobus* was absent in Arakan and Magpet, and *E. concinnus* was absent in the Magpet area. *R. everetti* is known to tolerate a range of habitat modifications, while *U. everetti* occurs in the primary forest from 750 m to 2,500 m (Heaney et al. 1998, 2006). On the other hand, *E. concinnus* can be found in primary and secondary lowland and montane forests from sea level to 2,000 m, while *B. bagobus* is widespread in lowland to the mossy forest from 200 m to 1,800 m (Heaney et al. 1998, 2006). The same observations were found in the present study. The low captures of these species can be attributed to the methods used. A combination of local traps and camera trapping methods might result in more detections of these species in the forest (Balete et al. 2006).

Low number of species richness was observed for bird species. Only four species were captured in the camera traps, including two Mindanao PAIC endemics, Giant Scops-owl *Otus gurneyi* and Bagobo Babbler *Leonardina woodi*, and the resident species Crested Goshawk *Accipiter trivirgatus* and Red Jungle Fowl *Gallus gallus*. Of these, the Giant Scops-owl is categorized as Vulnerable by BirdLife International (2017) in view of the rapid decline of its small population and severe fragmentation due to extensive deforestation. The remaining three species are still considered Least Concern by International Union for Conservation of Nature. The Mindanao endemic *L. woodi* was observed in both Arakan and Magpet, while the remaining three species were documented only in Arakan areas. Consistently, no species of birds were recorded in Davao areas both in the 2016 and 2020 surveys despite having almost the same forest structure and degree of disturbance with Arakan and Magpet. The possible reason for this might be the location of the camera trap. Davao area still has a large forest cover compared to Magpet and Arakan, where only limited forest cover remains due to the expansion of human settlement. Given that Magpet and Arakan only have a limited forest cover, bird species richness and relative abundance might be lower at these sites. Another probable reason for the documented low bird species richness is the elevation of the study areas. Several studies have shown that elevation has inverse effects on the diversity and richness of birds because it also negatively affects the vegetation structure (Kattan & Franco 2004; McCain 2009; Derhe et al. 2022). Tanalgo et al. (2019) and Gracia et al. (2021) revealed that more endemic and threatened species of birds were observed in lowland forests in Mt. Hilong-hilong and other areas in southern Mindanao. Given that in this study, the sites were found in Montane to the mossy forest with an elevation ranging 1,100–1,700 m, it could account for the low bird species detection rate. However, this result should be carefully analyzed as the number of camera trap days per site vary. Additionally, the camera trapping method employed in this study has limitations, such as the limited range the camera can detect and the location of the camera trap in the tree where it was installed. Additional surveys should be conducted utilizing various methods aiming for bird diversity and richness to understand the ecology of this taxon in the

unprotected areas of the Mt. Apo Range.

Philippine Warty Pigs as ecological engineers

A single camera trap during the 2016 survey captured videos of at least three species that used the same Philippine Warty Pig wallowing hole as drinking and bathing spots at different times of the day. At nighttime, *R. marianna* and *O. gurneyi* used the wallowing hole, while *A. trivirgatus* used it during daytime. This is the first documentation in the Philippines of other forest vertebrates drinking and bathing from the wallowing pit of a Philippine Warty Pig. Wallowing is a very important behavior and provides multiple physiological and welfare benefits to warty pigs (Bracke 2011; Bracke & Spoolder 2011). Wild pigs are regarded as ecological engineers because of their ability to disturb the soil and enhance vegetation succession (Fujinuma & Harrison 2012). The videos provide evidence that warty pigs also create important water holes that fulfill the physiological and other welfare needs of its wildlife co-inhabitants.

Anthropogenic Threats

Camera trapping methods recorded at least three species of IUCN "threatened" species (one endangered, and two vulnerable species) and one IUCN "Near-Threatened" species. Mt Apo Range was once declared by the IUCN as one of the world's most threatened protected natural areas (Lewis 1988). Parts of the unprotected regions of the Mt. Apo Range overlap with the Obu Manuvu Ancestral Domain (OMAD), inhabited mainly by the Obu Manuvu people. They consider the forest as 'Pusaka', an indigenous practice to sanctify biotic and abiotic materials that have cultural value to the community (Villegas et al. 2022a,b). With these, hunting any wildlife species in most parts of the forest is highly prohibited. Only traditional hunting at certain places is allowed, provided a ritual must be performed before hunting. Thus, the use of camera traps to conduct surveys in their lands gained a positive response from the local inhabitants since no wildlife, which they believe to be 'Pusaka', was harmed during the duration of the study. Despite such indigenous conservation practices, the following are the other threats observed in the area.

