REPTILES & AMPHIBIANS

# Richness and Distribution of Reptiles and Amphibians in the Tropical Lowland Habitats of Mt. Agad-Agad, Iligan City, Southern Philippines

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**Abstract**

Knowledge of Philippine herpetofauna is progressively increasing. However, there are still areas in the country that are poorly understood and remain unexplored, particularly in the southern Philippines. Mt. Agad-Agad in Iligan City (Lanao del Norte Province) is a secondary lowland evergreen tropical rainforest in the southern portion of the northern Mindanao region, popular with the general public and a biologically important mountain ecosystem. Herein, we present the species richness and distribution of herpetofauna using standardized sampling methods. We documented 37 species of amphibians and reptiles, recording 20 Philippine-endemic species, three exotic anurans, two threatened reptiles, and one unidentified species of lizard. Species richness was higher in a mixed agricultural area (18 species, n = 108 individuals) compared to secondary growth forest (17 species, n = 86 individuals). This research provides baseline information on the herpetofauna from Mt. Agad-Agad, and additional herpetological knowledge on the distribution and ecology of amphibians and reptiles from the northern Mindanao region.

Empirical field-based information plays a vital role in studying biodiversity. Species richness is the main component in community ecology (Longino et al. 2002; Magurran 2004; Gatti et al. 2018), revealing the assemblage of a particular taxonomic group across habitat types. In the case of the Philippines, only a small number of ecological studies on species composition, richness, diversity, and distribution across macrohabitats, particularly on amphibians and reptiles (Relox et al. 2011; Causaren 2016; Supsup et al. 2020; Clores et al. 2021; Pitogo et al. 2021b), are available.

With the immense pressure of global climate change (Bickford et al. 2010; Sodhi and Erlich 2010), unprecedented levels of habitat loss due to deforestation, over-extraction of natural resources and habitat modification (Clements et al. 2006), rapid population growth, and several anthropogenic pressures (Mallari et al. 2001; Ong et al. 2002), populations of amphibians and reptiles are at risk.

Mindanao Island is the second largest landmass in the Philippines and one of the biogeographically significant islands due to its complex geological history, diverse topography, its proximity to highly diverse mainland Borneo (Brown and Alcala 1970; Brown and Diesmos 2002; Diesmos et al. 2002; Brown et al. 2013), wide array of macro- and microhabitats, high elevation mountains, and lowland environments that support a high concentration of native and endemic species of amphibians and reptiles (Nuñeza et al. 2010; Beukema 2011; Relox et al. 2011; Plaza and Sanguila 2015; Sanguila et al. 2016, 2021; Supsup et al. 2017; Pitogo et al. 2021a). However, many provinces and lowland mountain ecosystems on this island remain undocumented and under-studied for herpetofauna — particularly Mt. Agad-Agad in the province of Lanao del Norte.

Mt. Agad-Agad is one of the remaining lowland habitat frontiers proposed as a protected area in the Philippine national congress and adjoins the large metropolitan area of Iligan City. It is located 69.7 km west of Mt. Malindang, 65.3 km east of Mt. Kalatungan, and 35.6 km south of Lake Lanao, which are all renowned areas of high biodiversity conservation impor-





Reptiles & Amphibians ISSN 2332-4961
https://doi.org/10.17161/randa.v29i1.18130

tance. This massif is also 16 km away from Maria Cristina Falls, well-known as a source of hydroelectric power that supplies electricity (> 60%) to the entire Mindanao Island. Mt. Agad-Agad is mainly composed of limestone karst aggregate with patches of semi-ultramafic soil forming a steep, rugged hilly terrain, and lowland ridges creating a spine reaching up to 520 m above sea level (asl), with river systems encompassing Sitio Langinlanon, Lumbatin, Mibolo, Pindugangan, Ulas of Barangays Pugaan, Tipanoy, and Ubaldo Laya. The mountain contains a relatively large patch of secondary growth forest and mixed agroforest plantation that harbors a diverse assemblage of terrestrial fauna and flora (Coritico et al. 2020; Mohagan et al. 2020; Mohagan et al. 2022).

In this work, we provide comprehensive information on the richness and distribution of amphibian and reptilian fauna on Mt. Agad-Agad, which we hope generates practical conservation initiatives, and policy recommendations for the protection of this ecologically important area.

## Methods

*Study area*.—This study was conducted on Mt. Agad-Agad, which is situated in the southwestern part of northern Mindanao Island, in an area covering approximately 50 hectares that includes barangays (administrative districts) Pugaan, Tipanoy, and Ubaldo Laya of Iligan City (Fig. 1; 8.209128°N, 124.271433°E; elevation 416 m asl). This mountain is characterized by ultramafic soil and aggregates of limestone karst outcrops, and consists of mixed agricultural areas, human-made plantations, and fragments of secondary forest. Vegetation in mixed agricultural areas includes non-endemic and exotic tree species of *Acacia mangium* Willd, *Cocos nucifera* L., *Gmelina arborea* Roxb., *Leucaena leucocephala* (Lam.), *Swietenia macrophylla* King, and secondary growth forest with indigenous tree species *Artocarpus blancoi* (Elmer) Merr., *Dillenia philippinensis* Rolfe, *Ficus balete* Merr, *Koordersiodenron pinnatum* (Blanco) Merr., *Pterocarpus indicus*, *Shorea* spp., and *Vitex parviflora* Juss (Coritico et al.

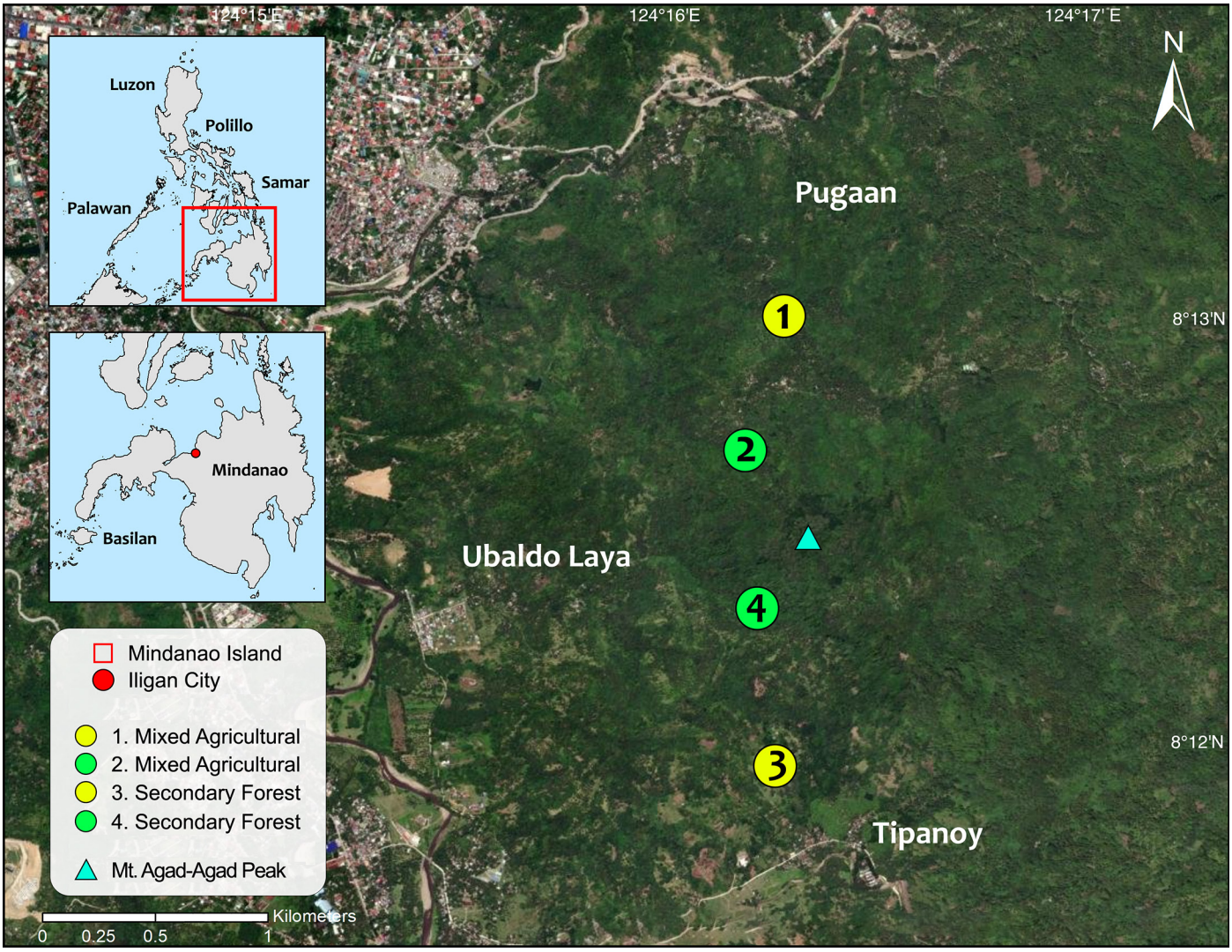


**Fig. 1.** Map of Mt. Agad-Agad in relation to the Philippines Archipelago and Mindanao Island (inset maps). Colored dots correspond to the different habitat types (MAA: yellow; SGF: green) sampled during our fieldwork, and the blue triangle represents the highest peak (520 m asl) of Mt. Agad-Agad.

