



A new species of limestone-forest frog, genus *Platymantis* (Amphibia: Anura: Ceratobatrachidae) from central Luzon Island, Philippines

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Abstract

We describe a new species of terrestrial limestone forest frog of the genus *Platymantis* from Biak Na Bato National Park in central Luzon Island, Philippines. *Platymantis biak* is assigned to the primarily arboreal *Platymantis guentheri* Species Group, and is distinguished from these and other congeners by features of its external morphology and preferred terrestrial limestone microhabitat. Several distinguishing morphological characters include a moderately large body (32.3–39.9 mm SVL for 23 males and 37.4–42.4 mm SVL for 8 females), moderately expanded finger discs and slightly expanded toe discs, smooth skin, and limb banding pattern. The new species is yet another species in a rapidly growing group of newly discovered Philippine forest frogs with preferences for forested, karst habitats.

Key words: Biodiversity; Cryptic species; Endemism; Limestone frogs; *Platymantis guentheri* Species Group; SW Pacific

Introduction

Frogs of the genus *Platymantis* exhibit extraordinary species diversity in the Philippine Archipelago (Brown, 2004; Brown *et al.*, 2008), with 28 species known thus far (Siler *et al.*, 2009). The rate of discovery of new taxa within the genus is remarkably high (Brown, 2004; Brown and Gonzales, 2007; Brown *et al.*, 2008; Siler *et al.*, 2007, 2009). Within the Philippines, three species groups are recognized on the basis of external morphology (Brown *et al.*, 1997a,c; Alcalá and Brown, 1999): the *P. dorsalis* Group, the *P. hazelae* Group, and the *P. guentheri* Group. In addition to the morphological variation among *Platymantis* in the Philippines, the advertisement calls and preferred microhabitats of the species also vary predictably, and are diagnostic of higher level clades (Brown *et al.*, 2002; Brown, 2004; Brown and Gonzales, 2007).

Herpetological field surveys undertaken in forested karst formations across the Philippines have recurrently resulted in the discovery of new and endemic species of frogs and lizards (e.g., Brown and Alcalá, 1970, 1982a; Rosler *et al.*, 2006; Siler *et al.*, 2007, 2009; Linkem *et al.*, 2010). Karst-obligate species are found inhabiting microhabitats such as limestone caves and inside deep crevices or on the surface of limestone boulders, cliffs, and outcrops (Brown and Alcalá, 1982a; Siler *et al.*, 2007, 2009; Linkem *et al.*, 2010). The continued field observations indicate that karst ecosystems may have an important role in the evolution of endemic and specialized forms of amphibians and reptiles in the Philippines.

Herpetological surveys were conducted on four separate occasions in 2009 in Biak Na Bato National Park, a nature reserve located in the east-central region of Luzon Island (Fig. 1). Surveys were conducted on January 17, February 1–2, March 15–16, and November 21. Among the species recorded during the field surveys include a striking form of *Platymantis* that was found inhabiting karst habitats within the Park.

Despite its moderately expanded finger and toe discs, typical of semi- to fully-arboreal species within the genus *Platymantis*, the new species appears restricted to terrestrial microhabitats. This combination of disc expansion and preference for terrestrial limestone substrates is characteristic of species of *Platymantis* that are known to be karst habitat-specialists. Among these species are *P. insulatus* from the island of South Gigante (Brown and Alcala, 1970; Brown and Alcala, 2000), *P. spelaeus* from Negros (Brown and Alcala, 1982a), *P. paengi* from Panay (Siler *et al.* 2007), and *P. bayani* from Samar (Siler *et al.*, 2009). Herein we describe a fifth karst-associated species of *Platymantis* from the island of Luzon and report on its natural history, ecology, and habitat.

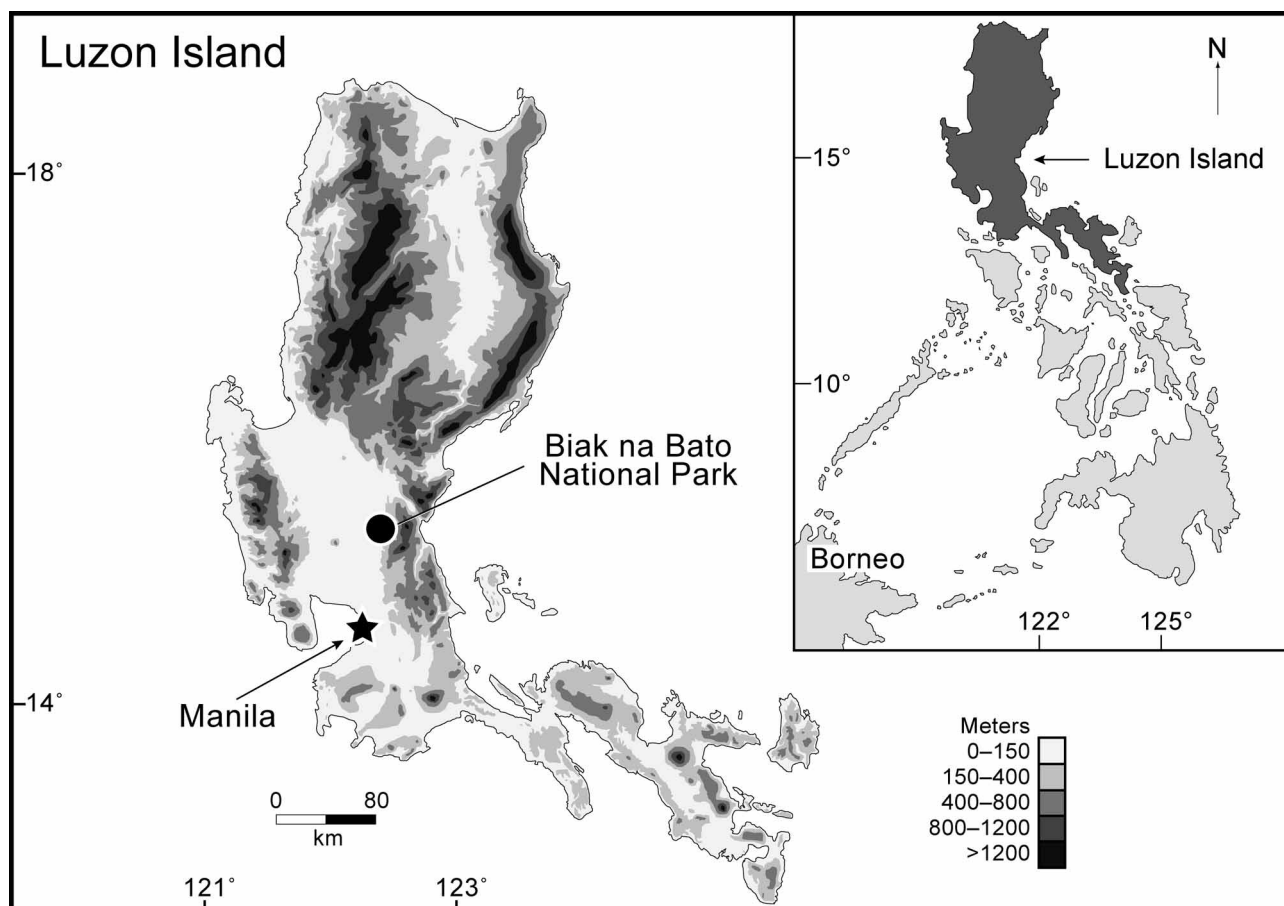


FIGURE 1. Known occurrence of *Platymantis biak* in northern Luzon Island, Philippines (black dot). The inset shows the location of Luzon Island (darkly shaded) within the Philippines.