Unregulated Forest Clearing

The most severe pressure documented at the site is the unregulated clearing of forested areas. Around three hectares of forest clearing was observed in Carmen and Tawan-tawan at 1,500 m. The clearing appeared to be slash-and-burn farming. The large trees were not felled, but the saplings and ferns in the understory were thoroughly clean.

Further downstream of the Kalatong River, a large tract of area (>10 ha), which is part of the Ancestral Domain, was converted as a grazing ground for cows. It is already located beyond 1,200 m. According to locals, the site was previously farmed with cassava, and after cropping, they started to haul cows to the site. Remains and feces of cows are running off into the bodies of Kalatong rivers and creeks, affecting their turbidity and, most likely, the water quality. Kalatong River is an important tributary of the Tamugan rivers, where it joins at the slopes of Mount Tipolog. Furthermore, forested portions adjacent to the ranch were also cleared as probably part of ranch expansion.

Another clearing was observed in Kagawasan, Barangay Tambobong at 1,200 m. At least 100 individuals were starting to occupy the area. These people mostly came from Baguio and Marilog Districts. The occupants were clearing a large area for their village. They had already built transient houses and bunkhouses made up of round timbers, and they used tarpaulins as temporary roofing. These people cleared at least 5 ha of forests in ecologically advanced succession forests.

In Salaysay, there were portions cleared for Kaingin even beyond 1,500 m. These areas are commonly planted with Kamote *Ipomoea batatas*, Corn *Zea mays*, and Gabi *Colocasia esculenta*. Two areas of least 0.25—0.5 ha were newly opened during density assessment. Some alleged individuals also have started to occupy the forest in anticipation of the Magpet-Davao road.

Indiscriminate Trapping

Hunting animals using snares is still very common within the study areas. The survey team documented several snares beside the trail during the assessment. In Tawan-tawan, two snares were found on the trail; one was intended for *S. philippensis,* while the other was meant for smaller mammals. Unfortunately, the smaller trap captured a Bukidnon Woodcock *Scolopax bukidnonensis*, a species endemic only to Mindanao. This was not documented in the camera traps, however, probably because the traps were established in the areas where mammals are expected to appear. *S. bukidnonensis* is known to be shy and secretive inhabiting extremely remote and rugged habitats. Thus, camera traps should be placed in areas they were previously observed (Kennedy et al. 2001). In Tambobong and Salaysay, the team found at least 15 traps along the trail. Most of the traps in Salaysay were intended for deer and warty pigs, while Tambobong

traps can even capture smaller animals like birds and rodents. The team documented one rodent and two birds hanging on the traps, with one of them already decomposing. Tanalgo (2017) listed down the most hunted species in Mt. Apo Range based on the local interviews, which include large mammal species (i.e., wild pigs, deer, bats, and wildcats), reptiles (monitor lizards, pythons), and birds. While the trapping method could capture individuals not recorded in the camera traps, the magnitude of the effects on wildlife could endanger other species, particularly rare and threatened species. If this indiscriminate trapping continues, forest vertebrate populations will continue to decline and face the threat of extinction.

Conservation Initiatives

The ancestral domain owners of the Obo Manuvu of Magpet have declared 8,626 hectares of forests as an Indigenous and Community Conserved Area or ICCA in 2018 and has since been managing it as an Indigenous protected area (Philippine Eagle Foundation 2019). Similarly, the Obu Manuvu of Davao City has declared forest lands and several wildlife species as protected.

The Obu Manuvu indigenous community has been known for its Pusaka philosophy, declaring several wildlife species to be culturally and historically valuable. They have declared the Philippine Eagle *Pithecophaga jefferyi,* Philippine Brown Deer *Rusa marianna*, Philippine Warty Pig *Sus philippensis*, Palm Civet *Paradoxurus hermaphroditus*, Philippine Long-tailed Macaque *Macaca fascicularis philippensis*, Rufous Hornbill *Buceros hydrocorax*, Malay Civet *Viverra tangalunga*, White-eared Brown Dove *Phapitreron leucotis*, Yellow-breasted Fruit Dove *Ptilinopus occipitalis*, Tarictic Hornbill *Penelopides affinis*, and woodpecker *Picidae* sp. as Pusaka species. Consequently, these species were afforded several protection and conservation initiatives (Donato 2011).