2020). Its unique landscape towering above the entire Iligan City provides aesthetic and recreational value to the general public. The annual mean temperature in the city ranges from 21.7–32.2 °C and annual mean precipitation is ~ 193.1 mm (Weather Spark 2020).

We conducted two field surveys during 21–29 February and 25 November – 04 December 2020, during the wet season, at two different sampling areas: Pugaan (~ 23 ha.) and Tipanoy (~ 25 ha.); approximately 1.5 km apart (Fig. 2). In each sampling area, we sampled two habitat types in a nine-day sampling period: (1) Mixed agricultural area (MAA: Sites 1 and 3) is mainly composed of coconut plantations, shrubs, non-native plants, and ferns, while vegetation on (2) Secondary growth forest (SGF: Sites 2 and 4) is primarily dominated by ferns and lycophytes, undergrowth foliage, decaying logs, and secondary dipterocarps. Geographical

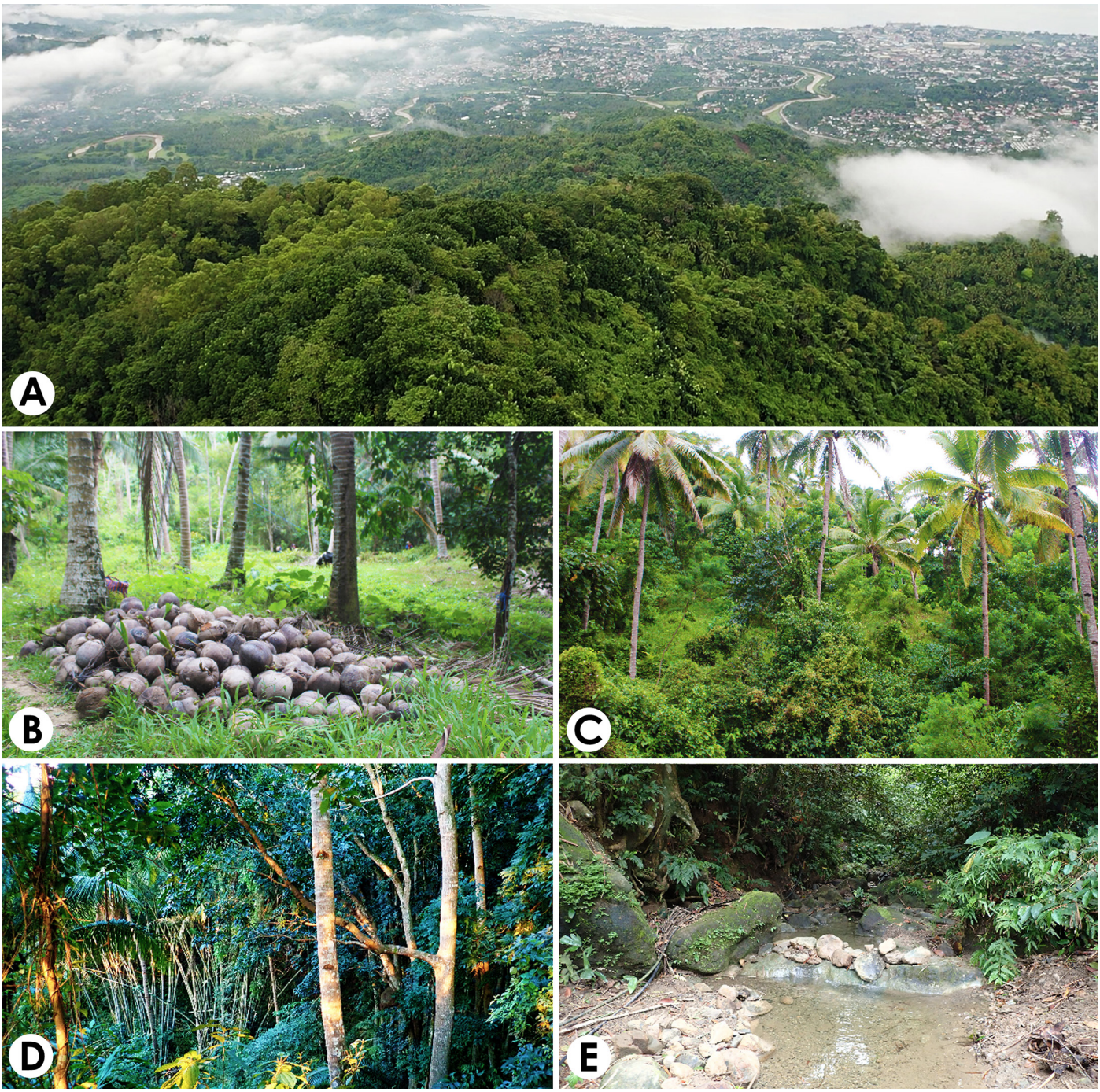


**Fig. 2.** Habitats assessed and sampled on Mt. Agad-Agad, northern Mindanao. (A) Aerial view of secondary-growth habitat at 520 m elevation, towering above Iligan City; (B) and (C) mixed agroforest habitat; (D) and (E) secondary-growth forest and streams. Photographs by Erl Pfian T. Maglangit and Romeo R. Patano Jr.

**Table 1.** Sampling sites on Mt. Agad-Agad, Iligan City, Mindanao Island.

| Site # | Locality | Coordinates | Elevation (m) | Habitat Types | Date Surveyed |
|---|---|---|---|---|---|
| 1 | Langinlanon | 8.221406 N 124.268558 E | 45–110 | MAA | 21–24 February 2020 |
| 2 | Langinlanon | 8.209903 N 124.271636 E | 400–451 | SGF | 25–29 February 2020 |
| 3 | Pindugangan | 8.201069 N 124.271467 E | 79–160 | MAA | 25–30 November 2020 |
| 4 | Pindugangan | 8.2067 N 124.267378 E | 169–203 | SGF | 01–04 December 2020 |

affinities, elevation, habitat types, and the sampling period (date and month) of the two sampling locations are summarized in Table 1.

*Herpetological sampling*.—Amphibians and reptiles were sought in all possible macro- and micro-environments by placing a standardized 100 m by 10 m strip transect (Heyer et al. 1994; Supsup et al. 2016) in two habitat types (i.e., mixed agricultural area, secondary growth forest). Sampling stations in each transect were employed 10 m apart, marked with a number in fluorescent ribbons (Supsup et al. 2020), and surveyed around 0730–1130 h during the day and 1830–2330 h at night by five to six individuals. Surveys were carried out through opportunistic catching by hand within the proximity of the pre-identified trails, trapping along the transect (e.g., pitfalls, adhesive tapes) and by carefully examining several microhabitats, e.g., fallen and decomposing logs, leaf litter, temporary and permanent bodies of water (Venturina et al. 2020), a pile of coconut husk, underneath rocks and boulders, tributary and riparian areas, and on understory tree branches up to ~ 3 m above the ground. General collection and listing outside the strip transect were also made through general random sampling following the same pattern of surveying amphibians and reptiles.

*Preservation of specimens*.—We photographed representative specimens of each species collected, measured morphological characters (e.g., snout-vent-length, bodyweight; Appendix A) using electronic digital calipers and a weight scale (± 0.1 g), fixed specimens using a 10% buffered formalin solution, and stored them in 70% ethanol solution following the standard preservation protocol developed by Heyer et al. (1994) and Simmons (2002). Identification was done using published literature for herpetofauna (Taylor 1920; Inger 1954; Diesmos et al. 2015; Taylor 1922a, b; Leviton et al. 2018; Weinell et al. 2020). We followed the nomenclature and taxonomic arrangements by Frost (2021) for amphibians and Uetz et al. (2021) for reptiles.

*Specimen Repository*.—The collected voucher specimens were deposited in the herpetological collection of Central Mindanao University – Zoological Museum following the museum collection code (CMU-MZ). Captured images of the uncollected specimens were also deposited at the digital archive of Lee Kong Chian Natural History Museum supplemented with a zoological reference collection code [ZRC(IMG)] for each photographic specimen. Conservation status of each species was assessed based on the Red List of Threatened Species by the International Union for the Conservation of Nature (IUCN 2021) and the Department of Environment and Natural Resources Administrative Order: DENR-DAO: No 2019-09.

*Data analysis*.—We evaluated the efficiency of our sampling effort by analyzing the abundance data of amphibians and reptiles in six transects (three 100 m by 10 m transects per habitat type) established in both habitats. We established and constructed a rarefaction curve based on Hill numbers ($q$ = 0, Chao1; Chao et al. 2014) to compare species richness between the two habitat types sampled with small sample sizes. The interpolated and extrapolated tendencies were computed using the *iNEXT* package (Hsieh et al. 2016) with a 95% confidence interval and plotted using the *ggplot2* package developed by Wickham (2016). Species diversity in two habitat types was calculated using the *vegan* package (*diversity* function; index = "Shannon"; Fisher et al. 1943; Hurlbert 1971; Oksanen 2013). Species recorded through general random sampling were not included in the data analysis. All analyses were performed using R Studio version 3.6.1 developed by R Core Team (2019).

## Results

*Species composition*.—Our survey resulted in documenting 37 species of amphibians and reptiles within our sampling transects on Mt. Agad-Agad, including 10 species of frogs (six endemic) in nine genera and seven families, 14 species of lizards (eight endemic) in 12 genera and four families, 12 species of snakes (six endemic) in 12 genera and six families, and one species of turtle, from 540 person-hours (n = 10, average of 54 hours per person) spent during the whole sampling period (Table 2; Figs 3–6).

