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A new forest frog of the genus *Platymantis* (Amphibia: Anura: Ceratobatrachidae: subgenus *Tirahanulap*) from Leyte and Samar islands, eastern Philippines

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Abstract

We describe a new species of Cloud Frog of the genus *Platymantis* Günther (subgenus *Tirahanulap*), ~~which is equivalent~~ to the the previously-defined *P. hazelae* Group~~)~~ from the Philippines based on morphological and bioacoustic datasets. The new species is phenotypically and ecologically most similar to members of *Tirahanulap*, an assemblage of small-bodied arboreal frogs inhabiting montane forests of the central and northern islands of the Philippine archipelago. The new species represents the first taxon in the Cloud Frog species known from the biogeographically unique Mindanao Pleistocene Aggregate Island Complex. Particularly susceptible to local extirpation following deforestation, all known species of *Tirahanulap* are important indicator species for environmental and conservation assessments, making this new species not only an exceptional addition to Philippine biodiversity but also an important symbol for conservation initiatives in the region.

Key words: endemism, forest conservation, Pleistocene Aggregate Island Complex, *Platymantis hazelae* Group, protected areas, Shrub Frogs

Introduction

The megadiverse Philippine archipelago is globally recognized for its high levels of endemic biodiversity (Myers *et al.* 2000; Mallari *et al.* 2001; Carpenter & Springer 2005), estimates of which suggest that the archipelago may possess one of the world's highest concentrations of endemic terrestrial vertebrates (Heaney & Mittermeier 1997; Heaney 2007; Brown & Diesmos 2009). Previously considered to have a depauperate amphibian fauna representing a reduced subset of Southeast Asian and Papuan faunal elements (Inger 1954; Brown & Alcala 1970), the archipelago is now recognized as a major center of amphibian diversity and endemism within the Indomalayan Biodiversity Realm (Brown 2007; Bain *et al.* 2008; Brown & Diesmos 2009; Diesmos & Brown 2011; Brown *et al.* 2013a; Diesmos *et al.* 2014, 2015). Among the amphibian groups exhibiting particularly remarkable diversity, Philippine frogs of the genus *Platymantis* Günther (Alcala & Brown 1999; Brown 2004; Brown *et al*. 2015) represent one-third of an

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impressive radiation of approximately 90 known species in the family Ceratobatrachidae (Brown 1997; Brown & Richards 2008; Siler *et al.* 2007, 2009, 2010; Brown *et al.* 2015). In addition, ongoing taxonomic works describing numerous new species of Philippine *Platymantis* will most likely double the number of taxa in the country (Brown *et al*. 2008; Brown & Diesmos 2009; Diesmos & Brown 2011; Diesmos *et al.* 2014).

Philippine Forest Frogs of the genus *Platymantis* were formerly (Brown *et al.* 1997a) arranged into three species groups based on external morphological characters, calls, and ecological characteristics (Brown *et al.* 1997a,b; Alcala & Brown 1999; Brown 2004). Ground frogs of the *P. dorsalis* Group Alcala & Brown, 1999 (with ten species currently known) are tiny- to large-bodied species (male snout–vent length, SVL = 15–55 mm) with narrowly expanded terminal disks on fingers and toes, protuberant subarticular tubercles, and a tendency towards complex (multi-syllable) advertisement calls; most prefer terrestrial microhabitats but males may call from slightly elevated perches (herbaceous layer vegetation). Rain frogs of the *P. guentheri* Group Brown, Alcala, Diesmos & Alcala, 1997 (12 species) are small to large frogs (SVL = 22–65 mm) with moderate to broad terminal disks on the digits, protuberant subarticular tubercles, and rapidly pulsed advertisement calls (Brown *et al.* 1997b; Brown 2004); most call from arboreal microhabitats (understory to canopy trees). Cloud Frogs (or Shrub Frogs) of the *P. hazelae* Group Brown, Brown & Alcala, 1997a (eight species) are small frogs (SVL = 20–30 mm) with moderately expanded digital discs, subarticular tubercles with flat ventral surfaces, broad dermal flanges along the sides of each digit, and markedly reduced first finger; they call from bushes and shrubs or higher forest strata, especially at high elevations where elfin cloud forests predominate (Scheffers *et al.* 2013). These understory and sub-canopy layer ecomorphs (Brown 2004) inhabit epiphytic plants (utilized as breeding microhabitats: bird's nest ferns, orchids, and screw pines; Scheffers *et al.* 2014), and males are frequently encountered calling from exposed surfaces of leaves (Brown *et al.* 1997a; Alcala & Brown 1999). In more recent years, the species of these three informal species groups were variably redistributed into five phylogenetically-defined, and formally diagnosed subgenera, on the basis of their forming strongly-supported clades in a comprehensive multilocus molecular phylogenetic analysis (Brown *et al.* 2015): Masked Frogs of the subgenus *Platymantis* (containing the type species for the genus *Platymantis*); Ground Frogs: *Lupacolus*; Rain Frogs: *Tahananpuno*; Variable Forest Frogs: *Lahatnanguri*; and Cloud Frogs: *Tirahanulap*.