One monitoring approach is the forest guarding scheme, wherein locals were capacitated to conduct regular biodiversity assessments and monitoring (Villegas et al. 2022a). Their mandates include foot patrolling activities in selected sites within the ancestral domain. They monitor the wild flora and fauna and document various anthropogenic threats. All observations were endorsed by the local government and several non-government organizations (NGOs). In this way, the indigenous community is heavily invested in conserving and managing natural resources.

The forest guards receive small remuneration and support for their ecosystem services. Consequently, they look for other economic opportunities to support their family's needs, making conservation work a lesser priority. Their provisions in monitoring activities, such as food, equipment, and materials, were also limited. This concern affected their effectiveness and efficiency. Fund support and continuous capacity and values-development programs are needed to enhance the support mechanisms for this conservation initiative.

CONCLUSION

The present study documented eight species of non-volant mammals and four species of birds in the unprotected areas of the Mt. Apo Range. This includes the endangered Philippine Brown Deer *Rusa marianna* and Philippine Long-tailed Macaque *Macaca fascicularis philippinensis*, and the Vulnerable Philippine Warty Pig *Sus philippensis*, and the Giant Scops-owl *Otus gurneyi*. This only showed that threatened species could also be found beyond the protected areas of the Mt. Apo Range. Thus, there is a need to continue monitoring the forest vertebrate species by supporting forest guarding initiatives, given that unsustainable human activities might continue to threaten the already-dwindling mammal and avian species population. A holistic approach in forest governance is necessary to reduce the anthropogenic pressures causing wildlife population decline. Future studies employing longer camera trap monitoring combined with other varying sampling methods and approaches are important to understand and explore the ecology of the documented species and the other species that might not be recorded in the study. This has been demonstrated by Tanalgo et al. (2019) and Gracia et al. (2021), which indicates that integrating findings from multiple datasets, such as those from rapid surveys and assessments, is an effective way to understand local biodiversity, especially in unprotected forested areas of the country. Although it yields limited data, camera trapping has been widely accepted by the community as a wildlife monitoring tool and has given them sufficient information to pursue local conservation initiatives. The data obtained were used as a baseline for championing wildlife conservation and fostering positive perception among locals.

REFERENCES

Abaño, T., G.G. Tampos, R.L. Taraya, D.J. Salvador & J. Ibañez (2015). Dispersal of Philippine eagles released in the forests of Mindanao, Philippines. *Journal of Raptor Research* 49(4): 506–512. https://doi.org/10.3356/rapt-49-04-506-512.1

Ali, N., M.L. Abdullah, S.A. Nor, T.M. Pau, N.A. Kulaimi & D.M. Naim (2020). A review of the genus *Rusa* in the Indo-malayan archipelago and conservation efforts. *Saudi Journal of Biological Science* 20(1): 10–26. https://doi.org/10.1016/j.sjbs.2020.08.024

Balete, D., R.S. Quidlat & J.C Ibañez (2006). The non-volant mammals of Mt. Hamiguitan, Eastern Mindanao, Philippines. *Banwa* 3: 65–80.

BirdLife International (2016). *Accipiter trivirgatus*. The IUCN Red List of Threatened Species 2016: e.T22695462A93510676. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22695462A93510676.en Downloaded on 07 March 2022.

BirdLife International (2016). *Gallus gallus*. The IUCN Red List of Threatened Species 2016: e.T22679199A92806965. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22679199A92806965.en Downloaded on 07 March 2022.

BirdLife International (2016). *Leonardina woodi*. The IUCN Red List of Threatened Species 2016: e.T22715801A94469963. https://doi.org/10.2305/IUCN.UK.20163.RLTS.T22715801A94469963.en Downloaded on 07 March 2022.

BirdLife International (2017). *Otus gurneyi* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2017:e.T22688911A110372685. https://doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22688911A110372685.en Downloaded on 07 March 2022.