Materials and methods

Morphological data. We recorded morphometric data from alcohol-preserved specimens that were fixed in 10% formalin (see Specimens Examined). Sex was determined by gonadal inspection, and measurements were taken with digital calipers to the nearest 0.1 mm. All measurements were scored by ACD and CWL. Descriptions of coloration were based on digital photographs and field notes of CWL. Characters measured follow the definitions of Siler *et al.* (2007) and include: snout–vent, head, snout, upper arm, forearm, tibia, femur, tarsus, foot, manus, Toe IV, Finger I, and Finger III lengths; eye–narial, snout–narial, interorbital, internarial, and eye–tympanum distances; eye and horizontal tympanic annulus diameters; Finger I disc, Finger III disc, Toe IV disc, Finger III penultimate phalanges, and Toe IV penultimate phalanges widths. In the description, ranges are followed by mean \pm standard deviation in parentheses. Specimens were deposited at the Philippine National Museum (PNM) and Kansas University (KU). We follow Kraus and Allison (2007) in maintaining the masculine formations of species names within the genus *Platymantis*.

Systematics

Platymantis biak sp. nov.

Figs. 2–4

Holotype. PNM 9679 (ACD Field No. 4543; KU 319973), adult male, collected on limestone outcrop in secondary-growth forest (20:00 hr) on 17 January 2009 in Barangay Biak na Bato, Municipality of San Miguel and Doña Remedios Trinidad, Bulacan Province, Luzon Island, Philippines (N 15.1084, E 121.0724; 190 m elevation), by ACD

Paratopotypes. Twenty-three males (KU 319977–78, 319981–82, 319987, PNM 9680, 9681, 9682–83, 9684–9697), eight females (KU 319974–75, 319979, PNM 9674–75, 9676, 9677–78), and seven juveniles (KU 319976, 319980, 319983, PNM 9698–9701) collected on karst formations in secondary-growth forest (18:00–23:00), January–March and November 2009, in Barangay Biak na Bato, Municipality of San Miguel and Doña Remedios Trinidad, Bulacan Province, Luzon Island, Philippines; collected by ACD, CDS, CWL, and. MLD.

Diagnosis. We assign the new species to the genus *Platymantis* on the basis of (1) its moderate body size, (2) absence of interdigital webbing, (3) the presence of a forked omosternum, (4) directly developing reproductive mode, and (5) terrestrial microhabitat preference (Brown and Alcala 1980; Brown *et al.*, 1997; Brown, 2004). *Platymantis biak* can be distinguished from other Philippine congeners by the following combination of characters: body size 32.3–39.9 mm SVL for males, 37.4–42.4 mm SVL for females; digital disc of Finger III 1.9–2.2 × width of penultimate phalanx in males and 1.4–2.4 in females (Fig. 3); Finger I slightly longer than Finger II; finger discs larger than toe discs; smooth skin; spotted flanks absent; supratympanic fold smooth, less protuberant; tympanum completely visible; dorsolateral stripes absent; dorsal folds, ridges, dermal tubercles absent; and a preference for terrestrial microhabitat in karst forest. Mensural and diagnostic differences are provided in Tables 1 and 2.

Description of holotype. A mature male; habitus robust; head broader than body, head length 35.5% snout–vent length, 90.4% head width; snout protruding moderately beyond lower jaw, snout tip comes to moderately sharp point in dorsal and lateral aspects; eyes moderate and protruding anterolaterally, eye diameter 12.7% snout–vent length, 35.9% head length; lips slightly flared and swollen (Fig. 2); interorbital region slightly convex; eye diameter 80.9% snout length, 134.2% eye–narial distance; pupil horizontally elliptical; canthus rostralis anteriorly concave in dorsal aspect; loreal region moderately concave, sloping ventrolaterally to labium; nostrils oriented posterolaterally; eye–narial distance 60.3% snout length; internarial region slightly concave; tympanic annulus distinct 56.8% eye diameter; supratympanic fold slightly protuberant, extending from posterior corner of eye across dorsal margin of tympanum to supra-axillary region.

Tongue elongate, wider posteriorly, with deep posterior notch and narrow anterior attachment; choanae situated at anterolateral edge of palate, oval, separated by distance two times greater than diameter of single choana; dentigerous process of vomer distinct, with no teeth visible on process; dentigerous process angled slightly anterolaterally, approximately at 20–30° incline with closest (posterior) points separated by distance equal to 2.0 × diameter of single choana, their most distant (anterior) ends separated by distance equal to 3.0 × diameter of single choana.

Hand length 54.6% foot length; tibia length 113.0% foot length, 54.3% snout–vent length; fingers slender, long; terminal discs moderately expanded (Fig. 3A) with pronounced distal, circum-marginal groove; dorsal surfaces of terminal phalanges with small, cutaneous supra-articular flaps between ultimate and penultimate phalanges; relative lengths of fingers II < I < IV < III; subarticular tubercles prominent, convex, smooth; one subarticular tubercle below Digits I and II, two tubercles under Digits III and IV; supernumerary tubercles present at bases of Digits I–IV, distinct, round, prominent for Digits II–IV; inner metacarpal tubercle enlarged, elongate, oval shaped; outer metacarpal tubercle fully divided into round, slightly raised postaxial tubercle equal in size to supernumerary tubercle, and oval preaxial tubercle equal in size to preaxial metacarpal tubercle; nuptial pads absent; forearms slender, not hypertrophied.