As presently understood, the eight species of Cloud Frogs in the subgenus *Tirahanulap* are distributed across three distinct zoogeographic regions or Pleistocene Aggregate Island Complexes (PAIC; Brown & Diesmos 2002, 2009). Two species (*P. hazelae* Taylor and *P. panayensis* Brown, Brown & Alcala) are found in the West Visayas PAIC islands of Negros and Panay, one species is known from the Romblon Island Group PAIC islands of Sibuyan and Tablas (*P. lawtoni* Brown & Alcala), and five species occur on the Luzon PAIC islands of Polillo and Luzon (*P. isarog* Brown, Brown & Alcala, *P. montanus* Taylor, *P. polillensis* Taylor, *P. sierramadrensis* Brown, Alcala, Ong & Diesmos, and *P. subterrestris* Taylor) (Brown *et al.* 1997a; Alcala & Brown 1999; Brown *et al.* 2013b).

Much of the original forests in the Philippines have been cleared and the remaining forested areas are seriously threatened by timber poaching, slash-and-burn farming, and destructive mining practices (Heaney and Regalado 1998; Mallari *et al.* 2001; Sodhi *et al.* 2004). However, remnant forests harbor rich and often undescribed biodiversity (Sodhi *et al*. 2004; Posa *et al.* 2008; Brown & Diesmos 2002, 2009; Diesmos & Brown 2011; Diesmos *et al.* 2014). One such area is the biologically unexplored mountain ranges on the eastern Visayan islands of Samar, Leyte, and other small nearby landmasses (Fig.1; Denzer *et al.* 1994; Gaulke 1994).

During a series of biodiversity inventories conducted in 2011 and 2013, a team of field biologists from Fauna & Flora International, the Philippine Department of Environment and Natural Resources, and the National Museum of the Philippines uncovered a biologically diverse fauna and flora on the Nacolod mountain range in the southern regions of Leyte Island (Mallari *et al.* 2013). Included in a collection of vertebrates from this poorly studied mountain range were specimens of a strikingly distinct and brightly colored arboreal frog. We identifed the putative new species as a member of the genus *Platymantis*, assignable to the former *P. hazelae* Group (now the formally diagnosed and phylogenetically defined subgenus *Tirahanulap* on the basis of having widely expanded terminal discs of fingers and toes, relatively flat subdigital surfaces with low subarticular tubercles, and greatly reduced digit lengths for Finger I (Brown *et al.* 2015). Subsequently, other field workers collected specimens of the lineage from several forested areas on Leyte and from the nearby island of Samar. Based on morphological and bioacoustic datasets, we describe this enigmatic new species as the first member of the *Platymantis* subgenus *Tirahanulap* to be recorded from the Mindanao PAIC (Brown 2004; Diesmos & Brown 2011). As such, the new species presents a previously undetected distribution pattern among Philippine *Platymantis* and its discovery has implications for the systematics, biogeography, and conservation of this diverse group of Philippine Forest Frogs.