Bracke, M.B.M. (2011). Review of wallowing in pigs: Description of the behaviour and its motivational basis *Applied Animal Behaviour Science* 132 (2011): 1–13. https://doi.org/10.1016/j.applanim.2011.01.002

Bracke, M., & H. Spoolder (2011). Review of wallowing in pigs: Implications for animal welfare. *Animal Welfare* 20(3): 347–363. https://doi.org/10.1017/S0962728600002918

Carreira, D. C., W. Dáttilo, D.L. Bruno, A.R. Percequillo, K.M. Ferraz & M. Galetti (2020). Small vertebrates are key elements in the frugivory networks of a hyperdiverse tropical forest. *Scientific Reports* 10(1): 1–11. https://doi.org/10.1038/s41598-020-67326-6

DENR 2019-09 (2019). Updated National List of Threatened Philippine Fauna and their Categories, Visayas Avenue, Diliman, Quezon City. Department of Environment and Natural Resources Administrative Order No. 2019-09.

DENR (2015). Analysis of Pressures to Natural Forests in DENR/B+WISER Sites. United States Agency for International Development. Department of Environment and Natural Resources, 31 pp.

Derhé, M.A., D. Tuyisingize, W. Eckardt, F. Emmanuel & T. Stoinski (2020). Status, diversity and trends of the bird communites in Volcanoes Natonal Park and surrounds, Rwanda. *Bird Conservaton Internatonal* 30(1): 1–20. https://doi.org/10.1017/S0959270919000121

Donato, J.L. (2011). Indigenous Knowledge on Forest Protection and Management: Focus on Obu-Manuvu of Davao City. Euro Generics International Philippines Foundation. http://egipfoundation.org/publications/reports/indigenous-knowledge-onforest-protection-and-management-focus-on-obu-manuvu-of-davao-city/. Downloaded on 3 May 2020.

Duckworth, J.W., R.J. Timmins, A. Choudhury, W. Chutipong, D.H.A. Willcox, D. Mudappa, H. Rahman, P. Widmann, A. Wilting & W. Xu (2016). *Paradoxurus hermaphroditus*. The IUCN Red List of Threatened Species 2016: e.T41693A45217835. https://doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41693A45217835.en. Accessed on 12 April 2023.

Fooden, J. (1995). Systematic review of Southeast Asian longtail macaques, *Macaca fascicularis* (Raffles, 1821). *Fieldiana Zoology* 81: 206.

Fujinuma, J., & Harrison, R. D. (2012). Wild pigs (*Sus scrofa*) mediate large-scale edge effects in a lowland tropical rainforest in peninsular Malaysia. *PLoS ONE* 7(5): e37321. https://doi.org/10.1371/journal.pone.0037321

Gomez-Roxas, P., R.D. Boniao, E.M. Burton, A. Gorospe-Villarino & S.S. Nacua (2005). Community-Based Inventory and Assessment of Riverine and Riparian Ecosystems in the Northeastern Part of Mt. Malindang, Misamis Occidental, 138 pp.

Gracia Jr, A.G., A.B. Mohagan, J.C. Burlat, W.L. Yu, J. Mondalo, F.M. Acma, H.P. Lumista, R. Calising & K.C. Tanalgo (2021). Conservation ecology of birds in Mt. Hilong-hilong, a Key Biodiversity Area on Mindanao Island, the Philippines. *Journal of Threatened Taxa* 13(5): 18110–18121. https://doi.org/10.11609/jott.6760.13.5.18110-18121

Gumert, M.D., A. Fuentes & L. Jones-Engel (eds.) (2011). Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and their Interface with Humans. Cambridge University Press, Cambridge, UK.

Hansen, M.F., A. Ang, T.T.H. Trinh, E. Sy, S. Paramasivam, T. Ahmed, J. Dimalibot, L. Jones-Engel, N. Ruppert, C. Griffioen, N. Lwin, P. Phiapalath, R. Gray, S. Kite, N. Doak, V. Nijman, A. Fuentes & M.D. Gumert (2022). Macaca fascicularis (amended version of 2022 assessment). The IUCN Red List of Threatened Species 2022: e.T12551A221666136. https://doi.org/10.2305/IUCN.UK.2022-2.RLTS.T12551A221666136.en Downloaded on 19 March 2023.