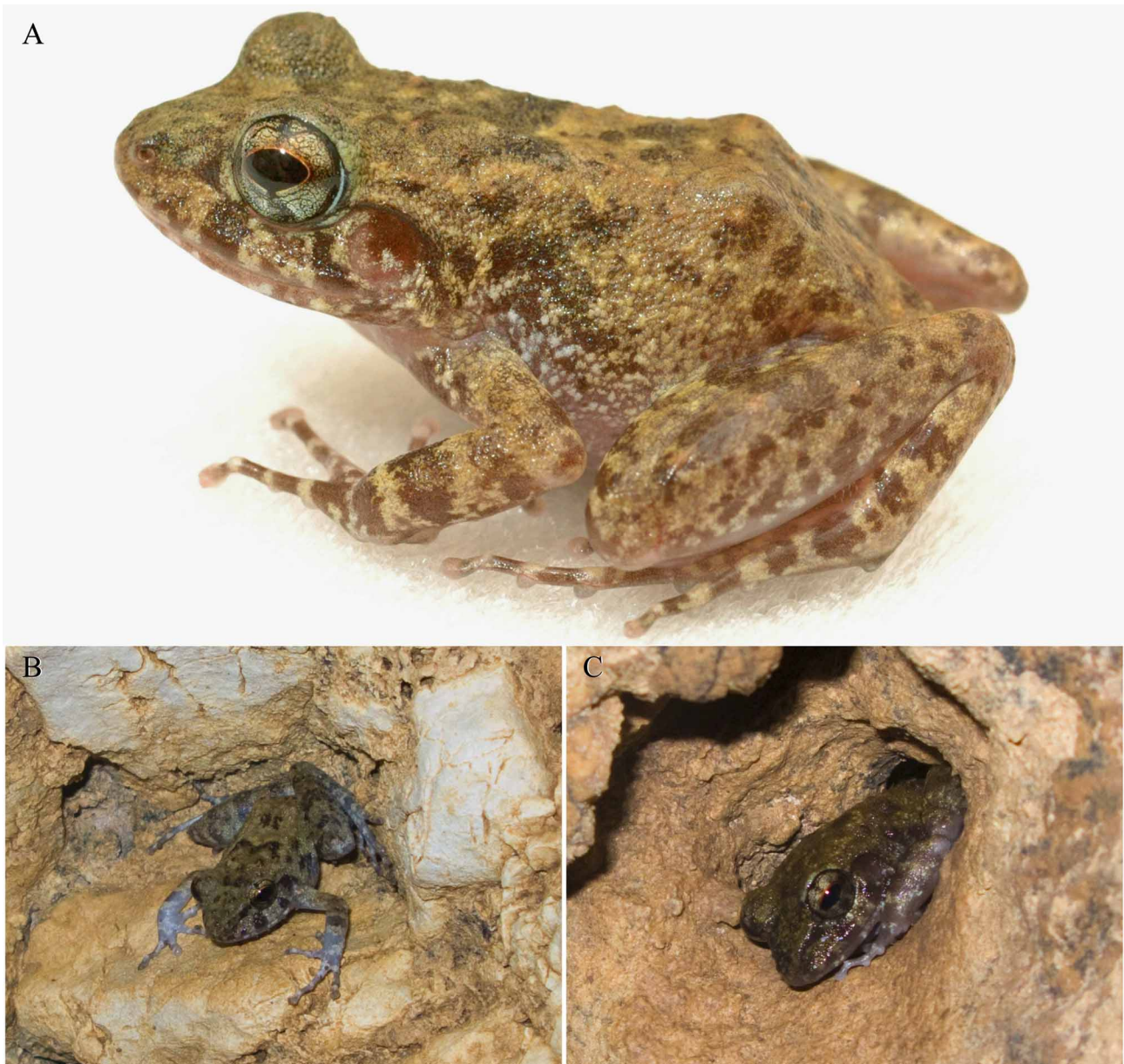


FIGURE 2. Photographs in life of *Platymantis biak* paratopotypes exhibiting (A) typical limestone-forest frog mottled color pattern, PNM 9678, female, SVL = 40.7 mm, and (B, C) perching behavior observed at type locality, PNM 9674, female, SVL = 40.8 mm. Photographs by A. Diesmos and C. Linkem.

Skin of dorsal and ventral surfaces of head, trunk, and limbs smooth. Terminal discs of toes slightly expanded, with circum-marginal grooves; supra-articular cutaneous flaps above ultimate-penultimate phalangeal articulations; plantar surface of foot smooth, with well-developed, prominently rounded subarticular tubercles (Fig. 3B); supernumerary tubercles absent; relative lengths of toes $I < II < V < III < IV$; outer metatarsal tubercle small, round; inner metatarsal tubercle moderately prominent, elongate, length 1.7 x length of round, pointed, outer, metatarsal tubercle.

Measurements of holotype (in mm). Snout-vent length 39.9; head length 14.2; head width 15.7; snout length 6.3; upper arm length 9.0; forearm length 9.3; tibia length 21.7; femur length 20.4; tarsus length 9.4; foot length 19.2; hand length 10.5; Finger I length 7.6; Finger III length 7.6; Toe IV length 10.4; eye-narial distance 3.8; snout-narial distance 2.0; interorbital distance 3.3; internarial distance 3.2; eye-tympanum distance 0.8; eye diameter 5.1; horizontal tympanic annulus diameter 2.9; Finger I disc width 1.2; Finger III disc width 1.8; Toe IV disc width 1.2; Finger III penultimate phalange width 0.6; Toe IV penultimate phalange width 0.5.

