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Cover: A Warty Hammer Orchid *Drakaea livida* gets pollinated by a male thynnine wasp through 'sexual deception' — a colour pencil reproduction of photos by ron_n_beths (flickr.com) and Rod Peakall; Water colour reproduction of Flame Lily *Gloriosa superba* -- photo by Passakoran_14; and a bag worm and its architectural genius (source unknown). Art work by Pannagasri G.

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ARTICLE

Fruit bat (Pteropodidae) composition and diversity in the montane forests of Mt. Kampalili, Davao De Oro, Philippines

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Abstract: Fruit bats are important bioindicators of tropical forests because of their species richness, ecological roles, and sensitivity to environmental changes. This study assessed the species composition and diversity of fruit bats on Mt. Kampalili, Davao de Oro, Philippines, through mist-netting conducted in May and July 2023 across lower and upper montane forests. A total of 423 individuals representing nine species from seven genera were recorded. Of these, six species (66.67%) are endemic to the Philippines and two (*Dyacopterus rickarti*, Endangered; *Ptenochirus wetmorei*, Vulnerable) are threatened. Four species, *Cynopterus brachyotis*, *Ptenochirus wetmorei*, *Harpyionycteris whiteheadi*, and *Eonycteris spelaea*, were newly recorded on Mt. Kampalili in Davao de Oro, increasing the known fruit bat richness in the area to nine species. Diversity was low (H' = 1.71), with no significant differences in species abundance between the two forest types. The presence of endemic and threatened species, combined with indications of disturbance tolerance by generalist species, highlights the ecological importance and vulnerability of Mt. Kampalili. Long-term monitoring and site-based conservation measures are recommended, particularly in lower montane areas where anthropogenic activities are more evident.

Keywords: Conservation, *Dyacopterus rickarti*, Eastern Mindanao Biodiversity Corridor, ecology, Endemism, *Ptenochirus wetmorei*, species richness, threatened species, wildlife.

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INTRODUCTION

Fruit bats (Family: Pteropodidae) are among the most diverse mammals that inhabit a diverse range of habitats and elevations in forest ecosystems. In the Philippines, 26 species of fruit bats have been recorded, 17 of which are endemic (Heaney et al. 2016). They play a vital role as seed dispersers and pollinators in tropical forest ecosystems, contributing significantly to forest regeneration, and plant community dynamics (Aziz et al. 2021). Given their high diversity and crucial ecological functions, bats have become a major focus of biodiversity research in the Philippines, particularly in forest ecosystems.

Between 2000 and 2017, research on Philippine bats averaged nearly eight published studies per year, with the majority focusing on biodiversity exploration (Tanalgo & Hughes 2018). Despite this progress, several areas, particularly in Mindanao, remain poorly studied and underexplored (Dela Cruz et al. 2023; Tanalgo et al. 2023). While bat diversity surveys have been conducted in various mountain ranges across the region, these efforts have largely concentrated on well-known sites such as Mt. Apo and Mt. Kitanglad (Heaney et al. 2006; Relox et al. 2014; Amoroso et al. 2019). As a result, many mid- to high-elevation zones and some isolated mountain systems in Mindanao lack comprehensive bat biodiversity assessments.

Mindanao Island, which forms a major part of the Mindanao Faunal Region, is recognized as a biodiversity hotspot in the Philippines. It faces serious threats such as deforestation, mining, and agricultural expansion. In addition to these challenges, biodiversity conservation in the region is hindered by significant knowledge gaps, with some areas still lacking, and limited biodiversity data (Agduma et al. 2023). One such understudied site is Mt. Kampalili in Eastern Mindanao. Rising to 2,388 m, it hosts a range of forest ecosystems, from lowland dipterocarp to mossy forests (BirdLife International 2022), and supports a high potential for endemic biodiversity, as evidenced by recent discoveries such as *Baletemys kampalili* (Rowsey et al. 2022), and *Nepenthes kampalili* (Lagunday et al. 2024). Despite its status as a Key Biodiversity Area (KBA), Mt. Kampalili remains unprotected under the National Integrated Protected Areas System (NIPAS), and is increasingly threatened by anthropogenic pressures, including logging, and small-scale mining activities. Notably, data on fruit bat diversity in Mt. Kampalili remain limited, with this study representing only the second documented assessment in the area (Ibañez & Baron 2011). The absence of comprehensive baseline information hinders the development of targeted, evidence-based conservation strategies, particularly for endemic, and threatened mammals that are sensitive to habitat disturbance (Tanalgo et al. 2023).