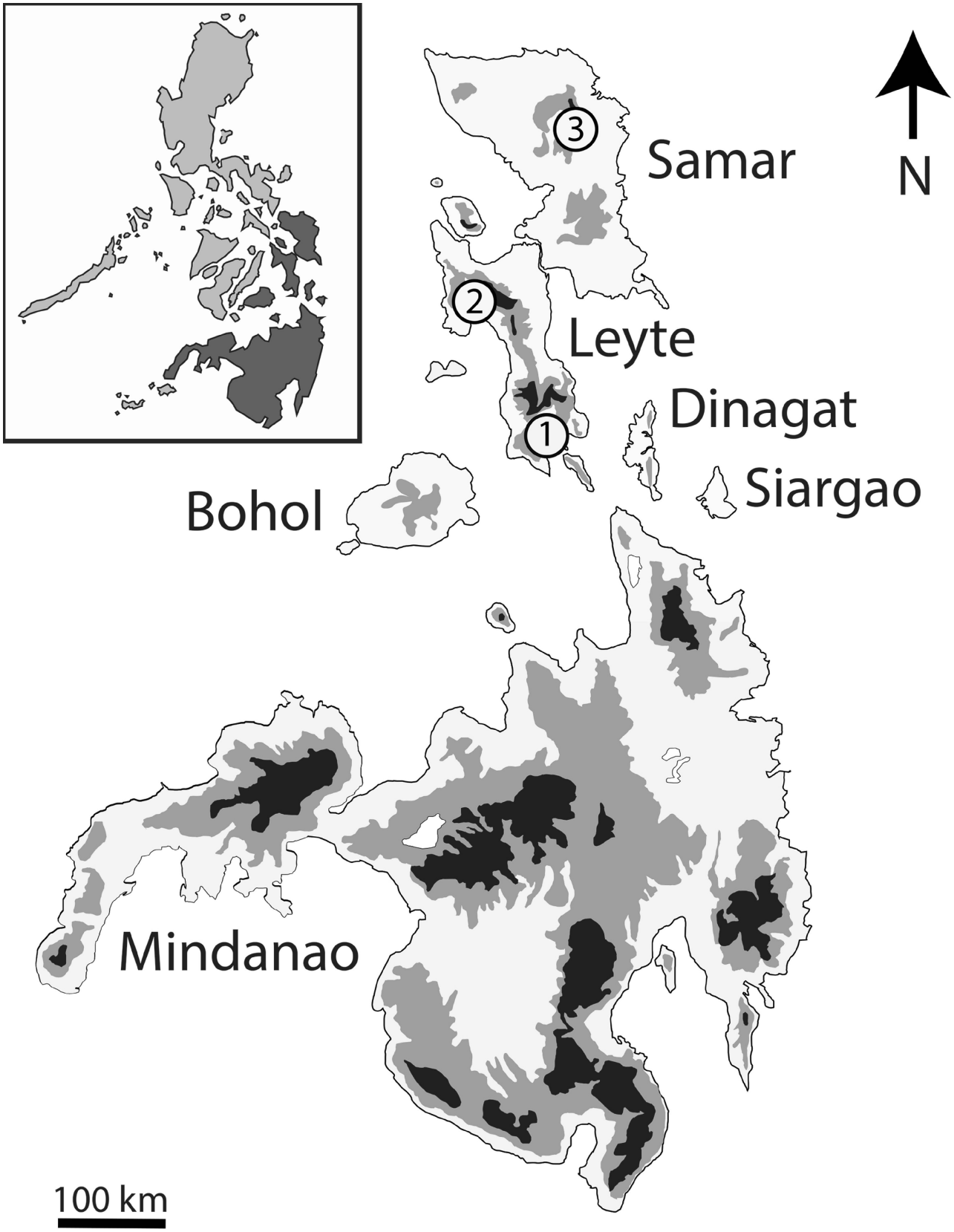

FIGURE 1. Map of the Philippines, showing the position of the Mindanao Pleistocene Aggregate Island Complex (PAIC) islands in relation to the major islands of the archipelago (inset: darkly shaded). (1) Type locality of *Platymantis navjoti* **sp. nov.** (Nacolod mountain range, Barangay San Juan, Municipality of Sogod, southern Leyte Province); (2) Mountains above Ormoc City, Leyte Island, where *P. navjoti* **sp. nov.** was recorded in 2013; and (3) north-central Samar Island (Municipality of San Jose de Buan) where *P. navjoti* **sp. nov.** was recorded in 2014. Shaded contours correspond to 500 m elevational increments.

Methods

Field work, sample collection, and specimen preservation.