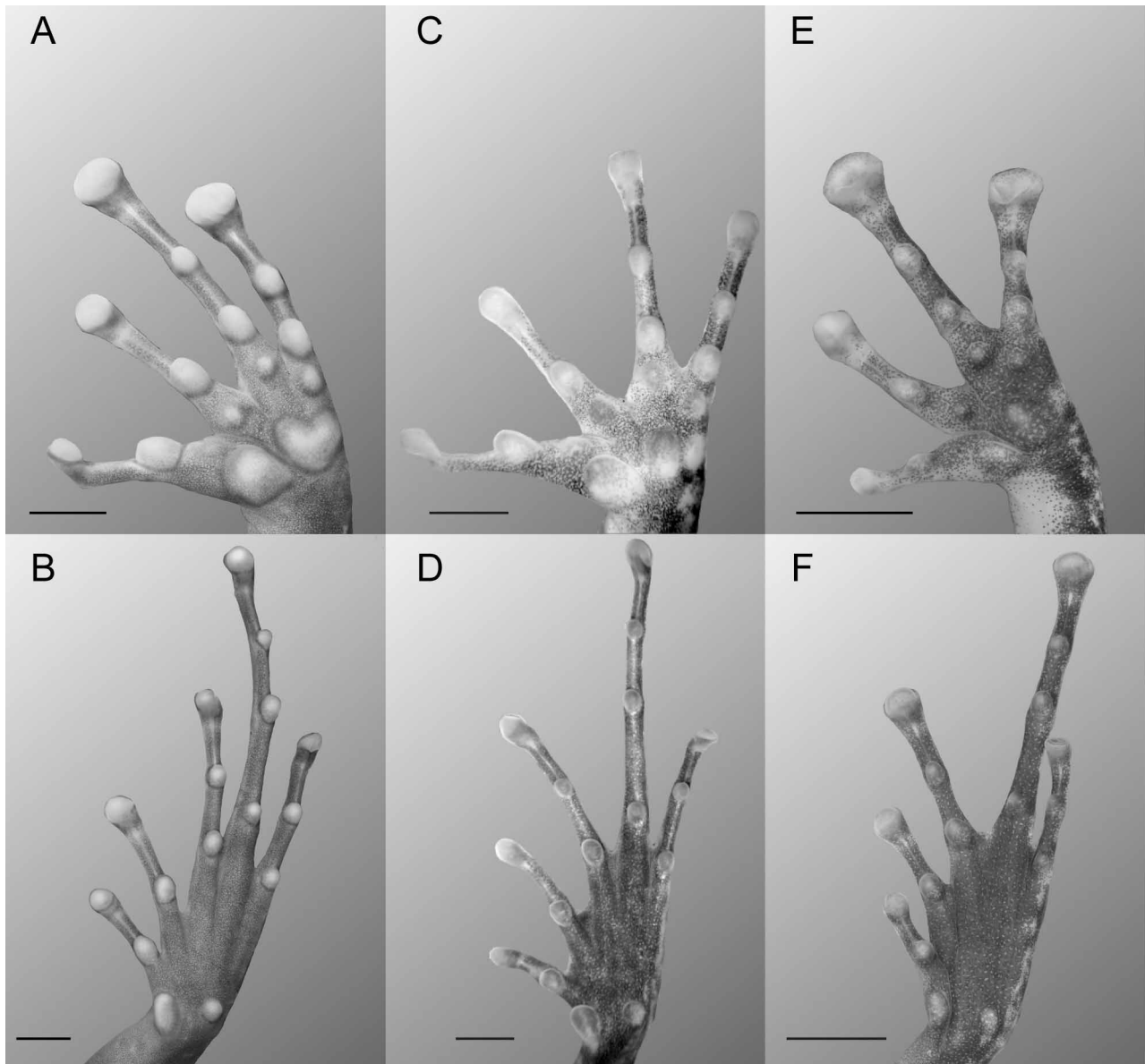


FIGURE 3. Ventral views of hand (A) and foot (B) of female paratopotype of *Platymantis biak* (KU 319974), hand (C) and foot (D) of male *Platymantis dorsalis* (KU 300356), and hand (E) and foot (F) of male *Platymantis guentheri* (KU 306324). Scale bar = 2 mm.

Coloration of holotype in preservative. The dominant dorsal color pattern on the head and body consists of dark mottled blotches of black interspersed with blotches of dark shades of brownish green. The dorsal surfaces of the limbs are banded with alternating black and dark green bars, separated by thin tan bands. An interorbital bar is present consisting of a thin, irregular, light-brown line. The head and snout region are darker than the dorsum, and nearly uniform black. A black bar extends across the dorsal half of the canthus rostralis to the anterior edge of eye. The tympanum is medium brownish-green with a dark blotch extending posterodorsally from the center. The temporal region is predominantly black with several small blotches of dark green. Lip coloration consists of alternating dark green and black vertical labial bars, bordered anteriorly by black lower edge of canthal and subocular regions. The transverse bars on the limbs have irregular widths, with an overall lighter coloration when compared to the dorsum due to the greater proportion of skin covered by tan and dark green bands. Arm banding patterns coalesce into mottled patterns on the elbows. Four black bars are present on the forearms, thighs, and tibia, with three bars present on the tarsus. Anterior flank coloration is predominantly black, progressively fading to lighter grayish-tan with dark brown blotches and

spots, blending into a black, dark brown, and tan mottled pattern posteriorly. The dorsal surfaces of the hands are light brown, with alternating bands of light brown and grayish-tan on Fingers I–III, and dark brown and grayish-tan on Finger IV. The dorsal surfaces of the feet are colored with alternating bands of light brown and grayish-tan.

The throat and chest are marbled light cream with several small tan speckles, while the periphery of the throat and lower lips are darker, with the anterior edge of the lower lip possessing an irregular outline of dark green blotches. The belly is homogeneous light tan bordered by light cream spots laterally. Ventral coloration on the arms consists of light tan coloration present on the upper arm and interior portions of the forearm, and dark green coloration present on the outer portions of the forearm and hand. Ventral surfaces of the thighs uniformly mottled cream anteriorly and light green-brown posteriorly. This coloration blends gradually down the legs into a homogenous dark brown color pattern on the tarsus and foot, similar to the dark coloration observed on the forearms. The subarticular tubercles of the hands and feet are light cream, and the iris is dark blue-gray around the pupil.



FIGURE 4. Photographs in preservative of *Platymantis biak* holotype (PNM 9679) in dorsal and lateral views of head. Scale bar = 5 mm.

TABLE 1. Summary of qualitative diagnostic characters (present, absent) in *Platymantis biak* and specimens of other members of the *P. guentheri* Species Group. Sample size for each sex, body size, eye diameter, digit disk proportions, and general geographical distribution (PAIC = Pleistocene Aggregate Island Complexes, sensu Brown and Diesmos, 2002) are included for reference (SVL and ED given as range over mean \pm standard deviation; digit disk proportions given as percentage over mean \pm standard deviation). Only adult specimens in good preservation condition were used for morphometric analyses.

	<i>biak</i> sp. nov. (24m, 8f)	<i>bayani</i> (9m, 9f)	<i>insulatus</i> (8m, 6f)	<i>negrosensis</i> (3m, 2f)	<i>luzonensis</i> (9m, 2f)
Range	Central Luzon Island	Samar Island	Gigantes Islands	Negros and Panay Islands	Luzon PAIC
SVL (m)	32.3–39.9 (35.9 \pm 1.8)	34.2–39.1 (37.1 \pm 1.8)	34.3–38.0 (36.7 \pm 1.3)	28.3–35.7 (31.1 \pm 4.0)	24.1–32.5 (29.7 \pm 2.4)
SVL (f)	37.4–42.4 (40.1 \pm 1.5)	44.3–49.8 (46.4 \pm 2.1)	40.2–42.9 (41.8 \pm 1.0)	41.7–42.2 (42.0 \pm 0.3)	32.6–33.8 (33.2 \pm 0.8)
ED (m)	3.3–5.2 (4.3 \pm 0.5)	4.8–6.1 (5.5 \pm 0.5)	3.7–4.9 (4.2 \pm 0.4)	3.1–4.1 (3.7 \pm 0.6)	2.7–3.9 (3.4 \pm 0.4)
ED (f)	4.3–5.2 (4.9 \pm 0.3)	5.4–6.8 (6.1 \pm 0.4)	5.1–5.7 (5.3 \pm 0.2)	4.4–4.7 (4.6 \pm 0.2)	3.6–3.9 (3.7 \pm 0.2)
Fin3DW/PpFin3 (m)	1.4–3.4 (2.1 \pm 0.5)	2.7–4.0 (3.3 \pm 0.4)	2.7–3.1 (2.9 \pm 0.1)	2.6–2.8 (2.7 \pm 0.1)	2.2–3.3 (2.8 \pm 0.4)
Fin3DW/PpFin3 (f)	1.4–2.7 (2.2 \pm 0.4)	2.8–4.5 (3.9 \pm 0.5)	2.3–2.8 (2.7 \pm 0.2)	3.5–4.7 (4.1 \pm 0.8)	3.0–3.2 (3.1 \pm 0.2)
Toe4DW/PpToe4 (m)	1.3–2.4 (1.7 \pm 0.3)	2.1–3.3 (2.8 \pm 0.4)	1.9–3.4 (2.6 \pm 0.4)	1.8–1.9 (1.8 \pm 0.1)	1.6–2.2 (1.9 \pm 0.2)
Toe4DW/PpToe4 (f)	1.6–3.1 (2.1 \pm 0.5)	2.9–3.7 (3.1 \pm 0.3)	2.0–2.6 (2.3 \pm 0.3)	1.8–1.8 (1.8 \pm 0.0)	1.8–1.9 (1.8 \pm 0.1)
Fin3DW/ Toe4DW (m)	0.9–1.7 (1.2 \pm 0.2)	1.1–1.5 (1.3 \pm 0.1)	1.1–1.5 (1.3 \pm 0.1)	1.8–2.0 (1.9 \pm 0.1)	1.6–2.0 (1.7 \pm 0.1)
Fin3DW/Toe4DW (f)	0.9–1.4 (1.2 \pm 0.2)	1.2–1.5 (1.3 \pm 0.1)	1.2–1.6 (1.4 \pm 0.1)	1.7–2.0 (1.9 \pm 0.3)	2.0–2.1 (2.1 \pm 0.1)
Greatly expanded digital disks	+, moderate	+	+	+	+
Dorsal skin rugosity	–	– to granular	–	+	+
Dorsal dermal tubercles	–	+, sparse	–	+	+
Tubercle color	N/A	Salmon	N/A	Cream	Dominant dorsal color
Dorsal folds/ridges	–	–	–	+	+
Tympanum hidden	No	No	No	Posterodorsal edge	Posteroventral edge
Supratympanic fold	Smooth, less prominent	Smooth, less prominent	Smooth, not prominent	Rugose, prominent	Rugose, prominent
Dorsolateral stripes	–	–	–	+	+ or –
Spotted flanks	–, blotches anteriorly	+	+	–	–
Limb bands	+, well defined	+, well defined	+ or –, poorly defined	+, well defined	+, well defined
Microhabitat preference	Ground, karst habitat	Ground; karst habitat	Ground; karst habitat	Arboreal	Arboreal