Heaney, L.R. (1993). Biodiversity patterns and the conservation of mammals in the Philippines. *Asia Life Sciences* 2(2): 261–274.

Heaney, L.R. & J.C. Regalado, Jr. (1998). Vanishing Treasures of the Philippine Rain Forest. The Field Museum, Chicago, IL. https://doi.org/10.1644/1545-1542(2001)082<0246:R>2.0.CO;2

Heaney, L.R., D.S. Balete, E.A. Rickart, R.C.B. Utzurrum & P.C. Gonzales (1999). Mammalian diversity on Mt. Isarog: a threatened center of endemism on southern Luzon Island, Philippines. *Fieldiana Zoology* 95: 1–62. https://doi.org/10.5962/bhl.title.3369

Heaney, L.R., B.R. Tabaranza Jr, E.A. Rickart, D.S. Balete & N.R. Ingle (2006). The mammals of Mt. Kitanglad Nature Park, Mindanao, Philippines. *Fieldiana Zoology* 112: 1–63. https://doi.org/10.3158/0015-0754(2006)186[1:TMOMKN]2.0.CO;2

Heaney, L., P. Alviola, M.R. Duya, M. Tabao, J.C. Gonzalez & D. Balete (2016). *Rattus everetti*. The IUCN Red List of Threatened Species 2016: e.T19329A115146445. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T19329A22441260.en Downloaded on 19 March 2023.

Heaney, L. (2016). *Bullimus bagobus*. The IUCN Red List of Threatened Species 2016: e.T3322A22436177. https://doi.org/10.2305/IUCN.UK.2016-2.RLTS.T3322A22436177.en Downloaded on 19 March 2023.

Heaney, L. & P. Ong (2016). *Exilisciurus concinnus*. The IUCN Red List of Threatened Species 2016: e.T8436A22244780. https://doi.org/10.2305/IUCN.UK.2016-2.RLTS.T8436A22244780.en Downloaded on 19 March 2023.

Hansen, M.F., M. Gill, V.A. Nawangsari, K.L. Sanchez, S.M. Cheyne, V. Nijman & A. Fuentes (2021). Conservation of long-tailed macaques: implications of the updated IUCN status and the COVID-19 pandemic. *Primate Conservation* 35: 1–11. http://www.primate-sg.org/storage/pdf/PC35_Hansen_et_al_conservation_M_fascicularis.pdf.

Ibañez, J.C., S. Bastian, F. Ates, E.M. Delima, T. Abano, J. Coronel, R. Gomez, A. Allado, R. Bravo & J. Montero (2004). Gaynawaan: Conservation of threatened vertebrates at Mount Sinaka, Mindanao. https://www.conservationleadershipprogramme.org/media/2014/11/000704_Philippines_FR_Gaynawaan.pdf.

Ingram, D.J., D. Willcox & D.W. Challender (2019). Evaluation of the application of methods used to detect and monitor selected mammalian taxa to pangolin monitoring. *Global Ecology and Conservation* 18: e00632. https://doi.org/10.1016/j.gecco.2019.e00632

Jenks, K.E., P. Chanteap, D. Kanda, C. Peter, P. Cutter, T. Redford, J.L. Antony, J. Howard & P. Leimgruber (2011). Using relative

abundance indices from camera-trapping to test wildlife conservation hypotheses – An example from Khao Yai National Park, Thailand. *Tropical Conservation Science* 4(2): 113–131. https://doi. org/10.1177/194008291100400203

Johann, F., M. Handschuh, P. Linderoth, C.F. Dormann & J. Arnold. (2020). Adaptation of wild boar (*Sus scrofa*) activity in a human-dominated landscape. *BMC Ecology* 20(1): 1–14. https//doi.org/10.1186/s12898-019-0271-7

Katan, G.H. & P. Franco (2004). Bird diversity along elevational gradients in the Andes of Colombia: area and mass efects. *Global Ecology and Biogeography* 13(5): 451–458. https://doi.org/10.1111/j.1466-822X.2004.00117.x

Kays, R.S., B. Tilak, P.A. Kranstauber, C. Jansen, M. Carbone, T. Rowcliffe, J. Fountain, J. Eggert & Z. He (2011). Camera Traps as Sensor Networks for Monitoring Animal Communities. *International Journal of Research and Reviews in Wireless Sensor Networks* 1(2): 19–29.