This study assessed the composition and diversity of fruit bat species across select forest habitats in Mt. Kampalili, Davao de Oro. By addressing a critical knowledge gap, the findings aim to contribute to the conservation of regional biodiversity, particularly within the Eastern Mindanao Biodiversity Corridor (EMBC).

MATERIALS AND METHODS

Permits and Clearances

All necessary permits and clearances were obtained in accordance with Philippine regulatory protocols. Coordination was conducted with the Municipal Government of Maragusan, Davao de Oro, and with representatives of the Mandaya-Mansaka Indigenous Cultural Communities / Indigenous Peoples (ICCs/IPs) in the Barangays of Bahi and Langgawisan to secure Prior Informed Consent (PIC). The project was also reviewed by the National Commission on Indigenous Peoples (NCIP) Davao de Oro Provincial Office. Following these processes, the Department of Environment and Natural Resources Region XI (DENR XI) issued a Wildlife Gratuitous Permit (WGP No. XI-2023-08), authorizing biodiversity assessment on Mt. Kampalili.

Study Site and Duration

Bat diversity data were collected from two forest types: the lower montane and upper montane forests of Mt. Kampalili, Davao de Oro. Mt. Kampalili is located along the boundary of Manay, Davao Oriental and the southeastern part of Maragusan, Davao de Oro (Figure 1), with an elevation of 2,388 m. The study was conducted in May and July 2023 at two sites within the montane forests of Mt. Kampalili.

The first site was classified as a lower montane forest ranging from 1,350–1,550 m (Image 1). The forest consists of dense portions of cultivated Abaca *Musa textilis*, banana *Musa* sp., bamboo *Bambusa* sp., as well as several types of fruits and wild trees. The forest canopy was dominated by Oak trees *Lithocarpus caudatifolius*, Igem *Dacrycarpus imbricatus*, Laurels *Litsea philippinensis*, and Nato *Palaquium luzoniense* with heights ranging 12–27 m and DBH ranging 8–60 cm. Furthermore, *Ficus* density was low but the density of other fruiting trees such as *Palaquium luzoniense,*

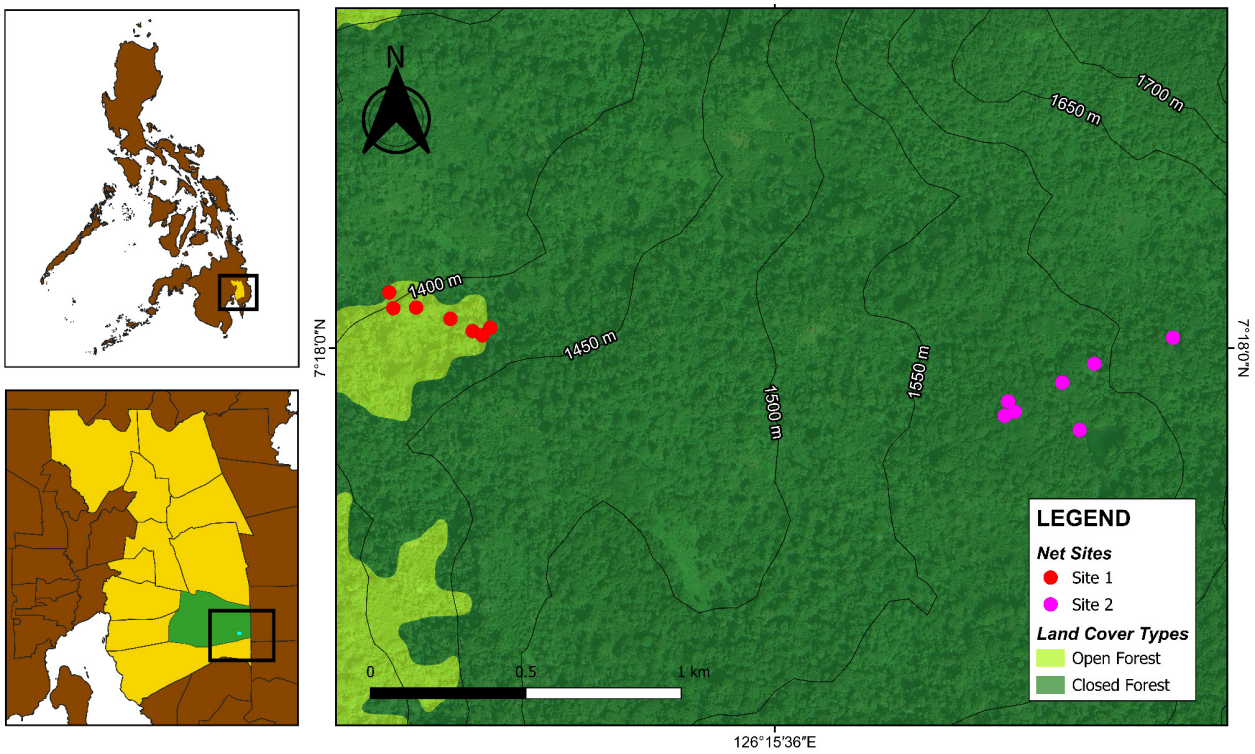

Figure 1. Vegetation map of Mt. Kampalili, Davao de Oro showing locations of mist nets in both lower montane (red) and upper montane (pink) forest. Maps generated using QGIS and Google Satellite Imagery.