Table 1. continued.

	<i>rabori</i> (2m, 6f)	<i>guentheri</i> (11m, 8f)	<i>banahao</i> (4m)	<i>cornutus</i> (3m)	<i>diesmosi</i> (8m, 2f)
Range	Mindanao PAIC	Mindanao PAIC	SE Luzon Island	N. Luzon Island	SE Luzon Island
SVL (m)	30.4–33.5 (32.0 ± 2.2)	26.5–29.8 (28.6 ± 1.1)	32.4–36.3 (33.9 ± 1.7)	26.3–30.4 (27.8 ± 2.2)	28.5–39.2 (35.3 ± 3.6)
SVL (f)	36.4–44.4 (41.5 ± 3.6)	32.3–37.3 (34.6 ± 2.0)	N/A	N/A	49.0–52.6 (50.8 ± 2.6)
ED (m)	3.8–3.9 (3.9 ± 0.1)	2.8–3.6 (3.3 ± 0.3)	3.6–4.1 (3.8 ± 0.2)	3.0–4.2 (3.5 ± 0.6)	3.7–5.4 (4.7 ± 0.5)
ED (f)	4.0–5.7 (4.9 ± 0.7)	3.7–4.5 (3.9 ± 0.3)	N/A	N/A	5.9–6.1 (6.0 ± 0.1)
Fin3DW/ PpFin3 (m)	2.8–3.5 (3.2 ± 0.5)	2.4–5.2 (3.2 ± 0.8)	2.8–3.2 (3.0 ± 0.2)	2.5–2.9 (2.7 ± 0.2)	1.5–2.1 (1.7 ± 0.2)
Fin3DW/PpFin3 (f)	3.3–4.2 (3.6 ± 0.3)	2.6–5.7 (4.0 ± 1.2)	N/A	N/A	1.6–1.7 (1.6 ± 0.1)
Toe4DW/PpToe4 (m)	2.0–2.7 (2.3 ± 0.5)	1.5–3.5 (2.4 ± 0.6)	1.9–2.3 (2.0 ± 0.2)	1.6–2.0 (1.7 ± 0.2)	1.2–2.2 (1.7 ± 0.4)
Toe4DW/PpToe4 (f)	1.6–2.5 (2.3 ± 0.3)	2.3–4.3 (3.2 ± 0.7)	N/A	N/A	1.7–2.1 (1.9 ± 0.3)
Fin3DW/Toe4DW(m)	1.3–1.6 (1.4 ± 0.2)	1.2–1.7 (1.4 ± 0.1)	1.8–1.9 (1.8 ± 0.0)	1.9–2.1 (2.0 ± 0.1)	0.9–1.4 (1.1 ± 0.2)
Fin3DW/Toe4DW (f)	1.4–1.9 (1.6 ± 0.2)	1.1–1.7 (1.4 ± 0.2)	N/A	N/A	0.8–0.8 (0.8 ± 0.0)
Greatly expanded digital disks	+	+, moderate	+	+	–
Dorsal skin rugosity	+	+	– to granular	–	– to granular
Dorsal dermal tubercles	+, dense	+	+	–	–
Tubercle color	Dominant dorsal color	Dominant dorsal color	Dominant dorsal color	N/A	N/A
Dorsal folds/ridges	+	+	–	–	–
Tympanum hidden	Posterior edge	Posteroventral edge	Posterodorsal edge	No	Posterodorsal edge
Supratympanic fold	Rugose, prominent	Smooth, less prominent	Smooth, less prominent	Smooth, not prominent	Smooth, less prominent
Dorsolateral stripes	+ or –	+ or –	–	+	–
Spotted flanks	–	–	–	–	–
Limb bands	+, well defined	+, well defined	+ or –, faint	+, poorly defined	+, well defined
Microhabitat preference	Arboreal	Shrub/Arboreal	Arboreal	Arboreal	Ground; cliff edges

Coloration in life. Dorsum and head mottled light green, dark green, and black (Fig. 4); interorbital bar distinct, black, and bordered anteriorly by lighter, green-brown border; lower surfaces of supratympanic fold black; black canthal blotch located just anterior to eye; black labial blotch located below eye, anterior to tympanic annulus; dorsal surfaces of limbs with alternating dark brown and green transverse bars, each bordered by thin cream transverse bars; dorsal surface of body with several large black blotches, irregularly distributed; area of black blotches and cream speckles on anterior portion of flanks; pupil bordered by copper ciliary ring of iris, sharply blending into predominant mottled gold and brown color pattern of iris.

TABLE 2. Summary of mensural characters (in mm) and selected qualitative diagnostic characters (present, absent) in *Platymantis biak* and other Philippine limestone forest frog species. Sample size, body size, species group, and general geographical distribution are included for reference (SVL given as range).

	<i>biak</i> sp. nov. (12m, 4f)	<i>bayani</i> (9m, 9f)	<i>insulatus</i> (8m, 6f)	<i>spelaeus</i> (4m, 3f)	<i>paengi</i> (15m)
SVL (m)	32.3–39.9	34.2–39.1	34.3–38.0	37.1–44.3	27.7–34.3
SVL (f)	37.4–42.4	44.3–49.8	40.2–42.9	53.5–57.5	N/A
Range	Central Luzon Island	Samar Island	Gigantes Islands	SW Negros Island	NW Panay Island
Species Group	guentheri	guentheri	guentheri	dorsalis	dorsalis
Digital disks	Moderately expanded	Widely expanded	Widely expanded	Non-expanded	Non-expanded
Dorsal skin rugosity	–	– to granular	–	+, –	+
Dorsal dermal tubercles	–	+, sparse	–	+, small	+
Flanks	Blotches anteriorly	Spotted	Spotted	Immaculate	Spotted

Variation. Dominant color pattern consistently mottled in all observed specimens. Variation exists in the w-shaped pattern of pigmentation on the dorsal surface of the body in line with the forearms. Some individuals possess a sharply defined w-shaped pattern (KU 319976, 319980, 319982–83, 319987, PNM 9684–86, 9688–89, 9691, 9693, 9695, 9697, 9700), while the pattern on many other specimens is either obscured by the background body coloration or is vaguely defined (KU 319973–75, 319977–79, 319981, PNM 9698–99, 9680–83, 9674–76, 9687, 9690, 9692, 9694, 9696, 9677–78, 9701, 9704–14). The outer metacarpal tubercle was fully divided in most individuals with the exception of a few individuals showing a single, large, connected outer metacarpal tubercle (KU 319974, 319980, 319981, 319983, 319987). Females are considerably larger and more robust. Summaries of univariate morphological variation in the series are presented in Table 3.

