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AMPHIBIANS AND REPTILES IN A KARST LANDSCAPE: FIRST RECORD OF HERPETOFAUNA DIVERSITY ON A SMALL ISLAND IN SOUTHERN PHILIPPINES

Maxine Prado-de Vega[a,c], Anna Pauline O. de Guia[b,c], Phillip A. Alviola[b,c], M. Niña Regina M. Quibod[c,d*]

[a]The Marine Science Institute, University of the Philippines, Diliman, Quezon City 1101, Philippines;
[b]Animal Biology Division, Institute of Biological Sciences, College of Arts and Sciences, University of the Philippines Los Baños, Laguna, 4031, Philippines;
[c]Museum of Natural History, University of the Philippines Los Baños, Los Baños, Laguna, 4031, Philippines;
[d]Center for Integrative Conservation & Yunnan Key Laboratory for Conservation of Tropical Rainforests and Asian Elephants, Xishuangbanna Tropical Botanical Garden, Menglun, Mengla, Yunnan 666303, China

*Corresponding author. E-mail: mquibod@gmail.com

Maxine Prado-de Vega: https://orcid.org/0009-0000-7388-9937
Anna Pauline O. de Guia: https://orcid.org/0000-0001-7475-9800
Phillip A. Alviola: https://orcid.org/0000-0001-5302-9825
Ma. Niña Regina M. Quibod: https://orcid.org/0000-0003-3552-2135

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Abstract. The herpetofauna of southern Philippines, especially Davao Region, though remarkable, remains the least studied, most especially in karst ecosystems like caves and subterranean habitats. To address this gap, we conducted the first herpetological survey of Samal Island, a small karst island in the Davao Region, and the first survey of any karst ecosystem in the area. Opportunistic sampling was carried out in 30 caves on the island, 17 of which yielded herpetofauna records either inside the cave or in its immediate vicinity. We documented 24 species (eight amphibians and 16 reptiles), including two potentially new species: *Platymantis* sp. and *Cyrtodactylus* sp. Of the 22 identified species, three are new records for Davao Region (*Kaloula picta*, *Brachymeles pathfinderi*, and *Bronchocela* cf. *cristatella*). Our survey recorded seven Mindanao endemics, five Philippine endemics, and ten native or non-endemic species. The discovery of potential new species, new island records, and expanded distribution records highlights the urgent need for comprehensive herpetofaunal surveys in the southern Philippines, particularly in overlooked habitats such as caves and karst landscapes, which serve as critical refugia for karst-associated species.

INTRODUCTION

The herpetofauna of the Philippines is unprecedented, with 114 native amphibian species, of which 85% are endemic (IUCN 2025), and 356 reptiles, of which 72% are endemic (IUCN 2025), making the Philippines worthy to be considered a global centre of herpetological diversity (Brown et al. 2013; Diesmos et al. 2015; Meneses et al. 2024). These numbers are still expected to rise with increasing efforts on biodiversity inventories, discoveries of new species by using both traditional and novel techniques (e.g., molecular analyses), rediscoveries of 'lost' species, and further taxonomic reclassifications at both ecological and molecular levels (Sanguila et al. 2016; Diesmos et al. 2020).

Mindanao Island, although the second largest among the three major islands in the Philippines, has been much less studied in terms of herpetofauna composition compared to the two other major islands (i.e., Luzon and Visayas), which may be attributed to existing socio-political conflicts, local bureaucracies, and logistic difficulties (Abdullah et al. 2023; Hilario-Husain et al. 2024). Despite these drawbacks, the herpetofauna of Mindanao Island is considered by many herpetologists to be zoologically remarkable (Brown et al. 2013; Diesmos et al. 2015; Sanguila et al. 2016). Herpetological surveys in Mindanao began as early as the 1910s (Taylor 1915, 1918, 1920, 1921, 1922), with significant growth in herpetological research over the past two decades (Brown et al. 2001; Meneses et al. 2024). However, research data from the southern part of Mindanao remain scanty as relatively fewer areas have been surveyed in this region (Abdullah et al. 2023; Meneses et al. 2024). Thus, the known herpetofauna composition on Mindanao Island

is likely underestimated. The MOBIOS+ database (Mindanao Open Biodiversity Information) currently lists only 35 published studies on the herpetofauna of Mindanao faunal region from 2000–2022 (Abdullah et al. 2023; Tanalgo et al. 2023), focused on watersheds, forest fragments, green spaces, disturbed landscapes, and protected forests and national parks.