A series of field expeditions were conducted on Samar and Leyte islands between 2011 and 2013, including surveys in the Nacolod Mountain Range in southern Leyte in November 2011 and June 2013, in northwestern Leyte in June 2013, and in north-central Samar in July 2014 (Fig. 1). During the course of these biodiversity surveys, 20 individuals of the putative new species of *Platymantis* were selected to represent vouchered collections were euthanized with aqueous chloretone before genetic material was removed via dissection and preserved in 100% laboratory grade ethanol. Specimens were then fixed in 10% buffered formalin and eventually transferred to 70% ethanol within two months. For comparative purposes, we examined specimens deposited at the California Academy of Sciences (CAS), Field Museum (FMNH), University of Kansas Biodiversity Institute (KU), and National Museum of the Philippines (PNM). Museum abbreviations for specimens examined follow Sabaj (2016).

Measurements were taken (to the nearest 0.1 mm) from preserved specimens with the use of needlepoint dial calipers. In an effort to reduce inter-observer bias (Lee 1982; Hayek *et al.* 2001), only data scored by ACD were used for morphometric comparisons. Morphological characters included snout–vent length (SVL), head length (HL), head width (HW), snout length (SL), interorbital distance (IOD), internarial distance (IND), eye-nostril distance (END), eye-tympanum distance (ETD), horizontal diameter of eye (ED), horizontal diameter of tympanum (TD), manus length (ML), pes length (PL), radius length (RL), femur length (FL), tibia length (TBL), tarsus length (TSL), Finger III length from proximal edge of basal tubercle (Fin3L), Finger III disk width (Fin3DW), Finger III penultimate phalanx width (Fin3PPW), Toe IV length (Toe4L), and Toe IV disk width (Toe4DW), and Toe IV penultimate phalanx width (Toe4PPW). Other morphological characteristics included color pattern, morphology of terminal disks of fingers and toes, structure of tubercles of hands and feet, and extent of interdigital webbing between fingers and toes.

Calls of the new species were recorded between 25° and 27°C with a Sennheiser® ME80 condenser microphone (equipped with K3U power module) on a Marantz® PMD670 digital recorder. Calls were recorded at distances ranging from 0.5–2.0 m and ambient temperatures were recorded immediately after recording. Calls were digitized and analyzed using RAVEN PRO v1.5 software (Bioacoustics Research Program 2014) installed on a Macintosh computer. We examined oscillograms (waveforms), audiospectrograms (sonograms) and results of the Fast Fourier Transformation (frequency spectrum) for a variety of temporal and spectral characters (Brown *et al.* 2006, 2013c; Brown & Richards 2008).

New species description

***Platymantis navjoti* sp. nov.**
(Figs. 2–4)

Holotype. PNM 9057 (field no. ACD 7221), an adult male collected on 30 November 2011 at 1900 hr by N. Puna, N. Antoque, and U. Carestia in montane forest at an elevation of 900 m above sea level on Nacolod mountain range, Sitio Puti, Barangay San Juan, Municipality of Sogod, Southern Leyte Province, Leyte Island, Philippines (10.45086º N, 125.07075º E; WGS 84).

Paratypes (Paratopotypes). PNM 9058, adult male, PNM 9059, sub-adult male, collected with the holotype on the same date; PNM 9063, ~~PNM~~ 9067, adult males, PNM 9066, adult female, collected 14–16 June 2013 in the same locality by U. Carestia, B. Redoblado, and J.M. Lillo at elevations ranging from 730–800 m in montane forest.

Other paratypes. PNM 9061–64, 9069, 9072, adult males, PNM 9065, sub-adult male, PNM 9060, 9068, 9070–71, 9073, adult females, collected by U. Carestia, B. Redoblado, and J.M. Lillo on 25–26 June 2013 between 730 and 800 m elevation in montane forest on Nacolod mountain range, Barangay Nahulid, Municipality of Libagon, Southern Leyte Province, Leyte Island, Philippines (10.36494º N, 125.06833º E; WGS 84); PNM 9925, adult male, collected by M. Pedregosa and party on March 2014 at 850 m elevation in original forest in the area of Tongonan Geothermal Power Plant, Barangay Tongonan, Ormoc City, Leyte Province, Leyte Island, Philippines (11.14458º N, 124.66564º E; WGS 84); and KU 338209, adult male, collected by C. D. Siler and J. B. Fernandez and party on 3 July 2014 at 616 m elevation in secondary growth forest on Mt. Huraw, Municipality of San Jose de Buan, Western Samar Province, Samar Island, Philippines (12.05284 º N, 125.0411º E; WGS 84).