Elaeocarpus sp., and *Syzygium* spp. were fairly high. The high presence of these trees corroborates the findings of Fernando et al. (2008) who stated that the tropical lower montane forest is dominated by oak trees, oil fruits, laurels, and *Syzygium* spp. The observed anthropogenic disturbances include the clearance of land for agriculture, cultivation of abaca plantations and other cash crops, and the minimal presence of human settlements.

Meanwhile, the second site is situated approximately 1 km from the first location with an elevation ranging 1,570–1,680 m and the forest type is categorised as upper montane (Image 2). The montane forest canopy was 20–25 m high and the maximum recorded DBH was 65 cm. Canopy trees such as Igem and Laurel *Cinnamomum mercadoi* dominated the forest, comprising a relative dominance of 32.75% and 22.41%, respectively. Other canopy trees observed in the area included *Agathis philippinensis, L. caudatifolius*, *Syzygium polyanthum*, *Elaeocarpus* sp., and *P. luzoniense*, which bear fruits that are essential food sources for bats. Moreover, *Ficus* species were denser at this location compared to Site 1. The increased density of fig trees was particularly significant. A lake, also locally called Lake Danao, was situated at a distance of 200–300 m between Point 2 (1,586 m elevation), and Point 3 (1,590 m elevation) along the established transect line. Additionally, the site had fewer human-caused disruptions with few abaca plantations in the area, but they were not as widespread as those at Site 1.

Bat Collection and Identification

Within the 2,000 m transect line, bat surveys were conducted using standard aerial and ground mist-netting techniques. Mist nets measuring 6 x 3 and 12 x 3 m were placed along the transect lines and the established flight paths of the bats. Nets were deployed strategically in areas with abundant fruit trees and bodies of water, maximizing the likelihood of capturing diverse species. This approach aimed to optimize catch yields by targeting areas rich in natural food sources and water access points. Nets were established in the afternoon until the dawn of the next day (1700–0400 h), and were regularly inspected at 3-hour intervals to prevent mortality. The accessibility of the sampling locations and the quality of the sites for collecting bats played a major role in the site selection process. Hence, high-quality sites, such as bat flyways in the forest understory and gaps between trees, were selected for the deployment of mist nets. Furthermore, during periods of heavy rains, the mist

Image 1. Sampling site 1: Lower montane forest area of Mt. Kampalili, Davao de Oro, featuring *Abaca Musa* textilis interspersed within the landscape. © MD Superio.

nets were removed earlier than usual.

In Site 1, data collection was conducted within three sampling nights, completing a total of 39 net nights of observation. Nets in these sites were meticulously positioned in locations exhibiting a high abundance of fruiting trees, capitalizing dietary preferences and foraging behaviors. Furthermore, a series of nets were strategically deployed proximal to the creek, which has diverse *Musa* species around its vicinity. Complementary tactics involved the strategic placement of nets along documented flight paths and in close proximity to their roosting sites.

Meanwhile, Site 2 accumulated 52 net nights across the four sampling nights (Image 2). The nets in this site were strategically positioned in the documented flight paths of bats. Additionally, while the abundance of fruiting trees was limited in the second area, efforts were concentrated near known food sources such as *Syzygium* sp., *Elaeocarpus* sp., and *Ficus* species. A net series was also established near Lake Danao, recognizing water bodies as areas commonly visited by bats.

Each captured fruit bat sample was then identified using field guides and taxonomic keys in situ (for example Ingle & Heaney 1992; Ingle et al. 1999). The degree of ossification of the carpal joints of the wing, the quality of the pelage, and the development of nipples, and testicles were used to determine the relative age and sex (Anthony 1988). Following identification and examination, bat species were marked on their wing membranes with nail polish before being returned to the forest. The conservation status and endemicity of the species were assessed using the latest database from the International Union for Conservation of Nature Red List version 2025-1 (IUCN 2025).