Located in the southernmost region of Mindanao Island, Davao Region, the Mount Hamiguitan Range Wildlife Sanctuary has by far the most published records of herpetofauna composition in Mindanao faunal region (Abdullah et al. 2023). This UNESCO World Heritage Site and National Park is a mountain range characterized by forest over ultramafic rocks and having about 90 species of amphibians and reptiles recorded, of which 60% are endemics (Delima et al. 2007; Relox et al. 2011; Supsup et al. 2017; Medina et al. 2020; Rosales et al. 2023). There are also herpetological surveys in the secondary forests and forest edges of Davao Region (Dacalus et al. 2017; Delima-Baron et al. 2019), watersheds (Ibañez et al. 2012; Tagoon et al. 2022), and synanthropic environments like local parks, university campus gardens, and urban green spaces (Jabon et al. 2019; Gersava et al. 2020; Delima-Baron et al. 2022; Gamalo et al. 2023, 2024). Despite Davao Region's suitability and potential habitats for karst-obligate and karst-associated species (Linkem et al. 2010; Siler et al. 2010; Brown et al. 2015), very limited herpetological surveys have been conducted in karst ecosystems like caves and subterranean habitats in this region and in the Mindanao faunal region for the most part. To date, there are only three published papers on cave herpetofaunal diversity in Mindanao Island (Belleza and Nuñeza 2014; Nuñeza et al. 2015; Obeña et al. 2021).

Karst ecosystems like caves and subterranean habitats offer refuge and foraging grounds for amphibians and reptiles. They are most likely visitors seeking temporary shelter and food. The crevices are important microhabitats, and the cave floor and walls often provide abundant food resources such as crickets, spiders, cockroaches, and other invertebrates. The findings of dos Santos et al. (2022) reported that amphibian use of caves was influenced by habit and developmental mode. Terrestrial species with direct development were likely to use caves. For reptiles, habit and foraging strategy influenced cave use. Terrestrial and semiaquatic ambush predators were likely to use caves.

Many amphibians and reptiles in the Philippines are found within a narrow range of distribution; karst-obligates and island endemics receive higher threats than any other wildlife groups (Siler et al. 2010; Brown et al. 2015; Abdullah et al. 2023). Karst landscapes, specifically caves, provide vital habitats for some herpetofauna species that utilize them either exclusively or at least in part of their life history. Hence, continuous and comprehensive surveys and inventories of herpetofauna in the islands within the archipelago are of much importance to fill in the gaps of our knowledge on the amphibian and reptile assemblages of the country, as well as to be able to address conservation urgencies at hand.

Samal Island and the adjacent Talikud Island, politically referred to as Island Garden City of Samal (IGaCoS), has at least 70 caves within a 30,130 hectare land area (IGaCoS-LGU 2025), highlighting its importance as a niche terrestrial habitat, especially to karst-obligate species. Our study provides initial herpetofauna records in the karst landscape of Samal Island, supplementing the gaps in the herpetological diversity of Mindanao Island, especially the Davao Region.

MATERIAL AND METHODS

In this study, we use the term "Samal Island" to refer to both the mainland Samal Island and the adjacent Talikud Island, for convenience. Samal Island is a small island within the political boundaries of Davao del Norte province and is surrounded by Davao Gulf on all sides. The island has two declared Marine Protected Areas (i.e., Aundanao and Coral Garden) (Nañola et al. 2013), thus scientific studies on the island focus mainly on marine rather than terrestrial ecosystems, especially karst ecosystems like caves. Previous studies have been conducted on the island, particularly on the diversity of terrestrial invertebrates (Medina et al. 2015; Lucañas et al. 2022) and vertebrate mammals (i.e., bats) (Carpenter et al. 2014; Quibod et al. 2019), but by far no published records of herpetological collections.