FIGURE 2. Photograph of (Top) male holotype (PNM 9057) and (bottom) ~~a~~ male paratype (KU 338209) in life. Photographs by ACD (holotype) and CDS (paratype).

Diagnosis. *Platymantis navjoti* **sp. nov.** is assigned to the genus *Platymantis* Günther as a member of the Philippine clade of ceratobatrachid frogs as defined by Brown *et al.* (2015) on the basis of the following suite of characters: absence of interdigital webbing; presence of median subgular vocal sacs; absence of nuptial pads; presence of supernumerary tubercles on the hands; and presence of metatarsal tubercles on the foot. Within the genus *Platymantis*, the new species is distinguished from congeners of the subgenus *Tirahanulap* (equivalent to the former *P. hazelae* Group) by a combination of the following characters: (1) small size; (2) iridescent emerald green, orange, or creamy yellow dorsal color pattern (Figs. 2, 3); (3) skin of dorsum smooth with fine granulations (Fig. 2); and (4) a "chirping" male advertisement call of 10–16 brief nodes, each characterized by slight internal amplitude and frequency modulation (Fig. 5).

Comparisons. Because of its highly distinctive phenotype and biogeographically circumscribed distribution (not co-distributed with any other known species of the *Platymantis* subgenus *Tirahanulap*), there is no conceivable way that the new species can be confused with any other Philippine *Platymantis*. We assign it to the subgenus *Tirahanulap* based on the definition by Brown *et al.* (1997a) and its possession of (1) a moderately expanded terminal digital disks, (2) digits with wide lateral dermal flanges (rendering digit cross sections widely ovoid), (3) subarticular tubercles with flat ventral surfaces, (4) greatly reduced Finger I length (Fig. 4), and (5) its "chirping" advertisement call of briefly repeated notes (Fig. 5). Each of these characters distinguishes all subgenus *Tirahanulap* species (including *P. navjoti* **sp. nov.**) from all other Philippine members of Philippine *Platymantis* (Brown *et al*. 1997a; Alcala & Brown 1999).

FIGURE 3. Color variation exhibited by four uncollected males of *Platymantis navjoti* **sp. nov.**. Clutch attendance by males (B) was observed on several occasions. Photographs by Fauna & Flora International Philippines.

Within the subgenus *Tirahanulap*, *P. navjoti* **sp. nov.** differs from *P. isarog*, *P. lawtoni*, *P. montanus*, and *P. subterrestris* by the presence of a unique iridescent emerald green or orange dorsal color pattern (vs. variably marked with dark brown ground coloration, and dorsolateral stripes), the absence (vs. presence) of distinctive brown and yellow flank areolations, and the absence of well-defined metatarsal tubercles and supernumerary tubercles (Fig. 4). The new species differs further from *P. isarog* by its unique iridescent emerald green (Fig. 2) or orange dorsal color pattern (Fig. 3; vs. tan or dark brown ground coloration, sometimes with dark flanks), by the presence of an immaculate white to creamy ventrum (vs. light ventrum with dark reticulate pattern), and by the absence (vs. presence) of

well-defined metatarsal tubercles and supernumerary tubercles. From *P. hazelae,* the new species is distinguished by its iridescent emerald green or orange dorsal color pattern (vs. variably marked with dark brown ground coloration, and dorsolateral stripes, or light tan dorsum), by the absence (vs. presence) of well-defined metatarsal tubercles and supernumerary tubercles, and by its advertisement call, consisting of "chirping" (vs. constant frequency) notes. From *P. polillensis* and *P. sierramadrensis*, the new species is diagnosed by its iridescent emerald green or orange dorsal color pattern (vs. white to bright yellow dorsum, faintly marked with irregular dark brown or black markings), and by the absence (vs. presence) of well-defined metatarsal tubercles and supernumerary tubercles. The new species is further distinguished from *P. sierramadrensis* by the consistently smaller body size of males and by its advertisement call, consisting of "chirping" (vs. constant frequency) notes.