Distribution. *Platymantis biak* is known only from the type locality (Fig. 1).

Ecology and natural history. *Platymantis biak* occurs in secondary-growth forest on karst substrate. Both males and females were observed perched on top of limestone rocks within large rock formations in the forest and around the entrances to cave systems. Additionally, males were observed up to 5 meters inside caves, some perched above the ground within depressions and holes in the karst rock walls (Fig. 2B, C). No specimens were observed perching in trees or shrubs, in contrast to the common behavior of most species in the *P. guentheri* Group (Brown and Gonzales, 2007).

Some individuals of *Platymantis biak* were well camouflaged against the limestone (much like *P. bayani*, *P. insulatus*, *P. speleaus*, and *P. paengi*; Fig. 2B, C), and field workers found it difficult to locate and capture individuals against the limestone substrate. This was especially true for many of the females. However, males were often more conspicuous while calling atop rocky outcrops. When disturbed, the new species immediately jumped back into the rocks and escaped into limestone crevices. No egg masses or juveniles were found; other species of *Platymantis* have direct development (Brown and Alcalá, 1982a,b). *Platymantis speleaus* has been observed by one of us (CDS) to deposit direct-developing eggs in limestone crevices and the same is suspected for *P. insulatus* (Brown and Alcalá, 2000). We assume that this species also breeds in limestone crevices and small caves (Brown and Alcalá, 2000; Brown *et al.*, 2003).

Sympatric anuran species include *Rhinella marina* (introduced), *Hoplobatrachus rugulosus* (introduced), *Kaloula picta*, *K. pulchra* (introduced), *Limnonectes macrocephalus*, *L. woodworthi*, *Occidozyga laevis*, *Platymantis cf. mimulus*, *Polypedates leucomystax*, *Rana erythraea* (introduced), and *R. similis*.

Etymology. We derive the specific epithet from the Tagalog term *biak*, meaning "crevice" or "crack," in reference to the preferred limestone karst habitat at the type locality, Biak na Bato (meaning "cracked rock" or "fragmented stone"), Bulacan Province.

TABLE 3. Summary of univariate morphological variation among mensural characters in the type series of *Platymantis biak*.

	Female <i>n</i> = 8	Male <i>n</i> = 24
SVL	37.4–42.4 (40.1 ± 1.5)	32.3–39.9 (35.9 ± 1.8)
HL	14.9–17.3 (15.7 ± 0.7)	11.8–16.0 (13.6 ± 0.9)
END	3.8–4.4 (4.1 ± 0.2)	3.2–3.9 (3.6 ± 0.2)
SNL	5.9–7.2 (6.6 ± 0.6)	5.1–6.4 (5.9 ± 0.4)
IOD	3.1–4.3 (3.6 ± 0.4)	2.6–4.2 (3.4 ± 0.4)
IND	3.0–4.0 (3.6 ± 0.4)	2.6–3.6 (3.2 ± 0.3)
ED	4.3–5.2 (4.9 ± 0.3)	3.3–5.2 (4.3 ± 0.5)
TAD	3.3–4.3 (3.8 ± 0.3)	2.7–4.0 (3.4 ± 0.3)
ETD	0.5–1.5 (0.8 ± 0.3)	0.3–1.4 (0.7 ± 0.2)
HW	15.1–17.2 (16.1 ± 0.7)	12.5–15.7 (14.1 ± 0.9)
UA	7.9–9.6 (8.6 ± 0.6)	7.2–9.7 (8.5 ± 0.7)
FAL	9.4–11.2 (10.0 ± 0.6)	7.9–10.3 (9.2 ± 0.7)
FL	18.8–22.0 (20.7 ± 0.9)	16.7–21.0 (18.8 ± 1.2)
TBL	20.0–23.6 (21.0 ± 1.1)	16.7–21.7 (19.0 ± 1.4)
TSL	10.3–18.6 (12.3 ± 2.7)	9.4–12.5 (10.8 ± 0.9)
PL	11.3–19.4 (17.8 ± 2.7)	14.7–20.4 (17.5 ± 1.5)
ML	10.3–12.1 (11.1 ± 0.6)	7.8–12.4 (10.2 ± 1.1)
Toe4L	10.8–13.4 (12.1 ± 0.8)	9.6–12.8 (11.4 ± 1.0)
Fin1L	5.4–7.3 (6.3 ± 0.8)	4.1–7.6 (5.5 ± 0.9)
Fin3L	7.6–8.8 (8.1 ± 0.5)	6.5–8.6 (7.6 ± 0.5)
Fin1DW	0.8–1.2 (1.1 ± 0.1)	0.8–1.2 (0.9 ± 0.1)
Fin3DW	1.3–1.9 (1.6 ± 0.2)	0.1–1.2 (1.3 ± 0.2)
Toe4DW	1.0–1.5 (1.3 ± 0.2)	0.7–1.3 (1.1 ± 0.2)
PpFin3	0.5–0.9 (0.7 ± 0.1)	0.4–0.9 (0.7 ± 0.1)
PpToe4	0.4–0.9 (0.7 ± 0.2)	0.5–0.8 (0.7 ± 0.1)

Comparisons. The new species is assignable to the *P. guentheri* Group (*P. banahao*, *P. bayani*, *P. cornutus*, *P. diesmosi*, *P. guentheri*, *P. insulatus*, *P. luzonensis*, *P. negrosensis*, and *P. rabori*) based on the following combination of characters: digital discs moderately expanded and larger in fingers than in toes, proximal portions of digits with narrow dermal folds in cross section, and subarticular tubercles large and highly protuberant (Brown *et al.*, 1997c; Fig. 3).

The new species is morphologically most similar to *Platymantis bayani* and *Platymantis insulatus*, the other two members of the *P. guentheri* Group with similar morphology and preference for karst forest microhabitats (Tables 1 and 2). *Platymantis biak* is distinguished from *P. bayani* and *P. insulatus* by the presence of moderately (vs. widely) expanded digital discs and the absence of fully spotted flanks (vs. spotted). From *Platymantis bayani*, the new species differs by its smaller female body size (maximum SVL 42.4 mm for *P. biak* vs. 49.8 mm for *P. bayani*), smaller eye diameter (maximum ED 5.2 mm for *P. biak* vs. 6.8 mm for *P. bayani*), and the absence of granular skin (vs. absence or presence) and dorsal dermal tubercles (vs. presence). The new species further differs from *Platymantis insulatus* by the presence of well-defined limb banding patterns (vs. absence or presence and poorly defined). Additional characters for distinguishing the new species from all species of the *P. guentheri* Group are summarized in Tables 1 and 2.