*Species endemism and distribution*.—Twenty out of thirty-seven sampled species of frogs, lizards and snakes are endemic to the country, of which more than 30% (n = 11) are also endemic to the Mindanao biogeographic region (Brown et al. 2013; Sanguila et al. 2016). This includes four frogs: Philippine Swamp Frog (*Limnonectes leytensis*), Mindanao Fanged Frog (*Limnonectes magnus*), Mindanao Striped Stream Frog (*Pulchrana grandocula*), and Mindanao Horned Frog (*Pelobatrachus stejnegeri*); five lizards: Annulated Bent-toed

**Table 2**. Herpetological records on Mt. Agad-Agad, Iligan City, Mindanao Island, Philippines. Summarized by family, distribution in two localities (Barangay Pugaan and Tipanoy), specimen and photo voucher number of collected specimen, and conservation status (LC = Least Concern, NT = Near Threatened, VU = Vulnerable, EN = Endangered, NE = Not Evaluated) based on IUCN (2021-3). Asterisk (*) represents Philippine endemic species and symbol (+) denotes invasive alien species of anurans.

| Species | Local Distribution | | Conservation Status | | Voucher Numbers |
|---|---|---|---|---|---|
| | Pugaan | Tipanoy | IUCN | DAO | |
| **AMPHIBIANS** (Frogs) | | | | | |
| **Bufonidae** | | | | | |
| Cane Toad<br>*Rhinella marina* (Linneaus 1758) + | ✓ | ✓ | LC | | CMU-MZ 3005 |
| **Dicroglossidae** | | | | | |
| Philippine Grass Frog<br>*Fejervarya vittigera* (Wiegmann 1824) * | ✓ | | LC | | ZRC(IMG) 1.226 |
| Philippine Swamp Frog<br>*Limnonectes leytensis* (Boetger 1893) * | ✓ | ✓ | LC | | CMU-MZ 3003.0–3003.3 |
| Mindanao Fanged Frog<br>*Limnonectes magnus* (Stejneger 1910) * | ✓ | ✓ | NT | OTS | CMU-MZ 3000.0–3000.4 |
| **Eleutherodactylidae** | | | | | |
| Greenhouse Frog<br>*Eleutherodactylus planirostris* (Cope 1862) + | | ✓ | LC | | ZRC(IMG) 1.227 |
| **Megophryidae** | | | | | |
| Mindanao Horned Frog<br>*Pelobatrachus stejnegeri* (Taylor 1920) * | ✓ | ✓ | LC | OTS | CMU-MZ 3001.0–3001.2 |
| **Microhylidae** | | | | | |
| Rufous-sided Sticky Frog<br>*Kalophrynus sinensis* (Peters 1867) * | | ✓ | LC | | CMU-MZ 3006 |
| Asian Painted Frog<br>*Kaloula pulchra* Gray 1831 + | | ✓ | LC | | ZRC(IMG) 1.228 |
| **Ranidae** | | | | | |
| Mindanao Striped Stream Frog<br>*Pulchrana grandocula* (Taylor 1920) * | ✓ | ✓ | LC | | CMU-MZ 3004.0–3004.8 |
| **Rhacophoridae** | | | | | |
| Asiatic Tree Frog<br>*Polypedates leucomystax* (Gravenhorst 1829) | | ✓ | LC | | CMU-MZ 3002.0–3002.4 |
| **REPTILES** (Lizards) | | | | | |
| **Agamidae** | | | | | |
| Green Crested Lizard<br>*Bronchocela* sp. | ✓ | ✓ | NE | | ZRC(IMG) 2.550 |
| Two-spotted Flying Lizard<br>*Draco bimaculatus* (Günther 1864) * | | ✓ | LC | | CMU-MZ 2006.0–2006.1 |
| Philippine Sailfin Lizard<br>*Hydrosaurus pustulatus* Escholtz 1829 * | | ✓ | VU | OTS | ZRC(IMG) 2.551 |
| **Gekkonidae** | | | | | |
| Annulated Bent-toed Gecko<br>*Cyrtodactylus annulatus* (Taylor 1915) * | ✓ | ✓ | LC | | CMU-MZ 2001.0–2001.3 |
| Tokay Gecko<br>*Gekko gecko* (Linneus 1758) | ✓ | ✓ | LC | OTS | CMU-MZ 2000.0–2000.1 |
| Common House Gecko<br>*Hemidactylus frenatus* (Duméril & Bibron 1836) | ✓ | ✓ | LC | | CMU MZ 2002.0–2002.1 |
| Flat-tailed House Gecko<br>*Hemidactylus platyurus* (Schneider 1792) | | ✓ | LC | | CMU-MZ 2005 |

| | | | | | |
|---|---|---|---|---|---|
| White-lined Smooth-scaled Gecko<br>*Lepidodactylus herrei* Taylor 1923 * | | ✓ | LC | | CMU-MZ 2008 |
| **Scincidae** | | | | | |
| Slender Skink<br>*Brachymeles* sp. | ✓ | ✓ | | | CMU-MZ 2004.0–2004.7 |
| Caraga Sun Skink<br>*Eutropis caraga* Barley et al. 2020 * | ✓ | ✓ | NE | | CMU-MZ 2008 |
| Many-striped Skink<br>*Eutropis multifasciata* (Kuhl 1820) | ✓ | ✓ | LC | | CMU-MZ 2003 |
| Green Tree Skink<br>*Lamprolepis smaragdina philippinica* (Mertens 1928) * | | ✓ | NE | | ZRC(IMG) 2.552 |
| Misamis Waterside Skink<br>*Tropidophorus misaminius* Stejneger 1910 * | ✓ | | LC | | CMU-MZ 2007.0–2007.4 |
| **Varanidae** | | | | | |
| Mindanao Monitor Lizard<br>*Varanus cumingi* Martin 1839 * | | ✓ | LC | OTS | No Specimens |
| **REPTILES** (Snakes) | | | | | |
| **Colubridae** | | | | | |
| Philippine Vine Snake<br>*Ahaetulla prasina preocularis* (Taylor 1922) * | | ✓ | LC | | ZRC(IMG) 2.553 |
| Dog-toothed Cat Snake<br>*Boiga cynodon* (H. Boie *in* F. Boie 1827) | ✓ | ✓ | LC | OTS | CMU-MZ 2501.0–2501.1 |
| Paradise Tree Snake<br>*Chrysopelea paradisi variabilis* Mertens 1968 * | | ✓ | NE | | CMU-MZ 2500 |
| Southern Philippine Rat Snake<br>*Coelognathus erythrurus erythrurus*<br>(Duméril, Bibron & Duméril 1854) | | ✓ | NE | OTS | No Specimens |
| Southern Triangle-spotted Snake<br>*Cyclocorus nuchalis taylori* Leviton 1967 * | | ✓ | NE | | No Specimens |
| Philippine Bronze-back Tree Snake<br>*Dendrelaphis philippinensis* Günther 1879 | ✓ | | NE | | ZRC(IMG) 2.554 |
| **Elapidae** | | | | | |
| Philippine Striped Coral Snake<br>*Calliophis philippina* Günther 1864 * | | ✓ | LC | | CMU-MZ 2504 |
| Southern Philippine Cobra<br>*Naja samarensis* Peters 1861 * | | ✓ | LC | OTS | No Specimens |
| **Homalopsidae** | | | | | |
| Dog-faced Water Snake<br>*Cerberus schneiderii* (Schlegel 1837) | ✓ | | LC | | ZRC(IMG) 2.555 |
| **Lamprophiidae** | | | | | |
| Non-banded Philippine Burrowing Snake<br>*Oxyrhabdium modestum*<br>(Duméril, Bibron & Duméril 1854) * | ✓ | ✓ | LC | | CMU-MZ 2502.0–2502.2 |
| **Pythonidae** | | | | | |
| Reticulated Python<br>*Malayopython reticulatus* (Schneider 1801) | | ✓ | NE | OTS | ZRC(IMG) 2.556 |
| **Typhlopidae** | | | | | |
| Brahminy Blind Snake<br>*Indotyphlops braminus* (Daudin 1803) | | ✓ | LC | | CMU-MZ 2503 |
| **REPTILES** (Turtle) | | | | | |
| **Geomydidae** | | | | | |
| Southeast Asian Box Turtle<br>*Cuora amboinensis* (Riche *in* Daudin 1802) | | ✓ | EN | OTS | ZRC(IMG) 2.557 |

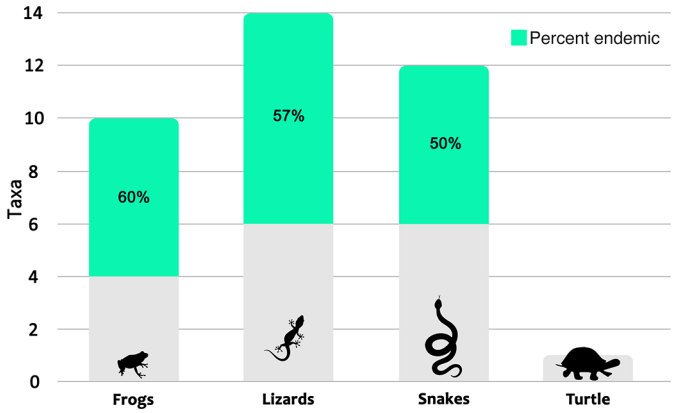


**Fig. 3.** Stacked bar chart representing the species composition and endemism of herpetofauna from Mt. Agad-Agad, Iligan City, Lanao del Norte Province, Philippines.