The herpetofauna survey was carried out from 1–31 May 2012. A total of 30 caves throughout Samal Island were surveyed, of which 17 had herpetofauna inside (Figure 1). Other habitat types of the caves' immediate vicinities and those encountered on the way to the caves such as residential and agricultural areas, secondary growth forest, and riverine habitats were also included in this study when herpetofauna was observed (Supplementary Table S1, Figure 2). Additionally, herpetofauna encountered and/or observed in the vicinity of the established basecamps, near the cave study sites, were also noted and included in the records. Every cave was thoroughly surveyed for herpetofauna along its full length, from the cave entrance to its opposite end, which included inspection of microhabitats such as cave crevices, cave substrates, and rock formations. Herpetofauna encountered during the cave surveys was recorded, captured, and preserved subsequently. Each cave was surveyed only once during the entire duration of the study.

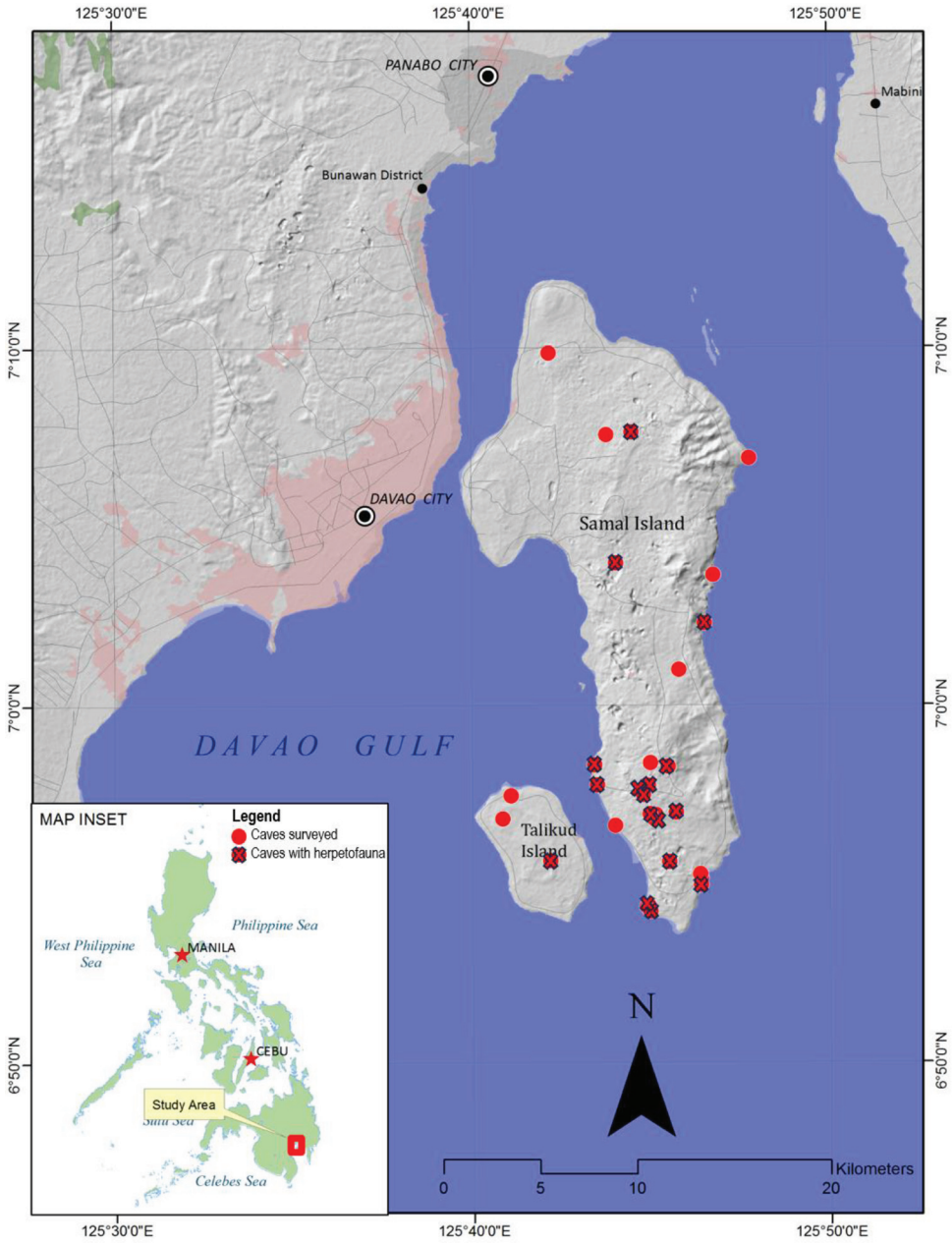

Figure 1. Caves surveyed in Samal Island, Davao del Norte (Mindanao Island), Philippines (n = 30), showing the caves where herpetofauna species were recorded (n = 17).

Morphometric parameters, namely body weight, snout-vent length, and tail length, whichever applicable, were taken prior to preservation. Other morphometric measurements were also taken from the preserved specimens afterwards. Identities of herpetofauna were determined on-site using field guides by Alcala and Brown (1998). Further verification of all specimens was made by A.C. Diesmos (ACD) and R.M. Brown (RMB). All collected voucher specimens were catalogued and deposited in the University of the Philippines Los Baños – Museum of Natural History (UPLB-MNH) (Supplementary Table S3).

We conducted a straightforward species accumulation curve analysis in R (v.4.4.1) using the iNEXT package (Hsieh et al. 2016), employing incidence (presence-absence) data for herpetofauna species recorded across 17 sampling sites in Samal Island. The resulting curve provided a basis for assessing whether expanding the number of sampling sites would likely yield additional species.

RESULTS AND DISCUSSION

A total of 24 species **(**Table 1, Figure 3**)** were recorded on Samal Island, two of which are potentially new species (*Platymantis* sp. and *Cyrtodactylus* sp.) (Figure 4; personal and direct specimen examination by ACD and