Kays, R.S. B.S., Arbogast, M. Baker-Whatton, C. Beirne, H.M. Boone, M. Bowler, S.F. Burneo, M.V. Cove, P. Ding, S. Espinosa, A.L.S. Gonçalves, C.P. Hansen, P.A. Jansen, J.M. Kolowski, T.W. Knowles, M.G.M. Lima, J. Millspaugh, W.J. McShea, K. Pacifici, A.W. Parsons, B.S. Pease, F. Rovero, F.Santos, S.G. Schuttler, D. Sheil, X. Si, M. Snider & W.R. Spironello (2020). An empirical evaluation of camera trap study design: How many, how long and when? *Methods in Ecology and Evolution* 11: 700–713. https://doi.org/10.1111/2041-210X.13370

Klapproth, J.C. & J.E. Johnson (2009). Understanding the Science behind Riparian Forest Buffers: Effects on Plant and Animal Communities. Virginia Cooperative Extension, 155 pp.

Kennedy, R.S., T.H. Fisher, S.C.B. Harrap, A.C. Diesmos & A.S. Manamtam (2001). A new species of woodcock from the Philippines and a re-evaluation of other Asian/Papuasian woodcock. *Forktail* 17(1): 1–12.

Kennerley, R. (2019). *Tupaia everetti*. The IUCN Red List of Threatened Species 2019: e.T22784A130877829. https://doi.org/10.2305/IUCN.UK.20191.RLTS.T22784A130877829.en Downloaded on 07 March 2022.

Lacher, T.E., A.D. Davidson, T.H. Fleming, E.P. Gómez-Ruiz, G.F. McCracken, N. Owen-Smith, C.A. Peres & S.B. vander Wall (2019). The functional roles of mammals in ecosystems. *Journal of Mammalogy* 100(3): 942–964. https://doi.org/10.1093/jmammal/gyy183

Lewis, R.E. (1988). Mt Apo and other national parks in the Philippines. *Oryx* 22(2): 100–109.

Meek, P.D., P. Fleming & G. Ballard. (2012). An introduction to camera trapping for wildlife surveys in Australia. Canberra, Australia: Invasive Animals Cooperative Research Centre.

McCain, C.M. (2009). Global analysis of bird elevatonal diversity. *Global Ecology and Biogeography* 18(3): 346–360. https://doi.org/10.1111/j.1466-8238.2008.00443.x

Mohagan, A.B., O.M. Nuñeza, A.G. Gracia, E.C.T. Selpa, J.A. Escarlos Jr, L.J.B. Baguhin, F.P. Coritico & V.B. Amoroso (2015). Species richness of avifauna in four Long-Term Ecological Research sites in Mindanao, Philippines. *Journal of Applied Environmental and Biological Sciences* 5(11): 88–89.

Morante-Filho, J.C. & D. Faria (2017). An appraisal of bird-mediated ecological functions in a changing world. *Tropical Conservation Science* 10: 1940082917703339. https://doi.org/10.1177/1940082917703339

Naing, H., Fuller, T. K., Sievert, P. R., Randhir, T. O., Po, S. H. T., Maung, M. & Myint, T. (2015). Assessing large mammal and bird richness from camera-trap records in the Hukaung Valley of northern Myanmar. *Raffles Bulletin of Zoology* 63: 376–388. https://lkcnhm.nus.edu.sg/app/uploads/2017/06/63rbz376-388.pdf

Olczak, K., J. Nowicki & C. Klocek (2015). Pig behaviour in relation to weather conditions - a review. *Annals of Animal Science* 15(3): 601–610. https://doi.org/10.1515/aoas-2015-0024

Oliver, W.L.R. (1992). The taxonomy, distribution, and status of Philippine wild pigs. *Silliman Journal* 36: 55–64.

Ong, P. & M. Richardson (2008). *Macaca fascicularis* ssp. *philippensis*. The IUCN Red List of Threatened Species 2008: e.T40788A10354490. https://doi.org/10.2305/IUCN.UK.2008.RLTS.T40788A10354490.en Downloaded on 07 March 2022.