Data Analysis

The adequacy of the sampling effort for species richness in each forest type was estimated using individual-based rarefaction curves, which were generated by iNEXT (iNterpolation and EXTrapolation) online (Hsieh et al. 2016). The Shannon-Wiener diversity index, Simpson dominance index, and Pielou's index of evenness were used to characterize the fruit bat diversity, dominance, and evenness in different sites with varying degrees of disturbances. These biodiversity indices were calculated using Paleontological Statistics Software (PAST) version 4.03 (Hammer-Muntz et al. 2001). Furthermore, a two sample t-test was used to determine if there is a significant difference in the abundance of each fruit bat species between the two sites.

Image 2. Sampling site 2: Upper Montane forest area of Mt. Kampalili, Davao de Oro, characterized by dense moss cover. © MD Superio.

RESULTS

Fruit Bat Composition and Species Accounts

A total of 423 individuals representing nine species from seven genera were recorded over 91 net-nights (Table 1). The bat assemblage exhibited a 66.67% endemism rate, with six Philippine endemic species: *Dyacopterus rickarti*, *Haplonycteris fischeri*, *Ptenochirus wetmorei*, *Harpyionycteris whiteheadi*, *Ptenochirus jagorii*, and *Ptenochirus minor*. The remaining three species were native non-endemic (Image 3). Two species are listed as threatened, representing 22.22% of the total species recorded: *D. rickarti* is classified as 'Endangered', and *Ptenochirus wetmorei* as 'Vulnerable'. Despite a slightly lower sampling effort in Site 1, all expected species appear to have been documented (Figure 2). In contrast, Site 2 has higher species richness, and data suggest that additional species may still be recorded with continued sampling (Figure 2).

Cynopterus brachyotis (Müller, 1838)

The Lesser Dog-Faced Fruit bat *Cynopterus brachyotis* is a frugivorous bat widespread across southern to southeastern Asia. In the Philippines, this species occurs from sea level to 1,600 m and is the most common bat in lowland disturbed habitats (Heaney et al. 2016). It was the most abundant species in this study, which is interesting considering that earlier explorations where this bat was not recorded (Ibañez & Baron 2011). During the current survey, several pregnant individuals of *C. brachyotis* were captured, and two were observed to have dependent offspring during the first field visit in May 2023. Notably, one individual, presumably stressed from entanglement attempts in mist nets, appeared to undergo premature parturition. Genomic analyses suggest that the Philippine population of *C. brachyotis*, particularly those on Mindanao Island, may represent a distinct species separate from other populations found outside the country (Gaite et al. 2022). *Cynopterus luzoniensis* is currently used in some literature for both Sulawesi and Philippine populations, but past studies suggest that these lineages show a clear geographical, and evolutionary distinction, and thus both should be raised as a separate species (see Campbell et al. 2004). The species is not classified as threatened under the IUCN Red List.

Dyacopterus rickarti Helgen, Kock, Gomez, Ingle & Sinaga, 2007

The Philippine Large-headed Fruit Bat *Dyacopterus rickarti* is a poorly known Philippine endemic bat, found only in the islands of Luzon and Mindanao (Gomez & Waldien 2020). It is only identified to be present in regenerating secondary or primary montane and mossy forests, at 550–1,680 m (Heaney et al. 2016). This species

was only recorded in this study in the lower montane forest. Five individuals were captured using mist nets placed along forest trails and near Abaca plantations at elevations ranging approximately 1350–1409 m, aligning with the known elevational occurrence of the species (Gomez & Waldien 2020). Of the five captured specimens, three were female, and two were male, and all individuals were identified as adults. Currently, the knowledge of the natural history of *D. rickarti* remains limited. Its primary diet is unknown, but our records in the species' capture sites in Mt. Kampalili includes *Elaeocarpus* spp., *Syzygium* spp., *Pandanus*, and fruiting palms, similar to previous observations (see Helgen et al. 2007). The species is classified as 'Endangered' (EN) on the IUCN Red List of Threatened Species, with its population status poorly understood due to lack of sufficient data.

***Eonycteris spelaea* (Dobson, 1871)**

The Dawn Bat *Eonycteris spelaea* is a southern and southeastern Asian native bat that is widespread throughout the Philippines. This cave-dwelling species typically occurs in the country from sea level to 1,100 m, being abundant in lowland agricultural areas, and secondary forests (Heaney et al. 2010). The dawn bat typically feeds on nectar, pollen, and soft fruits, hence, an important pollinator and seed disperser in regenerating forests. This study only recorded one adult female individual. Previous reports suggest *E. spelaea* is in lower elevations and avoids old-growth forests (Heaney et al. 2006, 2010, 2016), but the record of the individual in Mt. Kampalili was made on the upper montane forest at 1,589 m, with no observations made in the lower montane site. Additionally, this species was not reported in a previous study by Ibañez & Baron (2011), further suggesting a potentially low population density in the surveyed areas. The species is currently classified as 'Least Concern' on the IUCN Red List of Threatened Species.