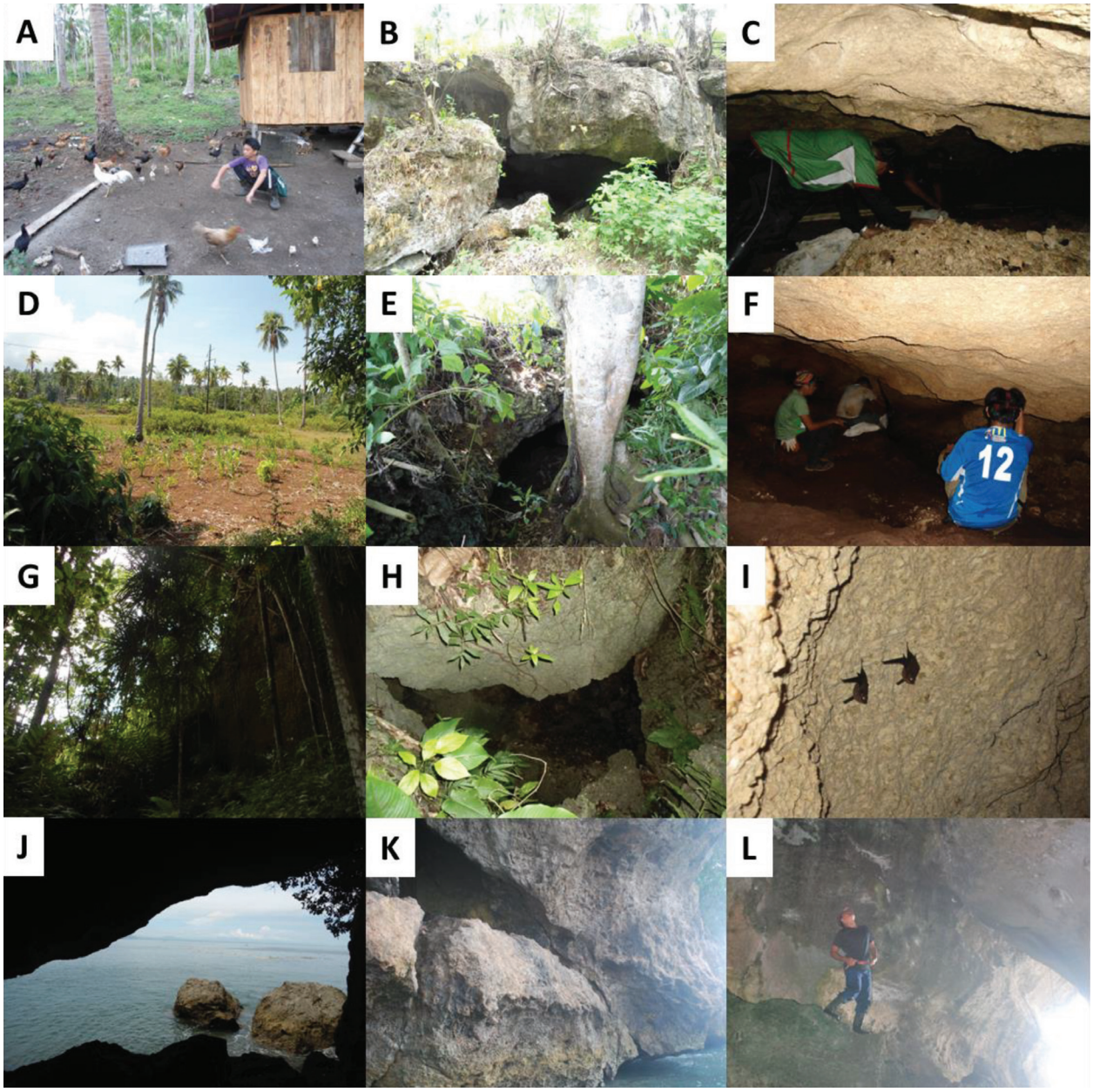

Figure 2. Characteristics of caves sampled in Samal Island, Davao del Norte (Mindanao Island), Philippines. A–C: Baga Cave (A: residential outside the cave, B: cave entrance, C: inner section of the cave); D–F: Cacao Cave (D: agricultural area outside the cave, E: cave entrance, F: inner section of the cave); G–I: Lasang 2 Cave (G: secondary forest outside the cave, H: cave entrance, I: inner section of the cave); J–L: Matanos 1 Cave (J: view from inside of the cave overlooking the sea, K: entrance of the cave from afar, L: inner section of the cave).

RMB). *Cyrtodacylus* sp. was suspected to be a new species based on its distinctly large body size relative to other Mindanao congeners *C. annulatus* and *C. agusanensis* (Welton et al. 2010), and prominently protruding dorsal tubercles (Welton et al. 2010). Additionally, its cave-dwelling habit was also noteworthy. Similarly, the suspected novel species *Platymantis* sp. was based on its relatively smaller size for an adult individual compared to other *Platymantis* species recorded in Mindanao faunal region, namely *P. corrugatus, P. guentheri,* and *P. rabori* (Sanguila et al. 2016). In addition, among the other possible new species of *Platymantis* listed by Sanguila et al. (2016), this is the only species found on karst-associated areas, on secondary forests outside caves. Further surveys and detailed taxonomic investigations need to be conducted to ascertain their identities and confirm their novelty.

Our findings showed that all herpetofauna species recorded in this study are new records for the island and the first record of herpetofauna in a karst landscape in Davao Region. To our knowledge, no herpetofauna records have been published for Samal Island and any karst habitats in Davao Region (see Supplementary Table S2A, B). Of the 22 described species, three are

Table 1. Individual counts of herpetofauna species from the caves and their vicinity in Samal Island, Davao del Norte (Mindanao), Philippines.