Palmer M.S., A. Swanson, M. Kosmala, T. Arnold & C. Packer (2018). Evaluating relative abundance indices for terrestrial herbivores from large-scale camera trap surveys. *African Journal of Ecology* 56(4): 791–803. https://doi.org/10.1111/aje.12566

Philippine Eagle Foundation (2019). Indigenous Knowledge, Systems, and Practices of the Obo Monuvu in Magpet, Cotabato, Philippines. https://www.researchgate.net/publication/369367231_Indigenous_Knowledge_Systems_and_Practices_of_the_Obo_Monuvu_in_Magpet_Cotabato_Philippines#fullTextFileContent. Downloaded March 20 2023.

Pla-ard M., W. Hoonheang, B. Kaewdee, T. Panganta, K. Charaspet, N. Khoiesri, P. Paansri, P. Kanka, Y. Chanachai, J. Thongbanthum, P. Bangthong & R. Sukmasuang (2021). Abundance, diversity and daily activity of terrestrial mammal and bird species in disturbed and undisturbed limestone habitats using camera trapping, Central Thailand. *Biodiversitas Journal of Biological Diversity* 22(8): 3620–3631. https://doi.org/10.13057/biodiv/d220864

Podgórski T., G. Baś, B. Jędrzejewska, L. Sönnichsen, S. Śnieżko, W. Jędrzejewski & H. Okarma (2013). Spatiotemporal behavioral plasticity of wild boar (Sus scrofa) under contrasting conditions of human pressure: primeval forest and metropolitan area. *Journal of Mammalogy* 94(1): 109–119. https://doi.org/10.1644/12-MAMM-A-038.1

Relox, R.E., F.B. Ates-Camino, S.T. Bastian Jr & E.P. Leano (2009). Elevational Gradation of Mammals in Tropical Forest of Mt. Hamiguitan Range, Davao Oriental. *Journal of Nature Studies* 8(1): 27–34.

Ripple, W. J., C. Wolf, T.M. Newsome, M. Hoffmann, A.J. Wirsing & D.J. McCauley (2017). Extinction risk is most acute for the world's largest and smallest vertebrates. *Proceedings of the National Academy of Sciences* 114(40): 10678–10683. https://doi.org/10.1073/pnas.1702078114

Sha, J.C.M. & G. Hanya (2013). Diet, activity, habitat use, and ranging of two neighboring groups of foodenhanced long-tailed macaques (*Macaca fascicularis*). *American Journal of Primatology* 75: 581–592. https://doi.org/10.1002/ajp.22137

Sutton, L.J., J.C. Ibañez, D.I. Salvador, R.L. Taraya, G.S. Opiso, T.L.P. Senarillos & C.J.W. McClure (2023). Priority conservation areas and a global population estimate for the critically endangered Philippine Eagle. *Animal Conservation [Early view].* https://doi.org/10.1111/acv.12854

Tanwar, K.S., A. Sadhu & Y.V. Jhala (2021). Camera trap placement for evaluating species richness, abundance, and activity. *Scientific Reports* 11(1): 1–11. https://doi.org/10.1038/s41598-021-02459-w

Thierry, B. (2007). The macaques. A double-layered social organization, pp. 224–239. In: Campbell, C.J., A. Fuentes, K.C. MacKinnon, M. Panger, & S.K. Bearder (eds.). *Primates in Perspective.* Oxford University Press, Oxford, United Kingdom.

Tanalgo, K.C. (2017). Wildlife hunting by indigenous people in a Philippine protected area: a perspective from Mt. Apo National Park, Mindanao Island. *Journal of Threatened Taxa* 9(6): 10307–10313. https://doi.org/10.11609/jott.2967.9.6.10307-10313.

Tanalgo, K.C., M.J.M.M. Achondo & A.C. Hughes (2019). Small Things Mater: The Value of Rapid Biodiversity Surveys to Understanding Local Bird Diversity Paterns in Southcentral Mindanao, Philippines. *Tropical Conservation Science* 12: 1940082919869482. https://doi.org/10.1177/1940082919869482

Villegas, J.P., J.R. Rosales & J.C. Ibañez (2022a). Conservation and Population Status of the Philippine Warty Pig (Sus philippensis) within the Obu Manuvu Ancestral Domain in Davao City, Mindanao Island, Philippines. *Sylvatrop, The Technical Journal of Philippine Ecosystems and Natural Resources* 32(1): 1–14.