From all members of the *P. dorsalis* Group (*P. cagayensis*, *P. corrugatus*, *P. dorsalis*, *P. indeprensus*, *P. levigatus*, *P. mimulus*, *P. naomiae*, *P. paengi*, *P. pseudodorsalis*, *P. pygmaeus*, *P. spelaeus*, and *P. taylori*), *Platymantis biak* is distinguished by the presence (vs. absence) of moderately expanded digital discs (Fig. 3) and larger finger discs than toe discs. *Platymantis biak* is further distinguished from all members of the *P. dorsalis* Group, except *P. levigata* by the absence of dorsal folds and ridges, dermal tubercles, and rugose skin (vs. presence of one, two, or all characters), and from all members except *P. paengi* and *P. spelaeus*, by its microhabitat preference (terrestrial substrates in limestone forest vs. leaf litter of forest floor and/or herb-layer vegetation in *P. cagayensis*, *P. corrugatus*, *P. dorsalis*, *P. indeprensus*, *P. mimulus*, *P. naomiae*, *P. pseudodorsalis*, *P. pygmaeus* and *P. taylori*, or river banks and rocks in *P. levigatus*). From *P. cagayensis*, *P. corrugatus*, *P. dorsalis*, *P. indeprensus*, *P. mimulus*, *P. naomiae*, *P. pygmaeus* and *P. taylori*, the new species is distinguished by the absence (vs. presence) of dorsal folds and ridges.

The new species is distinguished from all *P. hazelae* Group species (*P. hazelae*, *P. isarog*, *P. lawtoni*, *P. montanus*, *P. panayensis*, *P. polillensis*, *P. sierramadrensis*, *P. subterrestris*) by its larger body size; the first finger slightly longer than the second; narrow dermal phalanges on the digits; protuberant (vs. flattened) subarticular tubercles, and a preferred microhabitat of terrestrial substrates in limestone forest (vs. arboreal habitat, and/or shrub-layer vegetation).

Discussion

The description of *Platymantis biak* increases the number of recognized Philippine *Platymantis* to 29 species. Nonetheless, a twofold increase in species diversity of Philippine *Platymantis* is expected upon the completion of ongoing taxonomic work on this group (Brown, 2004; Brown *et al.*, 2008, unpublished data). The frequency with which new species of *Platymantis* are being discovered (e.g., Brown *et al.*, 1997*a,b,c*; Alcala *et al.*, 1998; Foufopoulos and Brown, 2004; Brown and Gonzales, 2007; Siler *et al.*, 2007, 2009; Brown *et al.*, 2006*a,b*) has been a direct outcome of a recent upsurge in field surveys of unexplored (and incompletely surveyed) areas across the Philippines, combined with detailed analyses of advertisement calls, morphological diversity, microhabitat preferences, and gene sequence data (Brown, 2004). This high rate of new species discoveries is similarly exhibited by other groups of amphibians and reptiles in the Philippine (Brown *et al.*, 2008), indicating that the diversity of Philippine amphibians and reptiles continues to be underestimated (Brown, 2009; Brown *et al.*, 2002; Diesmos *et al.*, 2002; Brown *et al.*, 2008).

Prior to a recent phylogenetic study (Brown 2004), Philippine frogs of the genus *Platymantis* were differentiated into three species groups on the basis of external morphology with emphasis on digital characters (Brown *et al.*, 1997*a,b*). Among these is the *guentheri* Group, characterized as having moderate to broad terminal discs on fingers and toes. Although most members of this species group are known to be arboreal (Brown *et al.*, 1997*b*), several species (including *P. biak*) are terrestrial forms, and were shown to have secondarily arisen from arboreal lineages that have reinvaded terrestrial habitats (Brown, 2004). *Platymantis biak* is the first karst-associated species to be described from Luzon. We are aware of at least one additional new species of *Platymantis* that occurs in similar habitats in other localities of Luzon Island (Brown and Diesmos, unpublished data). These and other data indicate that a number of undescribed species may exist in karst habitats occurring in various regions of Luzon.

The mottled color pattern of *P. biak* resembles *P. spelaeus*, *P. insulatus*, *P. paengi*, and *P. bayani*. The close similarity in color patterns among all known karst-associated Philippine frogs suggests the possibility of convergent selection on color pattern in limestone habitats. As with many parts of Southeast Asia (Clements *et al.*, 2007), karst ecosystems are severely threatened in the Philippines. Karst ecosystems are among the most heavily degraded habitats as a direct cause of human-related activities (Brown and Alcala, 2000). As a consequence, the unique and poorly studied biodiversity found in limestone karsts is correspondingly imperiled. For instance, most Philippine species of vertebrates that are known to be restricted to this habitat are recognized as “Threatened” by the IUCN (World Conservation Union; IUCN, 2009), suggesting that government efforts to institute measures affording legal protection to this fragile resource are warranted. One

such measure already in existence is Republic Act 9072 (“National Caves and Cave Resources Management and Protection Act”; <http://www.pawb.gov.ph/>). However, this important environmental legislation is currently restricted to the protection of limestone caves and associated natural and man-made resources. Such initial legislative efforts need to be expanded to include all karst formations if the majority of karst-associated biodiversity are to be conserved.

While we are convinced of the critical importance of karst ecosystems to the evolution, ecology, and conservation of amphibians and reptiles in the Philippines, the subject necessitates a comprehensive review in order to provide conservationists readily available information that can be integrated into existing habitat protection and management programs. In addition, immediate and exhaustive faunal surveys, ecological and life history studies, and an examination of the effects of habitat degradation and fragmentation on karst-associated biodiversity are warranted to accurately assess the conservation status of the karst endemic animals and plants of the Philippines.

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Specimens examined

All specimens examined are from the Philippines. Numbers in parentheses indicate the number of specimens examined for each species.

Platymantis banahao (6 specimens): LUZON ISLAND, QUEZON PROVINCE, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: TNHC 61968–71, PNM 9248–49.

Platymantis bayani (21 specimens): SAMAR ISLAND, EASTERN SAMAR PROVINCE, *Municipality of Taft*, Barangay San Rafael: PNM 9501 (Holotype), 9515–22 (Paratopotypes), KU 309252–54, 309256, 309258–59, 309261, 309263–64, 309266–67, and 309269 (Paratopotypes)

Platymantis cagayanensis (9 specimens): LUZON ISLAND, CAGAYAN PROVINCE, “Tagat Forest Reserve near Santa Praxedes Town:” PNM 7564, 7578, 7496–99, 7506, 7608, 7526.

Platymantis cornutus (3 specimens): LUZON ISLAND, KALINGA PROVINCE, *Municipality of Balbalan*, Barangay Balbalan: CAS 231498, 231501, CMNH 8128.