Gecko (*Cyrtodactylus annulatus*), Two-spotted Flying Lizard (*Draco bimaculatus*), Caraga Sun Skink (*Eutropis caraga*), Misamis Waterside Skink (*Tropidophorus misaminius*), and Mindanao Monitor Lizard (*Varanus cumingi*); and two snakes: Southern Triangle-spotted Snake (*Cyclocorus nuchalis taylori*) and Southern Philippine Cobra (*Naja samarensis*). Almost all of the amphibians and reptiles recorded in this work were recorded in Tipanoy except for the Philippine Grass Frog (*Fejervarya vittigera*), Misamis Waterside Skink (*Tropidophorus misaminius*), Philippine Bronze-back Tree Snake (*Dendrelaphis philippinensis*), and Dog-faced Water Snake (*Cerberus schneiderii*), that were documented only in Pugaan.

*Species richness*.—Species abundance for amphibians was higher in the secondary growth forest (n = 43 individuals; 6 species) compared to the mixed agricultural area (n = 22 individuals; 6 species). Individual-based rarefaction curves for amphibians in both SGF and MAA (Fig. 7A) showed an asymptotic bend indicating that the sampling effort was adequate. For reptiles, species richness and abundance is higher in MAA (n = 86 individuals; 12 species) compared to SGF (n = 43 individuals; 11 species). Unlike amphibians, the individual-based rarefaction curve for reptiles did not present a strong asymptotic inclination, suggesting that additional field sampling may yield additional reptile species.

The most abundant species of anurans recorded were stream frogs in the family Ranidae: Mindanao Striped Stream

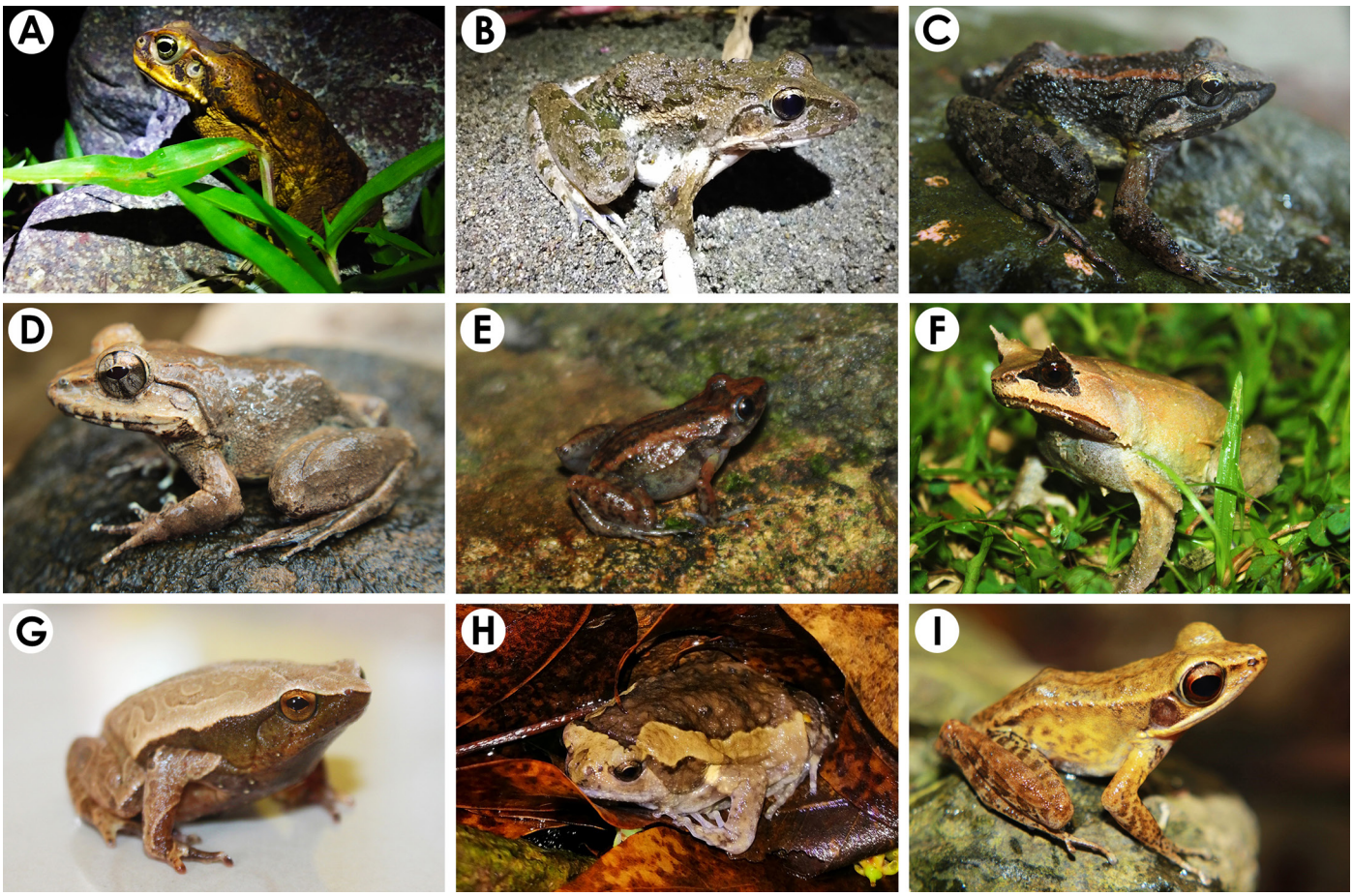


**Fig. 4.** Frogs of Mt. Agad-Agad. (A) Cane Toad (*Rhinella marina*), (B) Philippine Grass Frog (*Fejervarya vittigera*), (C) Philippine Swamp Frog (*Limnonectes leytensis*), (D) Mindanao Fanged Frog (*Limnonectes magnus*), (E) Greenhouse Frog (*Eleutherodactylus planirostris*), (F) Mindanao Horned Frog (*Pelobatrachus stejnegeri*), (G) Rufous-sided Sticky Frog (*Kalophrynus sinensis*), (H) Asian Painted Frog (*Kaloula pulchra*), (I) Mindanao Striped Stream Frog *Pulchrana grandocula.* Photographs by Erl Pfian T. Maglangit and Romeo R. Patano Jr.