***Haplonycteris fischeri* Lawrence, 1939**

Endemic only to the country, the Philippine Pygmy Fruit Bat *Haplonycteris fischeri* is among the most common bats in primary forests, uncommon in secondary forests, and absent in agricultural areas (Heaney et al. 2010). Preferring mid-elevation habitats, ranging from 150–2,250 m, a total of 42 individuals were recorded at the lower montane site, and 41 at the upper montane site of Mt. Kampalili. The highest elevation at which an individual was captured in this study was 1,630 m. Of the 83 captured individuals, 52 were female and 64 were identified as adults. The persistence of this species in forest fragments, especially at the lower montane site, suggests a degree of tolerance similar to previous observations (Heaney et al. 2016). The species is currently listed as 'Least Concern' (LC) in 2025 IUCN Red List of Threatened Species.

***Harpyionycteris whiteheadi* Thomas, 1896**

The Philippine endemic Harpy Fruit Bat *Harpyionycteris whiteheadi*, primarily inhabits lowland and montane forests ranging from approximately 500–1,800 m (Duya et al. 2021). This bat is distinguished by its pale mottled wing markings and forward-projecting

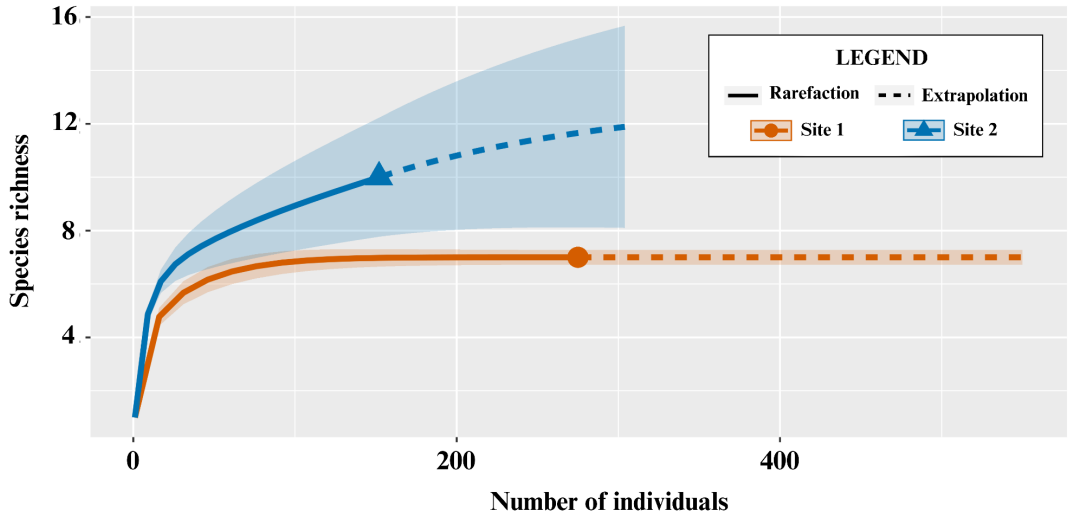

Figure 2. Individual-based rarefaction curve for site 1 (lower montane) and site 2 (upper montane) at Mt. Kampalili, Davao de Oro.

Table 1. Summary and comparison of fruit bat species recorded in Mt. Kampalili, Davao de Oro.

Species	Common name	IUCN Red List (2025)	Distribution status	Lower montane	Upper montane	Total	†p value (<0.05)
Cynopterus brachyotis (Müller, 1838)	Lesser Dog-faced Fruit Bat	LC	R	101	16	117	0.0987
Dyacopterus rickarti Helgen, Kock, Gomez, Ingle & Sinaga, 2007	Philippine Large-headed Fruit Bat	EN	PE	5	0	5	*
Eonycteris spelaea (Dobson, 1871)	Dawn Bat	LC	R	0	1	1	*
Haplonycteris fischeri Lawrence, 1939	Philippine Pygmy Fruit Bat	LC	PE	42	41	83	0.5959
Harpyionycteris whiteheadi Thomas, 1896	Harpy Fruit Bat	LC	PE	0	1	1	*
Macroglossus minimus (É. Geoffroy Saint- Hilaire, 1810)	Dagger-toothed Long-nosed Fruit Bat	LC	R	24	22	46	0.3636
Ptenochirus wetmorei (Taylor, 1934)	Mindanao Fruit Bat	VU	ME	7	27	34	0.8585
Ptenochirus jagorii (Peters, 1861)	Greater Musky Fruit Bat	LC	PE	86	30	116	0.0745
Ptenochirus minor Yoshiyuki, 1979	Lesser Musky Fruit Bat	LC	ME	10	10	20	0.8531
Total abundance				***275***	***148***	***423***	
Richness				***7***	***8***	***9***	
Dominance (Simpson dominance index, *D*)				**0.26**	**0.18**	**0.21**	
Evenness (Pielou's evenness index, J)				**0.70**	**0.75**	**0.61**	
Diversity (Shannon-Wiener index, *H'*)				***1.53***	***1.79***	***1.71***	