Description of holotype. An adult male specimen in excellent condition; SVL = 21.1 mm; habitus slender; head slightly distinct, equal in dorsal aspect to width of body, HL 40.1% SVL; HL 96.6% HW; snout moderate, terminating in sharply rounded point in lateral and doral aspects (Fig. 4), protruding only slightly beyond lower jaw; eyes protrude slightly beyond silhouette of head in dorsal aspect, and moderately beyond dorsal surface of head in lateral aspect; labial region slightly slightly flared, not extending beyond eyes in dorsal aspect; interorbital region flat, with two low ridges just medial to palpebra (Fig. 4); ED 90.3% IOD; pupil horizontally ovoid; canthus rostralis straight; loreal region slightly concave; ED 92.3% SNL; narial openings not laterally protuberant; eye-narial distance 6 times the distance from nostril to tip of snout; internarial region flat; tympannic annulus barely distinct; TD 44% ED; dorsal edge of tympanic annulus bordered but not concealed by supratympanic fold, the latter extending from dorsoposterior edge of tympanum, and terminating at supra-axillary (post-rictal) region (Fig. 4); post-rictal tubercles absent; tongue triangular, with shallow posterior notch and narrow anterior attachment; choanae round, minute, at anterolateral edge of palate, separated by a distance 7 or 8 times their diameter, partially obscured by palatal shelf; dentigerous process of vomer ovoid; vomerine teeth minute, translucent, numbering one or two; dentigerous process anterolaterally angled, with closest (posterior) points separated by a distance 1.5–2.0 times the diameter of one choana, their most distant (anterior) ends separated by a distance equal to three or four times diameter of choanae; openings to vocal sac minute slits, just interuor to angle of the jaw.

Skin of dorsal surfaces of body, head, and limbs entirely smooth, lacking texture, or dermal ornamentation of any kind; no dermal crests or flanges along lateral surfaces of limbs; ventral body surfaces smooth, except for slightly glandular texture to posterior surface of groin and medial ventral surfaces of thighs.

Hand length 63.9% PL; fingers (Fig. 4) wide and flat, bordered laterally along their entire lengths by dermal flange, resulting in compressed oval cross-section (Brown *et al.* 1997a: Fig. 1a); terminal disks barely expanded (Finger I) to widely expanded (= 2 times the width of penultimate phalanges), circummarginal groove absent on Finger 1, present but indistinct on Fingers II–IV; supra-articular folds of fingers indistinct, more evident above penultimate and ultimate phalangeal articulation of inner two fingers; interdigital webbing absent; decreasing finger length III, IV, II, I; subarticular tubercles low and barely distinct, flat on ventral surfaces; one subarticular tubercle under fingers II–IV; supernumerary tubercles flat indistinct, reduced to barely perceptible swellings, present at the base of Fingers II–IV; palmar surfaces basal to supernumerary tubercles nearly smooth, with wrinkled appearance; thenar (inner metacarpal), medial palmar and outer metacarpal tubercles unpigmented, moderate in size, flat on ventral surfaces, edges irregular and obscured by lack of pigmentation; thenar tubercle elongate, situated on medial edge of Finger I (Fig. 4); medial palmar (inner metacarpal) tubercle enlarged, broad, squarish, and flat; outer metacarpal tubercles thin, elongate, equal in length to inner (medial) metacarpal tubercle but only one fifth its width, not separated noticeably from medial metacarpal tubercle; nuptial pads absent, forearm musculature not well developed.

Hind limbs relatively long, slender; TBL 63.3% SVL, FL 92.5% TBL, PL 81.2% TBL; skin of dorsal hind limb surfaces smooth; tarsus smooth, with minute axial dermal ridge running length of posterior surface of tarsus, ending in a low fleshy conical tubercle on heel; terminal toe disks non-expanded (Toes I, V), or very narrowly expanded (1.1–1.3 times the width of penultimate phalanges (Toes II–IV), with barely perceptible circummarginal grooves and supra-articular cutaneous folds on Toes II–V; plantar surface of feet (Fig. 4) with smooth skin, wrinkled in appearance, supernumerary tubercles and plantar tubercles not evident; subarticular tubercles of digits well-developed, low, and flat (Fig. 4), numbering one under Toes I, II, and IV, two under Toe III, and three under Toe IV; decreasing toe length (longest to shortest when adpressed) IV, III, V, II, I; metatarsal "tubercles" reduced to a pair of fleshy swellings, lacking distinct borders, not pointed, and barely evident; metatarsal tubercular swellings with medial barely perceptible edges (contacting) but outer edges indistinct; toes with minute interdigital webbing, barely reaching level of first row of subarticular tubercles of digits (Fig. 4); cloacal region finely glandular, with small supracloacal dermal granules.