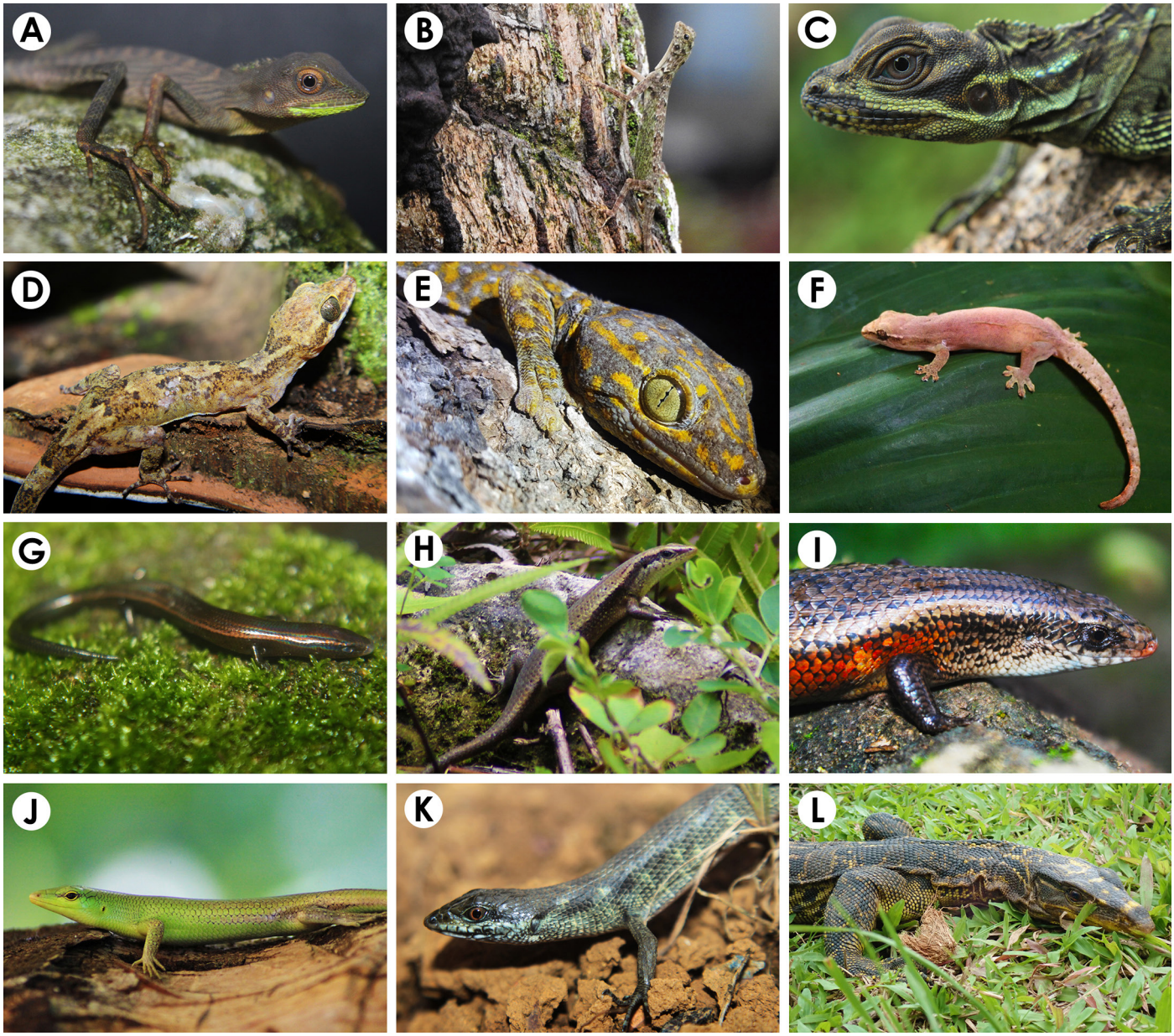


**Fig. 5.** Lizards of Mt. Agad-Agad. (A) Green Crested Lizard (*Bronchocela* sp.), (B) Two-spotted Flying Lizard (*Draco bimaculatus*), (C) Philippine Sailfin Lizard (*Hydrosaurus pustulatus*), (D) Annulated Bent-toed Gecko (*Cyrtodactylus annulatus*), (E) Tokay Gecko (*Gekko gecko*), (F) White-lined Smooth-scaled Gecko (*Lepidodactylus herrei*), (G) Slender Skink (*Brachymeles* sp.), (H) Caraga Sun Skink (*Eutropis caraga*), (I) Many-striped Skink (*Eutropis multifasciata*), (J) Green Tree Skink (*Lamprolepis smaragdina philippinica*), (K) Misamis Waterside Skink (*Tropidophorus misaminius*), (L) Mindanao Monitor Lizard (*Varanus cumingi*). Photographs by Erl Pfian T. Maglangit and Romeo R. Patano Jr.

Frog (*Pulchrana grandocula*; 8.76%) and family Dicroglossidae: Philippine Swamp Frog (*Limnonectes leytensis*; 6.70%) and Mindanao Fanged Frog (*Limnonectes magnus*; 5.15%). Among reptiles, the Two-spotted Flying Lizard (*Draco bimaculatus*; 12.9%) from family Agamidae and Caraga Sun Skink (*Eutropis caraga*; 9.28%) and an unidentified Slender Skink (*Brachymeles* sp.; 8.25%) from family Scincidae were the most abundant lizards, whereas the Non-banded Philippine Burrowing Snake (*Oxyrhabdium modestum*; 1.55%) in family Lamprophiidae and Dog-toothed Cat Snake (*Boiga cynodon*; 1.03%) from family Colubridae were the most frequently documented snakes.

The most diverse family of frogs represented in our sampling was Dicroglossidae (n = 3 species), while the most diverse families of reptiles were Gekkonidae (n = 5 species) for lizards and Colubridae (n = 6 species) for snakes.

*Species diversity*.—The Shannon index of diversity showed that MAA is more diverse (H = 2.479) documenting 18 species of amphibians and reptiles, compared to SGF (H = 2.449) which noted 17 species of herpetofauna. Although, species richness was moderately high in secondary growth forest, a relatively significant number of herpetofaunal species were found in mixed agricultural areas.


**Fig. 6.** Snakes and freshwater turtle of Mt. Agad-Agad. (A) Philippine Vine Snake (*Ahaetulla prasina preocularis*), (B) Dog-toothed Cat Snake (*Boiga cynodon*), (C) Paradise Tree Snake (*Chrysopelea paradisi variabilis*), (D) Philippine Tree Snake (*Dendrelaphis philippinensis*), (E) Philippine Striped Coral Snake (*Calliophis philippina*), (F) Dog-faced Water Snake (*Cerberus schneideri*), (G) Non-banded Philippine Burrowing Snake (*Oxyrhabdium modestum*), (H) Brahminy Blind Snake (*Indotyphlops braminus*), (I) Southeast Asian Box Turtle (*Cuora amboinensis*). Photographs by Erl Pfian T. Maglangit and Romeo R. Patano Jr.

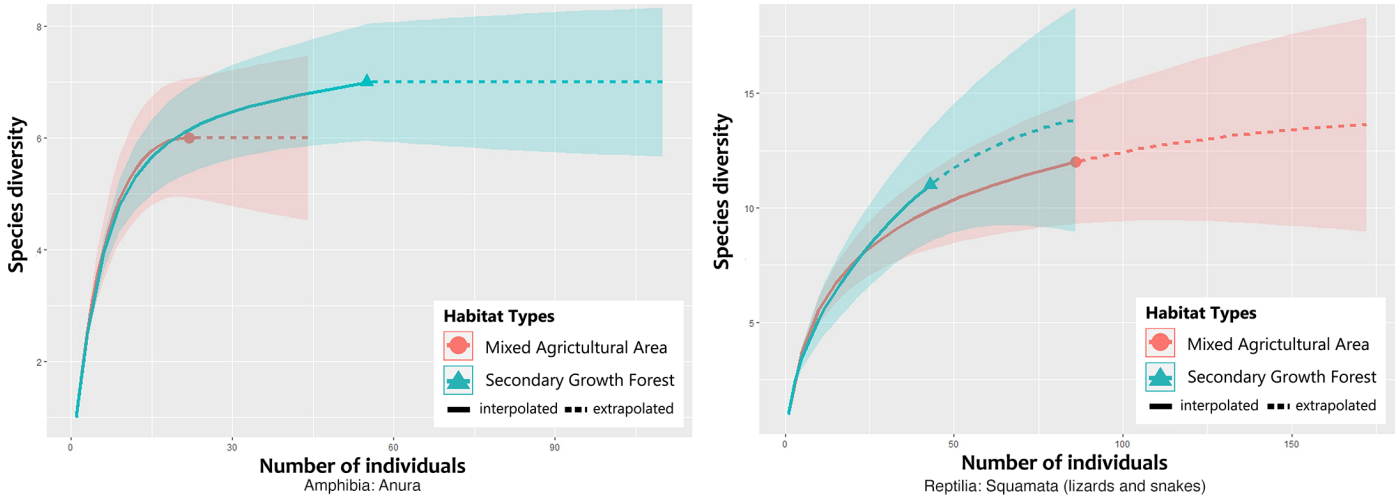


**Fig. 7.** Individual-based rarefaction curve of amphibians (Fig. 4A) and reptiles (Fig. 4B) in two habitat types. Richness was generated using *iNEXT* and *ggplot2* package ($q$ = 0, Chao1) in RStudio, represented by solid lines (rarefied individuals) and dashed lines (estimated extrapolation) with 95% confidence interval.

Using general random sampling, we recorded three species of frogs, four species of lizards, four species of snakes, and one species of turtle. Frogs included Greenhouse Frog (*Eleutherodactylus planirostris*), Asian Painted Frog (*Kaloula pulchra*), and Philippine Grass Frog (*Fejervarya vittigera*); lizards included an unidentified species of Green Crested Lizard (*Bronchocela* sp.; fide Sanguila et al. 2016), Philippine Sailfin Lizard (*Hydrosaurus pustulatus*), White-lined Smooth-

scaled Gecko (*Lepidodactylus herrei*), and Mindanao Monitor Lizard (*Varanus cumingi*); snakes included Philippine Vine Snake (*Ahaetulla prasina preocularis*), Dog-faced Water Snake (*Cerberus schneiderii*), Southern Philippine Rat Snake (*Coelognathus erythrurus erythrurus*), and Reticulated Python (*Malayopython reticulatus*); and turtles included the Southeast Asian Box Turtle (*Cuora amboinensis*).

*Threats and threatened herpetofauna*.—Two threatened species were recorded: Southeast Asian Box Turtle *C. amboinensis* (IUCN: Endangered) and Philippine Sailfin Lizard *H. pustulatus* (IUCN: Vulnerable). Anthropogenic disturbances observed within the study areas included the conversion of forest for agriculture, improper waste disposal by irresponsible mountaineers, small-scale timber extraction, wildlife hunting, and the presence of invasive alien anurans: *R. marina*, *E. planirostris*, and *K. pulchra*.

## Discussion

Our study provides new and extensive ecological information on species richness, diversity, and distributions of amphibians and reptiles on Mt. Agad-Agad, supporting a greater number of frogs, lizards, snakes, and turtle in northern Mindanao than was previously known. The species documented during the field survey, remarkably, supplemented new information on distributional ranges, endemism, updates on their conservation status, threats, and possible novel, unidentified taxa.

High species richness was recorded at all sampling sites (i.e., Pugaan, Tipanoy). Comparatively, species richness on Mt. Agad-Agad is slightly similar to the recent ecological and herpetological assemblage study in Taguibo Watershed of northeastern Mindanao which identified 44 herpetofaunal species (Sanguila et al. 2020). Both habitat types support a high number and diverse community of amphibians and reptiles on Mt. Agad-Agad. The notable differences in herpetofaunal assemblages between MAA and SGF habitat types may be attributed to differences in the available food resources, and habitat preferences or requirements of taxa. The high species richness of secondary growth forest demonstrates that this habitat shelters a high proportion of different thriving populations of amphibians and reptiles notwithstanding different anthropogenic pressures present in the area. Although some species can tolerate certain habitat modifications (e.g., *Kalophrynus sinensis*, *Lamprolepis smaragdina philippinica*, *Chrysopelea paradisi variabilis*), especially in mixed agricultural areas, still, the extent of their detrimental consequences to these populations are not yet fully known. Additionally, the disparity in the number of species detected in two sampling sites and habitat types is most likely attributed to the differences of sampling effort during each visit (hours spent/sampling location and pockets of microhabitats searched), inclement weather conditions (Pugaan: slightly humid, sunny, and light rainfall during the night; Tipanoy: relatively humid, cloudy, heavy rainfall in the late afternoon), and climate type [Iligan City: Type III, where seasons are not very pronounced – relatively dry from November to April and wet during the rest of the year (Silent Gardens 2021)].