EN—Endangered | VU—Vulnerable | LC—Least Concern | OWS—Other Wildlife Species | R—Resident | PE—Philippine Endemic | ME—Mindanao Faunal Region Endemic | *—minimal individuals caught | †—two-sample t-test (PAST ver 4.03).

teeth, including prominent canines (Heaney et al. 2016). An adult female *H. whiteheadi* was captured at the upper montane forest at 1,589 m elevation. As a forest specialist, this species is known to prefer undisturbed or minimally impacted habitats (Heaney et al. 2010; Fidelino et al. 2020), highlighting the species' potential sensitivity to anthropogenic disturbance. The species is currently classified as a 'Least Concern' (LC) species in IUCN Red List of Threatened Species.

***Macroglossus minimus* (É. Geoffroy Saint- Hilaire, 1810)**

The Dagger-toothed Long-nosed Fruit Bat *Macroglossus minimus* has a widespread geographical range that extends from Thailand to Australia. It is widely distributed in the Philippines and inhabits both primary and secondary tropical moist forests, but shows a particular preference for secondary growth, agricultural areas, and other disturbed environments. It has also been reported in woodlands, mangroves, swamp forests, various plantations, and urban habitats, with an elevation range from sea level to approximately 2,250 m (Heaney et al. 1998; Waldien et al. 2021; Dela Torre et al. 2024). It feeds on *Musa* species and other cultivated plants (Relox et al. 2014; Wibowo et al. 2022) which were numerous in the site, particularly in Site 1. This study documented 24 individuals of *Macroglossus minimus* in the lower montane forest and 22 in the upper montane forest. Notably, a substantial proportion of the recorded specimens were adults, comprising 80.43% of the total captures. Of the 46 individuals collected from all sites, 24 were male, and 22 were female. The species is not classified as threatened in the IUCN Red List of Threatened Species.

***Ptenochirus wetmorei* (Taylor 1934)**

The Mindanao Fruit Bat *Ptenochirus wetmorei* is a species endemic to the Mindanao Island. It was previously known to occur in primary and lightly disturbed lowland forests, and absent in montane forests (Heaney et al. 1998). The species was recorded in both lower and montane forests, with the highest elevational record of 1,589 m. This is consistent with previously reported elevation ranges for the species, from as low as 58 m to as high as 1,719 m (Heaney 1986; Achondo et al. 2014; Nuñeza et al. 2015). A notable proportion of the recorded specimens were adults (29 of 34), with a strong female bias (24 of 34). Previously known as *Megaerops wetmorei*, the recent molecular data support a taxonomic transfer of the Mindanao population to the genus *Ptenochirus* (Almeida et al. 2020). The

Image 3. Bat species documented in Mt. Kampalili, Maragusan, Davao de Oro: A—*Ptenochirus minor* | B—*Ptenochirus jagorii* | C—*Cynopterus brachyotis* | D—*Ptenochirus wetmorei* | E—*Haplonycteris fischeri* | F—*Dyacopterus rickarti* | G—*Harpyionycteris whiteheadi* | H—*Eonycteris spelaea* | I—*Macroglossus minimus*. © IJ Yangurin, LD Gamalo, MJM Achondo, & MD Superio.

species is currently classified as 'Vulnerable' (VU) under *Megaerops wetmorei* on the IUCN Red List because of the continued threat of habitat loss from deforestation, particularly in lower dipterocarp forests.

***Ptenochirus jagorii* (Peters, 1861)**

The Greater Musky Fruit Bat *Ptenochirus jagorii* is a Philippine endemic frugivorous bat, found almost all over the archipelago except in Palawan and Batanes regions (Alviola et al. 2021). The species primarily inhabits lowland and is uncommon in montane forests in the Philippines, with an elevation range from sea level up to 1,950 m (Heaney et al. 2010). Along with *C. brachyotis*, this bat was among the most abundant species recorded in the study areas. Individuals were captured from both sampling sites, and the majority were identified as adult females. Notably, approximately 25 individuals were recorded as pregnant, and four were observed with dependent young individuals already attached. According to the IUCN Red List of Threatened Species, *P. jagorii* is currently not classified as a threatened species.