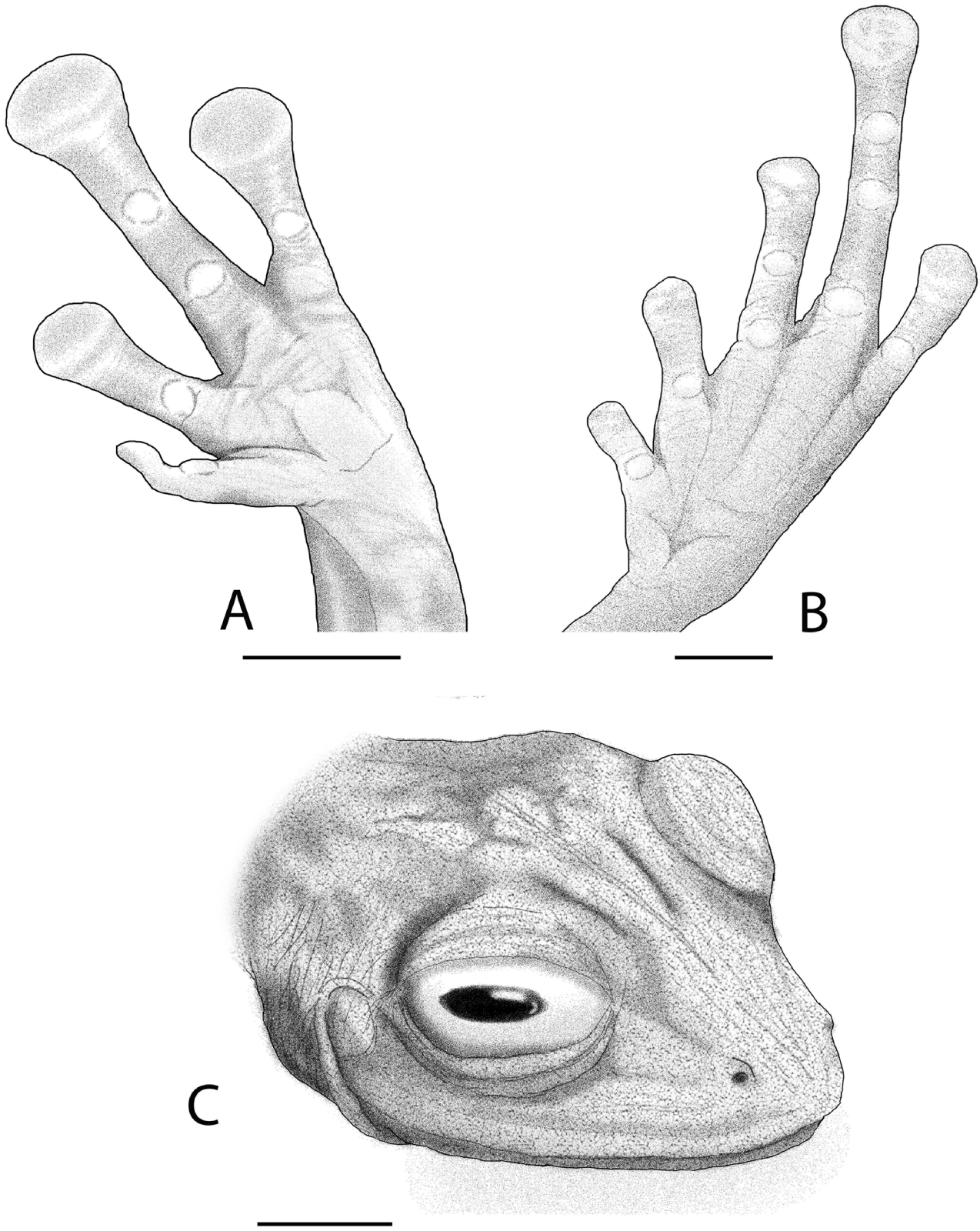

FIGURE 4. Ventral view of the palmar surface of the left manus (A), pes (B), and lateral view of head (C) of the male *Platymantis navjoti* **sp. nov.** holotype (PNM 9057). Scale bars = 1 mm.