During our fieldwork, undocumented herpetofauna belonging to the genera *Calamaria*, *Gonocephalus*, *Lycodon*, *Platymantis*, *Philautus*, *Pinoyscincus*, *Sphenomorphus*, *Tropidolaemus*, and *Trimeresurus* were reported by locals to be present in the area based on available photographic field guides and morphological descriptions (Diesmos et al., 2015; Sanguila et al. 2016; Leviton et al. 2018; Weinell et al. 2020). Possible explanations for these taxa not being detected during our field surveys could be related to varying seasonality (i.e., we only surveyed during the wet season, when some species may be inactive or less active compared to other seasons of the year) and microclimate conditions (Supsup et al. 2016, 2020); habitat modification (i.e., conversion of forest land to agricultural land), and the long history of systematic island-wide deforestation on Mindanao Island (Sanguila et al. 2016), which potentially impacted several amphibian and reptilian groups to a significant degree and warrants further ecological studies concerning impacts of habitat loss and modification to the herpetological community in Mt. Agad-Agad. Additional field expeditions and repeated surveys are needed to confirm the presence of these unrecorded genera at a particular season and climate of the year.

Despite some representative genera being undocumented, we report new locality records of *Boiga cynodon* and *Chrysopelea paradisi variabilis* in Mt. Agad Agad, extending their known localities in western Mindanao that were previously noted to occur in the provinces of Agusan del Sur, Cotabato, and Davao Oriental for *B. cynodon* (Supsup et al. 2017; Leviton et al. 2018); and in Agusan del Norte and Zamboanga del Sur for *C. paradisi variabilis* (Leviton et al. 2018). Additionally, a new island record of *Lepidodactylus herrei*, previously reported on the islands of Bohol, Camotes, Cebu, Leyte, Negros, Samar, Siquijor, and Unib Island (Brown and Alcala 1978; Supsup et al. 2016; Maglangit et al. 2021), extend the known geographic distribution ranges of these species across the southern Philippines. On the other hand, the unidentified slender skink *Brachymeles* sp. may be an undescribed species that is closely related to *Brachymeles hilong* in northeastern Mindanao (Siler et al. 2012; Sanguila et al. 2016), and *Brachymeles tiboliorum* in northern and southern Mindanao (Sanguila et al. 2016; Pitogo et al. 2021a), based on scale counts, external morphology, and snout-vent-length (Siler et al., 2010; Siler and Brown, 2010; Siler et al. 2012). Additional ecological and taxonomic research on this taxon is now being conducted to further facilitate the identification of the species, and findings will be published elsewhere.

In addition, a rare natural history occurrence was documented for *C. schneiderii* along the riverine and mountain

streams of Mt. Agad-Agad, extending its upper elevational limit from sea level to 150 m asl in Mindanao Island. Similar observations were reported by Binaday and Baltazar (2019) for *C. schneiderii* populations on Negros Island (239 m elevation) and on Catandaunes Island (75 m elevation). This additional observation warrants further ecological studies on several populations of *C. schneiderii* in the Philippines to determine the extent of its upper elevation limit and habitat utilization (e.g., breeding, foraging) of upstream and inland waters.

Tropical mountain ecosystems and habitats on Mindanao Island are important and shelter numerous endemic and poorly known herpetofauna (Nuñeza et al. 2010; Sanguila et al. 2016; Supsup et al. 2017; Pitogo et al. 2021a). Our findings combined with the collective records of recent amphibian and reptile studies from Mt. Kalatungan (Warguez et al. 2013; Toledo-Bruno et al. 2017; Dela Tore and Nuñeza 2021), Mt. Kitanglad (Buekema 2011; Baron et al. 2021), and Mt. Pantaron (Coritico et al. 2018) in Bukidnon Province; Mt. Timpoong (Camiguin Sur: Venturina et al. 2020), Mt. Lumot, Initao-Libertad Protected Landscape and Seascape, and Mt. Balatukan (Sanguila et al. 2016) in Misamis Oriental Province; and Mt. Malindang (Nuñeza et al. 2010) in Misamis Occidental Province, together include 115 species of herpetofauna (46 frogs, 1 caecilian, 41 lizards, 27 snakes, and 1 turtle) in the northern Mindanao region.

More than 30% of the total recognized amphibians and reptiles in the northern Mindanao region were documented on Mt. Agad-Agad. Despite this comprehensive information, we suspect that this is still an underestimation. Future herpetological expeditions, long-term inventories, and continued research may document enigmatic and peculiar amphibians and reptiles. Hence, this compelling field-based information provides substantial empirical evidence for declaring Mt. Agad-Agad as a local conservation area.

## Conclusion and Recommendations

Mt. Agad-Agad is a habitat frontier that must be carefully managed, conserved, and protected. The few remaining natural ecosystems in this massif are biologically important and support the surviving herpetofaunal species and other terrestrial faunal groups. We highly recommend planting of indigenous tree species to gradually replace exotic tree species (e.g., *S. macrophylla*, *A. mangium*), promoting sustainable use of natural resources, localizing priority-setting, supporting capacity-building activities to enrich the awareness of locals, and promoting conservation initiatives to mitigate the catastrophic effects of local weather disaster (i.e., tropical storms). Future work for herpetofauna should focus more on ecology (e.g., microhabitat utilization, habitat preference and requirement, population ecology), taxonomy, and systematics. We encourage field biologists, herpetologists, researchers, and government agencies to focus and give attention to the southernmost part of the northern Mindanao region, surveying adjacent ecologically significant massifs within Iligan City (i.e., Mt. Alihod, Mt. Gabunan, Mt. Rogongon, Mt. Sagada) and Lanao del Norte (Mt. Catmon [Magsaysay], Mt. Inayawan Range Natural Park (Nunungan), Mt. Peurai Complex [Pantao Ragat]).

## Acknowledgements

Funding support was provided by the National Research Council of the Philippines (NRCP) through the research program titled "*Biodiversity Inventory, Assessment and Conservation for Ecotourism Development in Mt. Agad-Agad, Lanao del Norte*". We thank the Department of Environment and Natural Resources, Region X (Wildlife Gratuitous Permit # R10-2020-05) for providing the research collection permit. We also thank the following offices for their technical support in logistics, security, and legal provisions: Office of Central Mindanao University President (Dr. Jesus Antonio G. Derije), Office of the Congressman (Cong. Frederick W. Siao), Office of the City Mayor (Mayor Celso G. Regencia), City Environment and Natural Resource Office (Envi. Mgt. Officer V.B. Encabo and Chief of Watershed Division A.M. Obach), Office of Barangay Pugaan and Tipanoy (Brgy. Captain V.M. Raman and M.G. Labrador Jr.), Philippine National Police - Special Action Force (PNP-SAF) and Inter-Agency Task Force (IATF) for Covid-19 in Iligan City. We are grateful to our enthusiastic field guides D. Balabag, R. Canillo, R. Balanay, J. Labasano, G. Habines, J. Labasano, N. Bakos, A. Lusano, E. Ilaya, A. Baylosis, R. Barbon, and our field colleagues H.G. Jebulan, H.C. Anches, A. Hongco, M. Acola, M. Apaap, A.J. Lagumbay, N.G. Casinillo, Y.L. Cariño, J. Caballero, and N. Lagunday. We also extend our appreciation to Dr. Arvin C. Diesmos from ASEAN Centre for Biodiversity (ACB) for verifying pre-identified herpetofaunal specimens, Mr. Dave P. Mohagan (Central Mindanao University – Zoological Section) for cataloguing specimen collections, and Mr. Kelvin Lim (Lee Kong Chian Natural History Museum of the National University of Singapore) for technical support in cataloging photographic vouchers. We also thank several reviewers including, R.R. Sanchez, R.E. Venturina, M. Sanguila, J.M. Bernstein, A. Aguilar, and J.L. Weinell for their comments and suggestions on an earlier draft of this manuscript.

## Literature Cited

Baron, E.M., M.O. Marin, B.A. Logramonte, and A.B. Mohagan. 2021. Species account of anurans from the western slope of Mt. Kitanglad, Mindanao Island, Philippines. *Asian Herpetological Research* 12: 76–87. https://doi.org/10.16373/j.cnki.ahr.200049.

Beukema, W. 2011. Herpetofauna of disturbed forest fragments on the lower Mt. Kitanglad Range, Mindanao Island, Philippines. *Salamandra* 47: 90–98.

Bickford, D., S.D. Howard, D.J.J. NG, and J.A. Sheridan. 2010. Impacts of climate change on the amphibians and reptiles of Southeast Asia. *Biodiversity Conservation* 19: 1043–1062. https://doi.org/10.1007/s10531-010-9782-4.

Binaday, J.W. and P.C. Baltazar. 2019. Dog-faced water snake (*Cerberus schneide-*

*rii*) in upstream rivers in Negros Island and Catanduanes Island, Philippines. *Southeast Asian Vertebrate Records* 2019: 16–18.

Brown, W.C. and A.C. Alcala. 1970. The zoogeography of the Philippine Islands, a fringing archipelago. *Proceedings of the California Academy of Sciences* 38: 105–130.

Brown, W.C. and A.C. Alcala. 1978. *Philippine lizards of the family Gekkonidae.* Silliman University Press, Dumaguete City, Philippines.