***Ptenochirus minor* Yoshiyuki 1979**

The Lesser Musky Fruit Bat *Ptenochirus minor* is restricted only to the Mindanao Faunal Region, where it inhabits lowland and montane habitats, as well as secondary forests from sea level to 1,600 m (Heaney et al. 2010). This broad elevation range and ecological adaptability show its resilience to varying environmental conditions in forests of different degrees of disturbance (Relox et al. 2014). This species, although occasionally misidentified as *P. jagorii*, can be distinguished by its smaller body size, and distinct adult morphometric characteristics. Of the 20 individuals recorded, 14 were identified as female and all individuals were confirmed to be adults. As expected, the species was recorded within the study sites since previous records indicate its preference towards montane forests (Heaney et al. 2010). The species is currently classified as non-threatened under the IUCN Red List of Threatened Species.

Fruit Bat Diversity

The overall Shannon-Wiener diversity index (H') was 1.71, reflecting a relatively low species diversity due to the low species richness and only a semi-balanced (J = 0.61) distribution of individuals among species. Diversity comparisons between sites showed that Site 2 had slightly higher diversity (H' = 1.79) and evenness (J = 0.75) compared to Site 1 (H' = 1.53; J = 0.70). Site 1 exhibited greater overall fruit bat abundance but showed no statistically significant difference between sites for each fruit bat species (Table 1).

DISCUSSION

This study recorded nine species of fruit bats in Mt. Kampalili, underscoring its status as one of the most species-rich sites within the Eastern Mindanao Biodiversity Corridor (EMBC). This result adds to existing records from other mountains in the EMBC, such as Mt. Hilong-hilong with nine species (Ibañez & Baron 2011) and Mt. Hamiguitan Range with eight species (Amoroso et al. 2019).

The earlier survey of Mt. Kampalili in 2008 reported only five species (Ibañez & Baron 2011). All of these bats were confirmed in the present study, along with four additional species, namely *Cynopterus brachyotis*, *Ptenochirus wetmorei*, *Harpyionycteris whiteheadi*, and *Eoncyteris spelaea*. The increase in species richness may reflect improved sampling effort, as the earlier survey was not able to have extended sampling periods, particularly in the lower elevation sites due to insurgency (Ibañez & Baron 2011). These results highlight the value of repeated biodiversity assessments in underexplored areas and point to the potential presence of additional undocumented taxa in Mt. Kampalili.

When comparing sites, Site 1 showed a greater overall abundance, but not statistically significant different from Site 2 in species abundance. For instance, *Haplonycteris fischeri*, *Macroglossus minimus*, and *Ptenochirus minor* exhibited nearly equal abundances at both sites. These species are typically associated with primary and secondary forests, and are known to tolerate habitat disturbance, especially *M. minimus* (Relox et al. 2014; Fidelino et al. 2020; Waldien et al. 2021). The availability of abundant food resources, such as *Ficus* and *Syzygium* species, which were observed at both sites, may help explain this lack of difference in abundance.

Although some species appeared more frequently in one site than the other (e.g., *Cynopterus brachyotis* and *Ptenochirus jagorii* in Site 1), no statistical differences were found. Their presence in both disturbed and intact habitats reflects their ecological flexibility, since both are known to feed on cultivated fruits and to roost in a variety of habitats, including tree hollows and urban areas (Heaney et al. 2010; Alviola et al. 2021; Dela Torre et al. 2025). In terms of diversity, however, Site 2 (upper montane forest) exhibited slightly higher diversity than Site 1. This pattern may be explained by the greater species richness detected in Site 2, which could still increase with additional sampling effort (see Figure 2). The relatively high dominance of *P. jagorii* and *C. brachyotis* in Site 1 likely contributed to its lower diversity score, despite the general expectation of declining bat diversity with increasing elevation (Heaney 2001; Heaney et al. 2016).

The record of the 'Endangered' *D. rickarti* and the 'Vulnerable' *Ptenochirus wetmorei* adds to the conservation relevance of the mountain ecosystem. Although these species were also detected in degraded areas, these findings likely indicate that remaining forest patches still provide essential resources. However, such observations should not be taken as evidence of long-term species persistence under ongoing disturbance. Forest fragmentation reduces structural complexity and resource availability, directly affecting sensitive bat species (Meyer et al. 2016; Duco et al. 2023). While plantations and agricultural areas may still continue to support bat populations as observed in this study, rare and threatened species, such as *D. rickarti,* might cease to exist (Tanalgo & Hughes 2018). Additional studies are needed to determine whether the presence of these species in degraded habitats reflects short-term foraging or potential adaptability.