Platymantis corrugatus (22 specimens): CAMIGUIN ISLAND, CAMIGUIN PROVINCE, *Municipality of Guinsiliban*, Barangay Cabuan: KU 300351, 300355; POLILLO ISLAND, QUEZON PROVINCE, *Municipality of Polillo*, Barangay Pinaglubayan, 62 m elevation, 14° 45' 9.3" N, 121° 58' 5.52" E: KU 300350, 300352–54; NEGROS ISLAND, NEGROS ORIENTAL PROVINCE, *Municipality of Valencia*, Barangay Bongbong, Camp Lookout, Cuernos de Negros Mt. Range, Mt. Talinis, 500 m elevation: TNHC 61972–87.

Platymantis diesmosi (10 specimens): LUZON ISLAND, ALBAY PROVINCE, *Municipality of Tiwi*, Barangay Banhaw: PNM 8499 (Holotype), 8500–1 (Paratypes), TNHC 62040–42 (Paratypes), UPLB-MNH 16, 21–23 (Paratypes).

Platymantis dorsalis (22 specimens): NEGROS ISLAND, NEGROS ORIENTAL PROVINCE, *Municipality of Valencia*, Barangay Bongbong, Sitio Tagaytay, Mt. Talinis, 1150 m elevation, 9° 15' 36" N, 123° 12' 196" E: KU 300356–300377.

Platymantis guentheri (19 specimens): DINAGAT ISLAND, SURIGAO PROVINCE, *Municipality of Loreto*, Barangay Esperanza: KU 306321–23, 306325; SAMAR ISLAND, EASTERN SAMAR PROVINCE, *Municipality of Taft*, Barangay San Rafael: KU 309185, 309189, 309191, 309195, 309203, 309217–19, 309221, 309228–30, 309232, 309236, 309238.

Platymantis hazelae (13 specimens): NEGROS ISLAND, NEGROS ORIENTAL PROVINCE, *Municipality of Valencia*, Barangay Bongbong, Sitio Tagaytay, Mt. Talinis, 1150 m elevation: KU 300403–15.

Platymantis indepressus (8 specimens): LUZON ISLAND, QUEZON PROVINCE, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: TNHC 061956-60; PNM 9257–59.

Platymantis insulatus (18 specimens): SOUTH GIGANTE ISLAND, ILOILO PROVINCE, *Municipality of Carles*, Barangay Gabi: CAS 117441 (Holotype), 119967–69 (Paratypes); KU 300338–44, 300346, 309088–89; NORTH GIGANTE ISLAND, ILOILO PROVINCE, *Municipality of Carles*, Barangay Granada: KU 300345, 300347–49.

Platymantis isarog (7 specimens): LUZON ISLAND, CAMARINE SUR PROVINCE, *Municipality of Naga City*, Barangay Panicuason, Mt. Isarog National Park, Mt. Isarog: TNHC 61961–67.

Platymantis lawtoni (1 specimens): TABLAS ISLAND, ROMBLON PROVINCE, *Municipality of San Agustin*, Mt. Progreso: CAS 135733.

Platymantis levigatus (15 specimens): SIBUYAN ISLAND, ROMBLON PROVINCE, *Municipality of Magdiwang*, Barangay Talaba, Mt. Guiting-Guiting Natural Park, 0 m elevation: KU 300416–30.

Platymantis luzonensis (27 specimens): LUZON ISLAND, LAGUNA PROVINCE, *Municipality of Los Baños*, Barangay Batong Malake, Mt. Makiling: CAS 196364, 196369–70, 200404–08, 210544–45 (Paratypes); CAMARINES SUR PROVINCE, *Municipality of Naga City*, Mt. Isarog: FMNH 251643–44; TNHC 62004–09, 62012–13, 62020–24; POLILLO ISLAND, QUEZON PROVINCE, *Municipality of Polillo*, Barangay Pinaglubayan: KU 305541–42.

- Platymantis mimulus* (12 specimens): LUZON ISLAND, LAGUNA PROVINCE, *Municipality of Los Baños*, Barangay Batong Malake, Mt. Makiling: TNHC 54930–31; PNM 9260–69.
- Platymantis montanus* (13 specimens): LUZON ISLAND, QUEZON PROVINCE, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: TNHC 62149–58; CAS 200998–1000.
- Platymantis naomiae* (3 specimens): LUZON ISLAND, QUEZON PROVINCE, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: TNHC 62169–71.
- Platymantis negrosensis* (7 specimens): NEGROS ISLAND, NEGROS ORIENTAL PROVINCE, Cuernos de Negros Mountain Range, Mt. Talinis, 750 m elevation: KU 300439–45.
- Platymantis paengi* (15 specimens): PANAY ISLAND, ANTIQUE PROVINCE, *Municipality of Pandan*, Barangay Duyong: PNM 9239 (Holotype), 9240–43 (Paratopotypes), KU 300206–13 (Paratopotypes), 300204–05 (Paratypes).
- Platymantis panayensis* (2 specimens): PANAY ISLAND, AKLAN PROVINCE, *Municipality of Nabas*: CAS 137641–42.
- Platymantis pseudodorsalis* (4 specimens): LUZON ISLAND, QUEZON PROVINCE, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: KU 207455–57, 207459 (Paratypes).
- Platymantis pygmaeus* (5 specimens): LUZON ISLAND, CAGAYAN PROVINCE, *Municipality of Calveria*, Barangay Mabnang, Mabnang Falls: PNM 7523, 9528–31.
- Platymantis rabori* (12 specimens): MINDANAO ISLAND, NEW BATAAN PROVINCE, Mt. Puting Bato: CMNH 2305, 2350; DAVAO CITY PROVINCE, *Municipality of Toril*, Barangay Baracatan, Sitio Upper Baracatan: CMNH 1462; *Municipality of Calinan*, Barangay Malagos: PNM 9504–05; SAMAR ISLAND, EASTERN SAMAR PROVINCE, *Municipality of Taft*, Barangay San Rafael: KU 309121–27.
- Platymantis sierramadrensis* (6 specimens): LUZON ISLAND, AURORA PROVINCE, *Municipality of San Luis*; Dipiningan branch of the Kobatangan River drainage; 15° 40' 12" N, 121° 20' 48" E: CMNH 5678–79, 5904; ISABELA PROVINCE, *Municipality of Palanan*, Barangay Didian, Sitio Natap Dukan, Northern Sierra Madre National Park, 16° 57' 55.8" N, 122° 24' 13.8" E: CAS 204739–41.
- Platymantis spelaeus* (7 specimens): NEGROS ISLAND, NEGROS ORIENTAL PROVINCE, *Municipality of Basay*, Tiyabanan Barrio: CAS 153477–78, 153482 (Paratypes); NEGROS OCCIDENTAL PROVINCE, *Municipality of Cauayan*, Sitio Banso, Barangay Camalandaan, 320 m elevation: KU 300435–38.
- Platymantis subterrestris* (3 specimens): LUZON ISLAND, MOUNTAIN PROVINCE, Mt Data: CAS 204319–204321.
- Platymantis taylori* (4 specimens): LUZON ISLAND, ISABELA PROVINCE, *Municipality of Palanan*, Barangay Didian, Sitio Natapdukan: CAS 207443–207446 (Paratypes).