Villegas, J.P., J.C. Ibañez & C.K.T. Cabrido (2022b). Abundance and Distribution of the Philippine Brown Deer (*Rusa marianna* Desmarest, 1822) in the Obu Manuvu Ancestral Domain, Mindanao

Island, Philippines. *Acta Biologica Universitatis Daugavpiliensis* 22(1): 67–89.

Willcox, D., H.C. Nash, S. Trageser, H.J. Kim, L. Hywood, E. Connelly, G.I. Ichu, J.K. Nyumu, C.L.M. Moumbolou, D.J. Ingram & D.W. Challender (2019). Evaluating methods for detecting and monitoring pangolin (Pholidata: Manidae) populations. *Global Ecology and Conservation* 17: e00539. https://doi.org/10.1016/j.gecco.2019.e00539

Yanuar, A., D. J. Chivers, J. Sugardjito, J., D. J. Martyr & T. Jeremy (2009). The population distribution of pig-tailed macaque (*Macaca nemestrina*) and long-tailed macaque (*Macaca fascicularis*) in west central Sumatra, Indonesia. *Asian Primates Journal* 1: 2–11. http://www.primate-sg.org/storage/asian-primates-journal/volume-12/APJ1.2.MacaquesSumatra.pdf

Zhang, C., R. Zhu, X. Sui, K. Chen, B. Li & Y. Chen (2020). Ecological use of vertebrate surrogate species in ecosystem conservation. *Global Ecology and Conservation* 24: e01344. https://doi.org/10.1016/j.gecco.2020.e01344

Zhang, J., H. Qian, M. Girardello, V. Pellissier, S.E. Nielsen & J. Svenning (2018). Trophic interactions among vertebrate guilds and plants shape global patterns in species diversity. *Proceedings of the Royal Society B: Biological Sciences* 285(1883): 20180949. https://doi.org/10.1098/rspb.2018.0949

Filipino Abstrak: Ang ihalas nga mga mananap, sama sa mga non-volant mammals ug mga langgam, adunay importante nga papel sa pagmintinar sa kahimsog sa ekosistema. Gikonsiderar sila nga mga ecological engineers nga nag-impluwensya sa komposisyon sa mga tanum sa lasang. Apan tungod sa pagkaguba sa kalasangan, pagkawala sa puy-anan, ug paglutos sa tawo, ang populasyon niini mikunhod sa nilabay nga mga katuigan. Kini nga pagtuon naninguha sa pagpahigayon ug imbentaryo sa mga mananap ug pagkuwenta sa gidaghanon sa non-volant mammals ug mga langgam gawas sa protektadong luna sa Mt. Apo Range, Philippines, pinaagi sa camera trapping method. Dugang pa, gitun-an ang mga tawhanong hulga nga nakita sa mga nahisgotang lugar. Sa kinatibuk-an, 1,106 ka adlaw sa camera trapping ang gihimo sa 2016 ug laing 500 ka adlaw sa 2020. Base sa 260 ka independent sequences para sa 2016 ug 2020 nga mga survey, 12 ka mananap ang giila, nga naglangkob sa walo ka non-volant mammals ug upat ka langgam. Lakip sa giila nga mga mananap mao ang Endangered Philippine Brown Deer Rusa marianna ug ang Philippine Long-tailed Macaque Macaca fascicularis philippensis. Nakita usab ang Vulnerable Giant Scops-owl Otus gurneyi ug ang Philippine Warty Pig Sus philippensis. Nakuha usab sa unang higayon ang mga video nga ebidensya sa Philippine warty pig Sus philippensis nga naghimo ug importanteng papel isip ecological engineer sa tropikal nga kalasangan sa Pilipinas. Laing 61 ka independent sequences sa wala mailhi nga mga ilaga ang nakit-an sa mga camera traps, nga nanginahanglan dugang pang mga teknik sa pagmonitor sa mga mananap. Kinahanglang palig-onon ang konserbasyon lapas sa giprotektahan nga mga luna sa Mt. Apo Range pinaagi sa pagdumala sa kalasangan nga nakabase sa komunidad. Kini magsiguro nga ang mga mananap sa lasang mapanalipdan ug makonserba gikan sa dugang nga tawhanong hulga.

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