Brown, R.M. and A.C. Diesmos. 2002. Application of lineage-based species concept to oceanic island frog population: the effects of differing taxonomic philosophies on the estimation of Philippine Biodiversity. *Silliman Journal* 42 (Special Wildlife Issue): 133–162.

Brown, R.M., C.D. Siler, C.H. Oliveros, J.A. Esselstyn, A.C. Diesmos, P. Hosner, C.W. Linkem, A.J. Barley, J.R. Oaks, M.B. Sanguila, L.J. Welton, D.S. Blackburn, R.G. Moyle, A.T. Peterson, and A.C. Alcala. 2013. Evolutionary processes of diversification in a model island archipelago. *Annual Review of Ecology, Evolution, and Systematics* 44: 411–435. https://doi.org/10.1146/annurev-ecolsys-110411-160323.

Causaren, R.M. 2016. Species diversity, abundance, and habitat distribution of anurans in Mts. Palay-Palay Mataas-na-Gulod protected landscape, Luzon Island, Philippines. *Philippine Journal of Systematic Biology* 10: 52–62.

Chao, A., N.J. Gotelli, T.C. Hsieh, E.L. Sander, K.H. Ma, R.K. Colwell, and A.M. Ellison. 2014. Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies. *Ecological Monographs* 84: 45–67. https://doi.org/10.1890/13-0133.1.

Clements, R., N.S. Sodhi, M. Schilthuizen, and P.K.L. Ng. 2006. Limestone karst of Southeast Asia: Imperiled arks of biodiversity. *BioScience* 56: 733–742. https://doi.org/10.1641/0006-3568(2006)56[733:LKOSAI]2.0.CO;2.

Clores, M.A., J.B. Bautista, J.B. Fernandez, M.A. Cuesta, and R.M. Brown. 2021. Diversity and distribution of amphibians and reptiles in the Caramoan Island Group, Maqueda Channel, Southern Luzon, Philippines. *Journal of Asia Pacific Biodiversity* 14: 1–14. https://doi.org/10.1016/j.japb.2020.11.005.

Coritico, F.P., E.B. Sinamban, A.B. Mohagan, and V.B. Amoroso. 2018. Preliminary report on the anurans of Mt. Pantaron Range, Bukidnon, Central Mindanao, the Philippines. *Journal of Nature Studies* 17(1): 9–23.

Coritico, F.P., M.M. Guiang, M.C. Salolog, I.R. Pescadero, and V.B. Amoroso. 2020. Checklist of ferns and lycophytes of Mount Agad-Agad, Lanao del Norte, Southern Philippines. *The Thailand Natural History Museum Journal* 14: 95–102.

Dela Tore, V.C., and O.M. Nuñeza. 2021. Species diversity, distribution, and microhabitats of anurans on Mt. Kalo-Kalo of the Mt. Kalatungan Range Natural Park, Bukidnon, Philippines. *Asian Herpetological Research* 12: 58–75. https://?doi.org:10.16373/j.cnki.ahr.200024.

Diesmos, A.C., R.M. Brown, A.C. Alcala, R.V. Sison, L.E. Afuang, and G.V.A. Gee. 2002. Philippine amphibians and reptiles: An overview of species diversity, biogeography, and conservation, pp. 26–44. In: P.S. Ong, L.E. Afuang, and R.G. Rosell-Ambal (eds,), *Philippine Biodiversity Conservation Priorities: A Second Iteration of the National Biodiversity Strategy and Action Plan*.

Diesmos, A.C., J.L. Watters, N.A. Huron, D.R. Davis, A.C. Alcala, R.I. Crombie, L.E. Afuang, G. Gee-Das, R.V. Sison, M.B. Sanguila, M.L. Penrod, M.J. Labonte, C.S. Davey, E.A. Leone, M.L. Diesmos, E.Y. Sy, L.J. Welton, R.M. Brown, and C.D. Siler. 2015. Amphibians of the Philippines, Part I: Checklist of the species. *Proceedings of the California Academy of Sciences* 62: 457–539.

Fisher, R.A., A.S. Corbet, and C.B. Williams. 1943. The relation between the number of species and the number of individuals in a random sample of animal population. *Journal of Animal Ecology* 12: 42–58. https://doi.org/10.2307/1411.

Frost, D.R. 2021. *Amphibian species of the World: An Online Reference*. Version 6.1. American Museum of Natural History, New York, New York, USA, <https://amphibiansoftheworld.amnh.org/>.

Gatti, F.D., T.H.A. Rodrigues, L.A.D. Figueiredo, and M.A.A. Carneiro. 2018. Longhorn beetle (Coleoptera: Cerambycidae) Assemblage and the structural heterogeneity of habitat at the Brazilian Atlantic Forest. *Environmental Entomology* 47: 1413–1419. https://doi.org/10.1093/ee/nvy158.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.A.C. Hayek, and M.S. Foster. 1994. *Measuring and monitoring biological diversity; standard methods for amphibians (XVII)*. Smithsonian Institution Press, Washington, D.C.

Hsieh, T.C., K.H. Ma, and A. Chao. 2016. iNEXT: An R package for rarefaction and extrapolation of species diversity (Hill numbers). *Methods in Ecology and Evolution* 7: 1451–1456. https://doi.org/10.1111/2041-210X.12613.

Hurlbert, S.H. 1971. The nonconcept of species diversity: A critique and alternative parameters. *Ecology* 52: 577–586. https://doi.org/10.2307/1934145.

Inger, R.F. 1954. Systematics and zoogeography of Philippine Amphibia. *Fieldiana* 33: 181–531.

IUCN. 2021. *The IUCN Red list of threatened species.* Version 2020–3. <https://www.iucnredlist.org/>.

Leviton, A.E., C.D. Siler, J.L. Weinell, and R.M. Brown. 2018. Synopsis of the snakes of the Philippines: A synthesis of data from biodiversity repositories, field studies and literature. *Proceedings of the California Academy of Sciences* 64: 399–568.

Longino, J.T., J. Coddington, and R.K. Colwell. 2002. The ant fauna of a tropical rain forest: Estimating species richness three different ways. *Ecology* 83: 689–702. http://doi.org/10.1890/0012-9658(2002)083[0689:TAFOAT]2.0.C0;2.

Maglangit, E.P., R.C.Jr. Medija, R.J.C. Tapdasan, M.F.P. De Alba, L.A.A. Adamat, A.O. Amparado, O.M. Nuñeza, M.L.L. Diesmos, and A.C. Diesmos. 2021. Range extension of the White-lined Smooth-scaled Gecko (*Lepidodactylus herrei*) and predation by the Paradise Tree Snake (*Chrysopelea paradisi variabilis*), Unib Island, Philippines. *Sonoran Herpetologist* 34: 1–20.

Magurran, A.E. 2004. *Measuring Biological Diversity*. Blackwell, Oxford. UK.

Mallari, N.A.D., B.R. Tabaranza Jr., and M.J. Crosby. 2001. *Key conservation sites in the Philippines.* Bookmark Inc., Philippines.

Mohagan, A.B., R.R. Patano Jr., E.P. Leaño, M.G. Melencion, F.P. Coritico, and V.B. Amoroso. 2020. Morphology and morphometrics of *Diotarus verrucifer* (Stål, 1877), a pygmy grasshopper endemic to Mindanao. *Philippine Journal of Science* 149: 571–579.

Mohagan, A.B., M.M.M. Guiang, O.M. Nuñeza, F.P. Coritico, H.C.T. Anches, H.G.H Jebulan, R.R.Jr. Patano, E.P.T. Maglangit, and V.B. Amoroso. 2022. Species composition and assessment of Sphingidae in Mt. Agad-Agad, Iligan City, Philippines. *Journal of Tropical Life Science,* 12: 131–140. http://dx/doi.org/10.11594/jtls.12.01.14.

Nuñeza, O.M., F.B. Ates, and A.A. Alicante. 2010. Distribution of endemic and threatened herpetofauna in Mt. Malindang, Mindanao, Philippines. *Biodiversity Conservation* 19: 503–18.

Pitogo, K.M.E., A.J.L. Saavedra, and L.E. Afuang. 2021a. Amphibians and reptiles of Mount Busa, Sarangani Province: A glimpse of the herpetological community of Southern Mindanao, Philippines. *Philippine Journal of Science* 150: 1279–1306.

Pitogo, K.M.E., A.J.L. Saavedra, M.E.B. Aurellado, A.P.O. de Guia, and L.E. Afuang. 2021b. Functional traits and environments drive montane amphibian distribution in the southern Philippines. *Biodiversity and Conservation* 2021: 4177–4197. http://doi.org/10.1007/s10531-021-02299-0.

Oksanen, J. 2013. *Vegan: an introduction to ordination. CRAN*. < https://cran.r-project.org/web/packages/vegan/index.html>.

Ong, P., L.E. Afuang, and R.G. Rossel-Ambal. 2002. *Philippine biodiversity conservation priorities: A second iteration of the National Biodiversity Strategy and Action Plan*. Quezon City: Department of Environment and Natural Resources - Protected Areas and Wildlife Bureau, Conservation International Philippines, Biodiversity Conservation Program - University of the Philippines Center for Integrative and Development Studies and Foundation for the Philippine Environment.

Plaza, J.L. and M.B. Sanguila. 2015. Preliminary report on the anurans of Mount Hilong-hilong, Agusan del Norte, Eastern Mindanao, Philippines. *Asian Herpetological Research* 6: 18–33.