Herpetofauna species	Habitat						Total number of individuals per species recorded
	Cave		Cave vicinity				
	Inside	Cave entrance	Residential area	Agricultural area	Secondary forest	Riverine	
Amphibians							
(1) *Pulchrana (Hylarana) grandocula*	14	–	–	–	1	3	18
(2) *Limnonectes leytensis*	–	–	–	–	–	15	15
(3) *Kalophrynus pleurostigma*	4	–	4	–	–	–	8
(4) *Kaloula conjuncta*	–	–	6	–	–	2	8
(5) *Platymantis* sp.	–	–	–	–	6	–	6
(6) *Polypedates leucomystax*	–	–	4	–	–	–	4
(7) *Kaloula picta*	–	–	–	–	–	3	3
(8) *Limnonectes magnus*	1	–	–	–	–	1	2
Reptiles							
(9) *Cyrtodactylus* sp.	16	–	–	–	1	–	17
(10) *Brachymeles pathfinderi*	–	13	–	2	–	–	15
(11) *Sphenomorphus fasciatus*	2	7	–	2	–	–	11
(12) *Draco cyanopterus*	–	1	1	4	–	–	6
(13) *Cyrtodactylus annulatus*	1	–	–	–	2	–	3
(14) *Bronchocoela* cf. *cristatella*	–	–	–	–	2	–	2
(15) *Ahaetulla prasina*	–	–	–	–	–	1	1
(16) *Aplopeltura boa*	–	–	–	–	1	–	1
(17) *Coelognathus erythrurus*	1	–	–	–	–	–	1
(18) *Dendrelaphis marenae*	–	–	–	–	1	–	1
(19) *Gehyra mutilata*	–	–	1	–	–	–	1
(20) *Hemidactylus platyurus*	–	–	1	–	–	–	1
(21) *Naja samarensis*	–	–	1	–	–	–	1
(22) *Oxyrhabdium leporinum*	–	1	–	–	–	–	1
(23) *Pinoyscincus coxi*	–	–	–	–	1	–	1
(24) *Sphenomorphus variegatus*	–	1	–	–	–	–	1
Total	**39**	**23**	**18**	**8**	**15**	**25**	**128**

new records for the Davao Region (*Kaloula picta, Brachymeles pathfinderi,* and *Bronchocela* cf. *cristatella*), adding to the limited information available on the herpetofauna of the region and Mindanao Island. New distribution records extend the geographical range in which these species were previously known to exist, which is particularly relevant to the archipelagic context of the Philippines. Welton et al. (2010) have pointed out the need for more surveys in Mindanao Island to understand species diversity of *Cyrtodactylus* species, although this statement is also applicable to other herpetofauna species. These results highlight the importance of karst landscapes as a habitat to herpetofauna species, a habitat often understudied (Meneses et al. 2024). The species accumulation curve generated from incidence data across the 17 sampling sites suggests that additional surveys and further sampling efforts could result in the detection of more herpetofauna species in Samal Island (Figure 5).

Our study recorded herpetofauna species that were previously documented inside the caves in the Philippines: *Pulchrana (Hylarana) grandocula, Limnonectes magnus, Kalophrynus pleurostigma, Coelognathus erythrurus, Cyrtodactylus annulatus,* and *Sphenomorphus fasciatus* (Nuñeza et al. 2015; Sanguila et al. 2016; Dela Cruz et al. 2018). In addition to these identified species, a potentially new *Cyrtodactylus* sp. is likely to be a karst-obligate species, with 16 out of 17 individuals captured inside the caves and a single individual captured in a secondary forest in the immediate cave vicinity. Additionally, this species also had a relatively high capture rate among the other herpetofauna species (41% of the total capture inside the cave; see Table 1). This is highly plausible given that studies have already validated the critical importance of karst ecosystems in maintaining *Cyrtodactylus* diversity and functioning as centres of speciation (Grismer et al. 2020, 2021). The karst-obligate habit of this particular *Cyrtodactylus* sp. underscores the need for active protection of cave habitats and likely less vulnerability to threats of deforestation.