These findings emphasize the need for stronger conservation measures in Mt. Kampalili, particularly the protection of the remaining forest patches and the integration of biodiversity safeguards into land-use planning and agricultural expansion (e.g., abaca cultivation, which is more prevalent in Site 1). In 2008, a conservation framework for the EMBC which includes Mt. Kampalili, was developed by Philippine Eagle Foundation, Department of Environment and Natural Resources, and Conservation International-Philippines, suggesting mainly its local legislation as an IP-protected area under ancestral domain certification (Philippine Eagle Foundation, Conservation International-Philippines, Department of Environment and Natural Resources, 2008). Building on the bat conservation framework proposed by Tanalgo & Hughes (2018), conservation priorities in the area should include (1) securing legal protection of the mountain under the National

Integrated Protected Areas Management (NIPAS) Act, (2) restoring degraded habitats and maintaining structurally complex forests, and (3) establishing long-term biodiversity monitoring to track changes in bat assemblages. Moreover, continuous information and educational campaigns (IECs) with stakeholders should be done for the overall biodiversity conservation of the habitat and to highlight the importance of bats in the area. As suggested by PEF-CI and DENR, an IEC core group can be formed and trained for the implementation of these IECs for community-based conservation activities (Philippine Eagle Foundation, Conservation International-Philippines, Department of Environment and Natural Resources, 2008).

Some limitations, however, should be considered when interpreting the results. Net placement and the number of net nights were constrained by logistical challenges, particularly the unpredictable weather in Mt. Kampalili. While richness estimates may help account for this limitation, the findings still indicate that additional sampling would likely document more species, particularly in Site 2 (Figure 2). Even so, the conclusion that Site 2 has higher species richness than Site 1 remains valid. With this result, further studies are recommended to complete the bat inventory of Mt. Kampalili, particularly in other habitat types (e.g., dipterocarp forest), and other locations in the mountain (e.g., Davao Oriental side) which were not part of the current and previous (Ibañez & Baron 2011) studies in Mt. Kampalili. Another limitation is the absence of analyses on the potential drivers of the observed patterns (e.g., higher richness in Site 2). Studies on food source availability and habitat preferences in the site are highly recommended for future studies as it is hypothesized that they might be important factors that affect bat composition. Despite these constraints, the study provides valuable information on the bat assemblages of Mt. Kampalili which warrants additional protection due to the presence of endemic and threatened species, and contributes to the broader understanding of bat diversity in Mindanao, especially on the new geographical records of bat species observed in this study.

CONCLUSIONS

This study provides updated data on the fruit bat assemblage of Mt. Kampalili in Davao de Oro, the Philippines. A total of nine species were recorded, including threatened Philippine (e.g. *Dyacopterus rickarti*) and Mindanao (e.g. *Ptenochirus wetmorei*) endemics. The presence of these species highlights the ecological importance of Mt. Kampalili and the Eastern Mindanao Biodiversity Corridor (EMBC), underscoring its role in sustaining endemic and threatened bat populations. The study also revealed the dominance of disturbance-tolerant generalists such as *Cynopterus brachyotis* and *Ptenochirus jagori*, which were more abundant in the lower montane forest. This dominance may have contributed to the lower diversity observed at that site, in contrast to the higher diversity found in the upper montane area.

This study further emphasizes Mt. Kampalili's ecological significance, and thus needs stronger protection of its forest ecosystem of both lower and higher elevations. Such protection would enable stricter regulation of land use and help prevent further habitat degradation.

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Appendix Table. Summary of the demography of bats recorded in this study.

Species	Common name	Number of individuals captured	Male to female ratio	Number of adults
Cynopterus brachyotis (Müller, 1838)	Lesser Dog-faced Fruit Bat	117	49:68	91
Dyacopterus rickarti Helgen, Kock, Gomez, Ingle & Sinaga, 2007	Philippine Large-headed Fruit Bat	5	2:3	5
Eonycteris spelaea (Dobson, 1871)	Dawn Bat	1	0:1	1
Haplonycteris fischeri Lawrence, 1939	Philippine Pygmy Fruit Bat	83	31:52	64
Harpyionycteris whiteheadi Thomas, 1896	Harpy Fruit Bat	1	0:1	1
Macroglossus minimus (É. Geoffroy Saint-Hilaire, 1810)	Dagger-toothed Long-nosed Fruit Bat	46	22:24	37
Ptenochirus wetmorei (Taylor, 1934)	Mindanao Fruit Bat	34	10:24	29
Ptenochirus jagorii (Peters, 1861)	Greater Musky Fruit Bat	116	50:66	109
Ptenochirus minor Yoshiyuki, 1979	Lesser Musky Fruit Bat	20	6:14	20

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