R Core Team. 2019. *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. <https:// www.R-project.org/>.

Relox, R.E., E.P. Leaño, and Bates-Camino F. 2011. Herpetofaunal endemism and diversity in tropical forests of Mt. Hamiguitan in the Philippines. *Herpetological Conservation and Biology* 6: 107–113. DOI?

Sanguila, M.B., K.A. Cobb, C.D. Siler, A.C. Diesmos, A.C. Alcala, and R.M. Brown. 2016. The amphibians and reptiles of Mindanao Island, southern Philippines, II: the herpetofauna of northeast Mindanao and adjacent islands. *Zookeys* 624: 1–132. https://doi.org/10.3897/zookeys.624.9814.

Sanguila, M.B., J.L. Plaza, M.Y. Mahinay, R.C. Edma, Jr., and R.M. Brown. 2020. Herpetological assemblages in tropical forests of the Taguibo Watershed, Butuan City, eastern Mindanao, Philippines. *Philippine Journal of Science* 150: 415–431.

Silent Garden. 2021. *Philippine Climate.* <https//: www.silent-gardens.com/climate.php>.

Siler, C.D., A.C. Diesmos, and R.M. Brown. 2010. New loam-swimming skink, genus *Brachymeles* (Reptilia: Squamata: Scincidae) from Luzon and Catanduanes Islands, Philippines. *Journal of Herpetology* 44: 49–60.

Siler, C.D., R.M. Jones, A.C. Diesmos, M.L. Diesmos, and R.M. Brown. 2012. Phylogeny-based species delimitation in Philippine slender skinks (Reptilia: Squamata: Scincidae) III: Taxonomic revision of the *Brachymeles gracilis* complex, with description of three new species. *Herpetological Monographs* 25: 135–172.

Siler, C.D. and R.M. Brown. 2010. Phylogeny-based species delimitation in Philippine slender skinks (Reptilia: Squamata: Scincidae: *Brachymeles*): Taxonomic revisions of pentadactyl species groups and description of three new species. *Herpetological Monographs* 24: 1–54. DOI?

Simmons, J. 2002. Herpetological collecting and collections management. Revised edition, *Society for the Study of Amphibians and Reptiles Herpetological Circular* 31: 1–153.

Sodhi, N.J. and P.R. Erlich. 2010. *Conservation Biology for All*. Oxford University Press Oxford, UK.

Supsup, C.E., N. Puna, A. Asis, B.R. Redoblado, M.F. Panaguinit, F.M. Guinto, E.L. Rico, A.C. Diesmos, R.M. Brown, and N.A.D. Mallari. 2016. Amphibians and reptiles of Cebu, Philippines: the poorly understood herpetofauna of an island with very little remaining natural habitat. *Asian Herpetological Research* 7: 151–179. <https://www.cnki.net/kcms/doi/10.16373/j.cnki.ahr. 150049.html>.

Supsup, C.E., F.M. Guinto, B.R. Redoblado, and R.S. Gomez. 2017. Amphibians and reptiles from the Mt. Hamiguitan Range of eastern Mindanao Island, Philippines: new distribution records. *Check List* 13: 2121. https://doi.org/10.15560/13.3.2121.

Supsup, C.E., A.A. Asis, U.V. Carestia Jr., A.C. Diesmos, N.A. Mallari, and R.M. Brown. 2020. Variation in species richness, composition and herpetological community structure across a tropical gradient of Palawan Island, Philippines. *Herpetozoa* 33: 95–111. https://doi.org/10.3897/herpetozoa.33.e47293.

Taylor, E.H. 1920. Philippine Amphibia. *Philippine Journal of Science* 16: 213–359.

Taylor, E.H. 1922a. *The Snakes of the Philippine Islands*. Department of Agriculture and Natural Resources and Bureau of Science, Manila.

Taylor, E.H. 1922b. The lizards of the Philippine Islands. *Philippine Journal of Science*. Government of the Philippine Islands, Department of Agriculture and Natural Resources, Bureau of Science, Manila.

Toledo-Bruno, A.G., D.G. Macas, D.P. Buenavista, M.P. Medina, and R.R.C. Forten. 2017. Amphibian and reptile diversity in Mt. Kalatungan Range Natural Park, Philippines. *Environmental and Experimental Biology* 15: 127–135.

Uetz, P., P. Freed, and J. Hošek. (eds.) 2021. *The Reptile Database*. < https://reptile-database.reptarium.cz/>.

Venturina, R.E.L., Y.L.C. Del Prado, R.A.C. Kamir, M.N. Balmores, and A.C. Diesmos. 2020. A revised checklist of amphibians and reptiles in Camiguin Sur, Misamis Oriental, Mindanao, Philippines. *Asian Herpetological Research* 11: 28–43.<https://kns.cnki.net/kcms/detail/detail.aspx?doi=10.16373/j.cnki.ahr.190036>.

Warguez, D.A., E.P. Mondejar, and C.G. Demayo. 2013. Frogs and their microhabitat preference in the agricultural and secondary forest areas in the vicinity of Mt. Kalatungan Mountain, Bukidnon, Philippines. *International Research Journal of Biological Sciences* 2: 51–63.

Weather Spark. 2020. Average weather in Iligan City [brochure]. <https//:www.weatherspark.com/y/140729/Average-Weather-in-Iligan-City-Philippines-Year-Round>.

Weinell, J.L., E. Hooper, A.E. Leviton, and R.M. Brown. 2020. Illustrated Key to the Snakes of the Philippines. *Proceedings of the California Academy of Sciences* 66: 1–49.

Wickham, H. 2016. *ggplot2: Elegant graphics for data analysis*. Springer-Verlag New York. https://doi.org/10.1007/978-0-387-98141-3.

**Appendix A.** Voucher specimens deposited with the herpetological collection of zoological archives in Central Mindanao University – Zoological Museum, Mindanao Island, Philippines. Measurements of length (snout-vent length = SVL and tail length (intact only; no regenerated or partial tails) = TL) are listed to the nearest mm and (weight = W) mass to the nearest 0.1 g. Note: *Eutropis multifasciata* has no tail length measurement; lizard was encountered and sampled after a predation attempt by *Naja samarensis*.

**Amphibians** (Anura): *Rhinella marina*, CMU MZ 3005 • SVL = 112.0 mm, W =138.7 g; *Limnonectes leytensis*, CMU MZ 3003.0–3003.3 • n = 3, SVL = 18–49 mm, W = 6.5–11.5 g; *Limnonectes magnus*, CMU MZ 3000.0–3000.4 • n = 5, SVL = 33–103 mm, W = 6.8–33.2 g; *Pelobatrachus stejnegeri*, CMU MZ 3001.0–3001.2 • n = 3, SVL = 26–83 mm, W = 20.5–42.2 g; *Kalophrynus sinensis*, CMU MZ 3006 • SVL = 38.0 mm, W = 4.8 g; *Pulchrana grandocula*, CMU MZ 3004.0–3004.8 • n = 9, SVL = 42–70 mm, W = 6.5–21.7 g; *Polypedates leucomystax*, CMU MZ 3002.0–3002.4 • n = 5, SVL = 50–53 mm, W = 6.6–8.2 g.

**Reptiles** (Squamata: lizards): *Draco bimaculatus*, CMU MZ 2006.0–2006.1 • n = 2, SVL = 62–64 mm, TL = 107.5–152 mm; *Cyrtodactylus annulatus*, CMU MZ 2001.0–2001.3 • n = 4; SVL = 52–63 mm, TL = 48–55 mm, W = 2.8–4.5 g; *Gekko gecko*, CMU MZ 2000–2000.1 • n = 2, SVL = 156–168 mm, TL = 149 mm, W = 65.2–75.2 g; *Hemidactylus frenatus*, CMU MZ 2002.0–2002.1 • n = 2, SVL = 53–53 mm, TL = 38.5–57 mm, W = 3.2–3.7 g; *Hemidactylus platyurus*, CMU MZ 2005 • SVL = 50 mm, TL = 51 mm, W = 3.6 g; *Lepidodactylus herrei*, CMU MZ 2008 • SVL = 74 mm, TL = 85 mm, W = 1.4 g; *Brachymeles* sp., CMU MZ 2004.0–2004.7 • n = 8, SVL = 22–72 mm, TL = 9–37 mm, W = 0.3–1.2 g; *Eutropis caraga*, CMU MZ 2008 • SVL = 36 mm, TL = 93 mm; *Eutropis multifasciata*, CMU MZ 2003 • SVL = 135 mm, W = 55.5 g; *Tropidophorus misaminius*, CMU MZ 2007.0–2007.4 • n = 5, SVL = 48–87 mm, TL = 41–150 mm.

**Reptiles** (Squamata: snakes): *Boiga cynodon*, CMU MZ 2501.0–2501.1 • n = 2, SVL = 341–1137 mm, TL = 207–304 mm, W = 41.0–91.4 g; *Chrysopelea paradisi variabilis*, CMU MZ 2500 • SVL = 508 mm, TL = 219 mm, W = 30.8 g; *Calliophis philippina*, CMU MZ 2504 • SVL = 563.5 mm, TL = 46.5 mm, W = 31.5 g; *Oxyrhabdium modestum*, CMU MZ 2502.0–2502.2 • n = 3, SVL = 447–552 mm, TL = 91–126 mm, W = 34.7–42.3 g; *Indotyphlops braminus*, CMU MZ 2503 • SVL = 182 mm, TL = 4 mm, W = 1.1 g.