Of the 22 described species recorded by our survey in

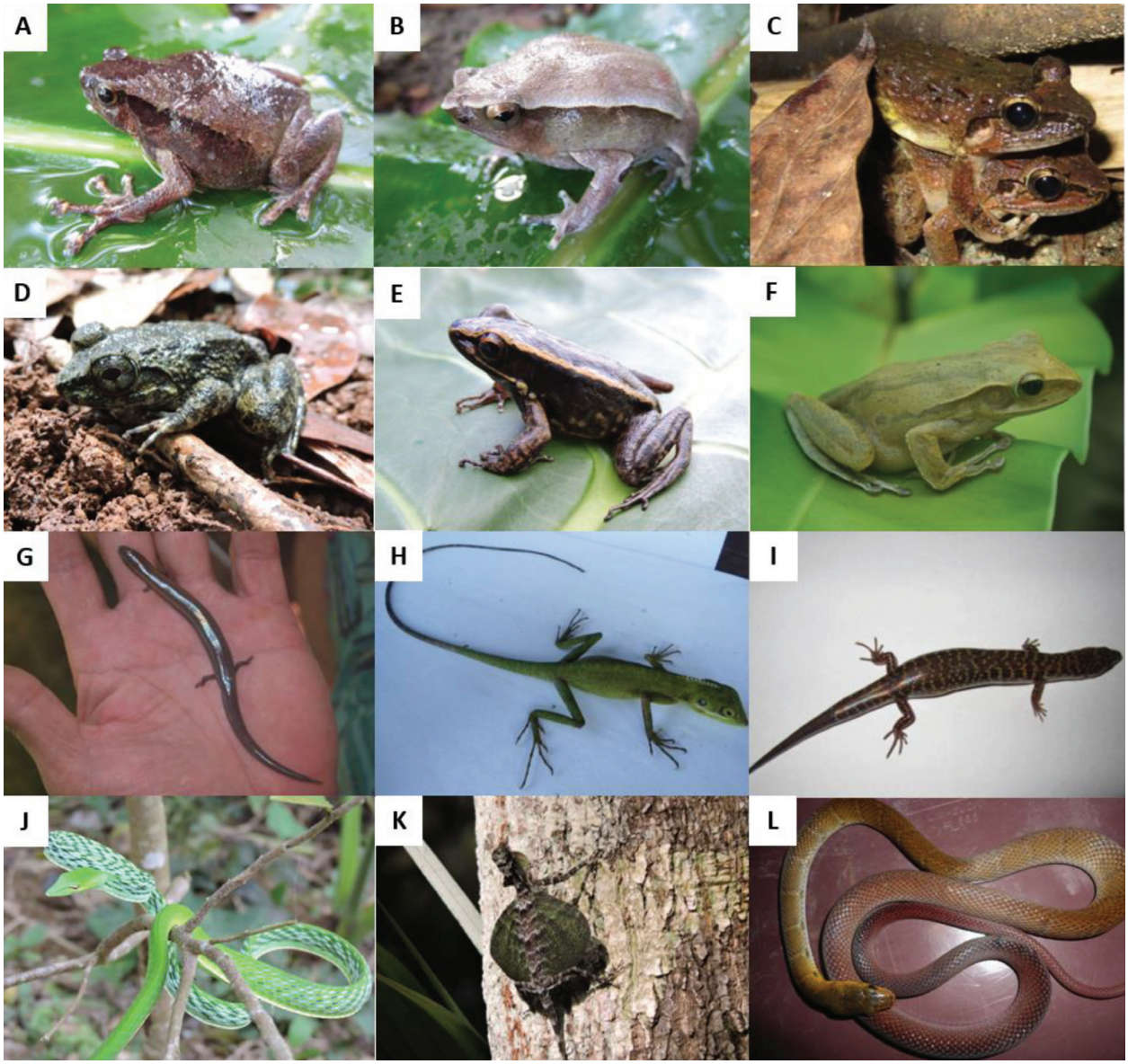

Figure 3. Selected herpetofauna species from the caves and their vicinities in Samal Island, Davao del Norte (Mindanao Island), Philippines. A. *Kaloula conjuncta*; B. *Kalophrynus pleurostigma*; C. *Limnonectes leytensis*; D. *Limnonectes magnus*; E. *Pulchrana (Hylarana) grandocula*; F. *Polypedates leucomystax*; G. *Brachymeles pathfinderi*; H. *Bronchocoela* cf. *cristatella*; I. *Sphenomorphus fasciatus*; J. *Ahaetulla prasina*; K. *Draco cyanopterus*; L. *Coelognathus erythrurus*.

Samal Island, 32% are endemic to Mindanao Island, 23% are Philippine endemic, while the rest (45%) are native and non-endemic species. It should be noted that although *Platymantis* sp. and *Cyrtodactylus* sp. are yet to be described, they have a huge potential to be Mindanao Island endemics (*pers. comm.* ACD and RMB). Among all the species observed, only *Limnonectes magnus* is classified as Near Threatened, while the majority of the herpetofauna are categorized as Least Concern (IUCN 2025). None of the herpetofauna recorded are categorized as Threatened under the National Red List (DENR 2019) (see Supplementary Table S2 for more information on each species).

The herpetofaunal species recorded in this study reflect the lack of previous surveys on small islands within Mindanao Island. The straightforward species accumulation curve shows that expanding sampling sites would likely reveal additional herpetofauna species. Our findings underscore the need for more intensive and comprehensive herpetological surveys across Mindanao Island, particularly in understudied areas such as the Davao Region and overlooked karst landscapes like caves and other subterranean habitats. Documenting the previously unrecorded herpetofauna of Samal Island highlights the potential of small islands to support rich and diverse herpetofaunal communities. Furthermore, this study demonstrated the value of cave habitats to a variety of herpetofaunal assemblage, providing impetus for further research and exploration in the Davao Region and Mindanao Island as a whole.

Figure 4. Potential new species of herpetofauna in Samal Island, Davao del Norte (Mindanao Island), Philippines. A: *Platymantis* sp. (adult male; average snout-to-vent length = 23.52 cm; average body weight (live) = 1.5 g); B: *Cyrtodactylus* sp. (adult male; average snout-to-vent length = 122.50 cm; average body weight (live) = 28.93 g).

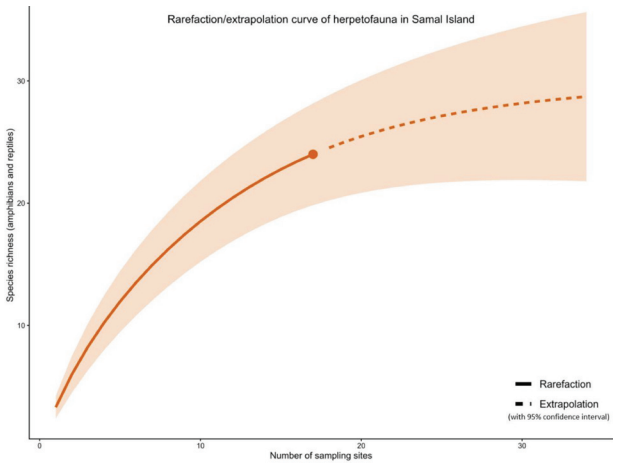

Figure 5. Rarefaction (solid line segment) and extrapolation (dotted line segment) sampling curve with 95% confidence interval (shaded area) of herpetofauna species in caves and its vicinities in Samal Island, Davao del Norte (Mindanao Island), Philippines, based on species richness (presence/absence) data.

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Conflicts of interest

The authors declare no conflicts of interest.

Data availability

The data used in this article are available in the supplementary material available at Zoology and Ecology online.

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SUPPLEMENTARY MATERIALS