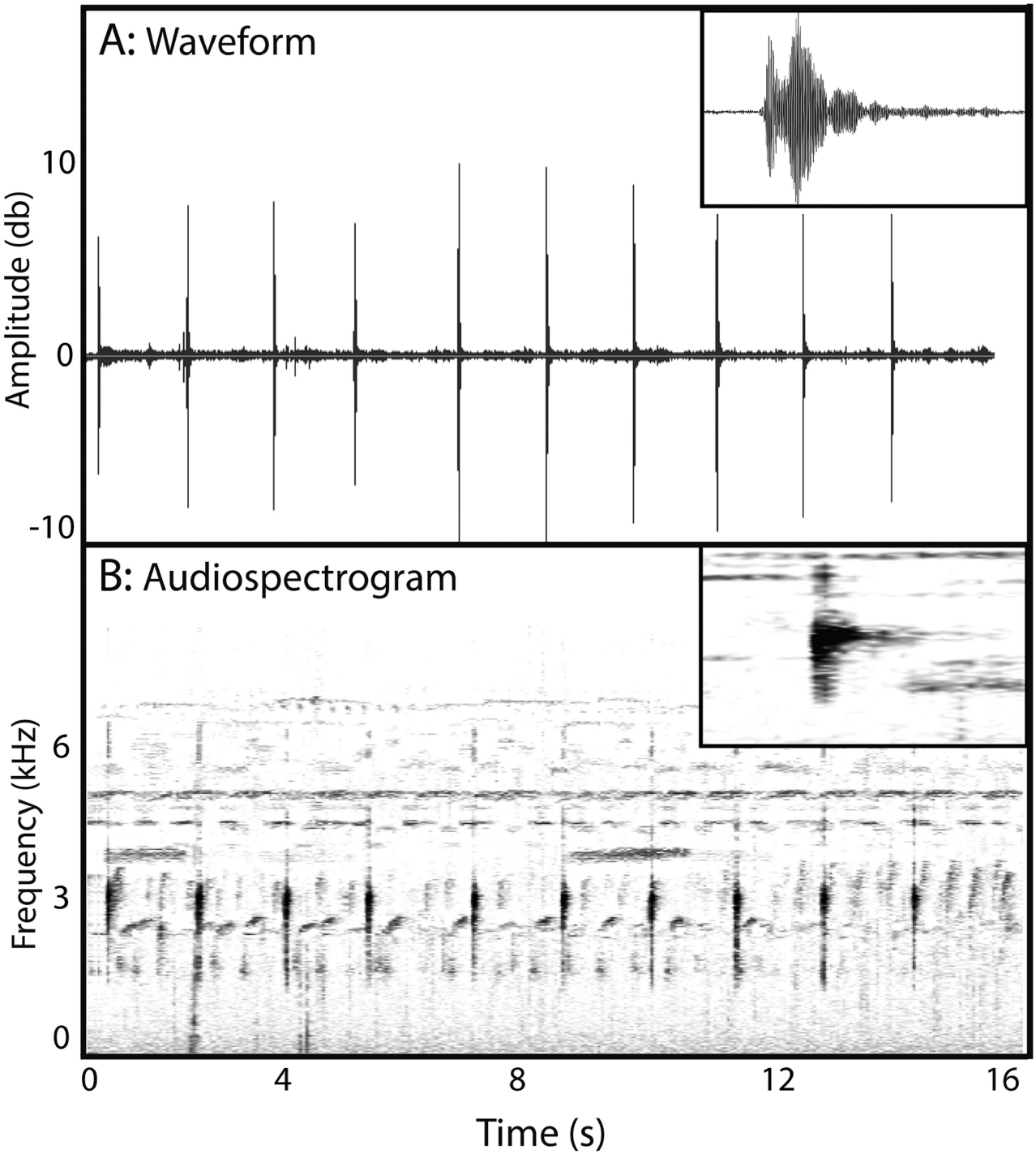

FIGURE 5. Advertisement call of *Platymantis navjoti* **sp. nov.** ~~Included are~~ a 16 s waveform (A; relative amplitude vs. time) and audiospectrogram (B; frequency in kHz vs. time) of the holotype (PNM 9057); ~~,~~ both contain upper right inset ~~panels~~ of expanded 0.5 s call segments illustrating spectral and temporal characteristics of a single note (the second note in the 16 s call segment). ~~Call~~ was recorded at ambient temperature of 25–27°C at 900 m above sea level, Nacolod mountain range, Barangay San Juan, Municipality of Sogod, Leyte Island~~.~~

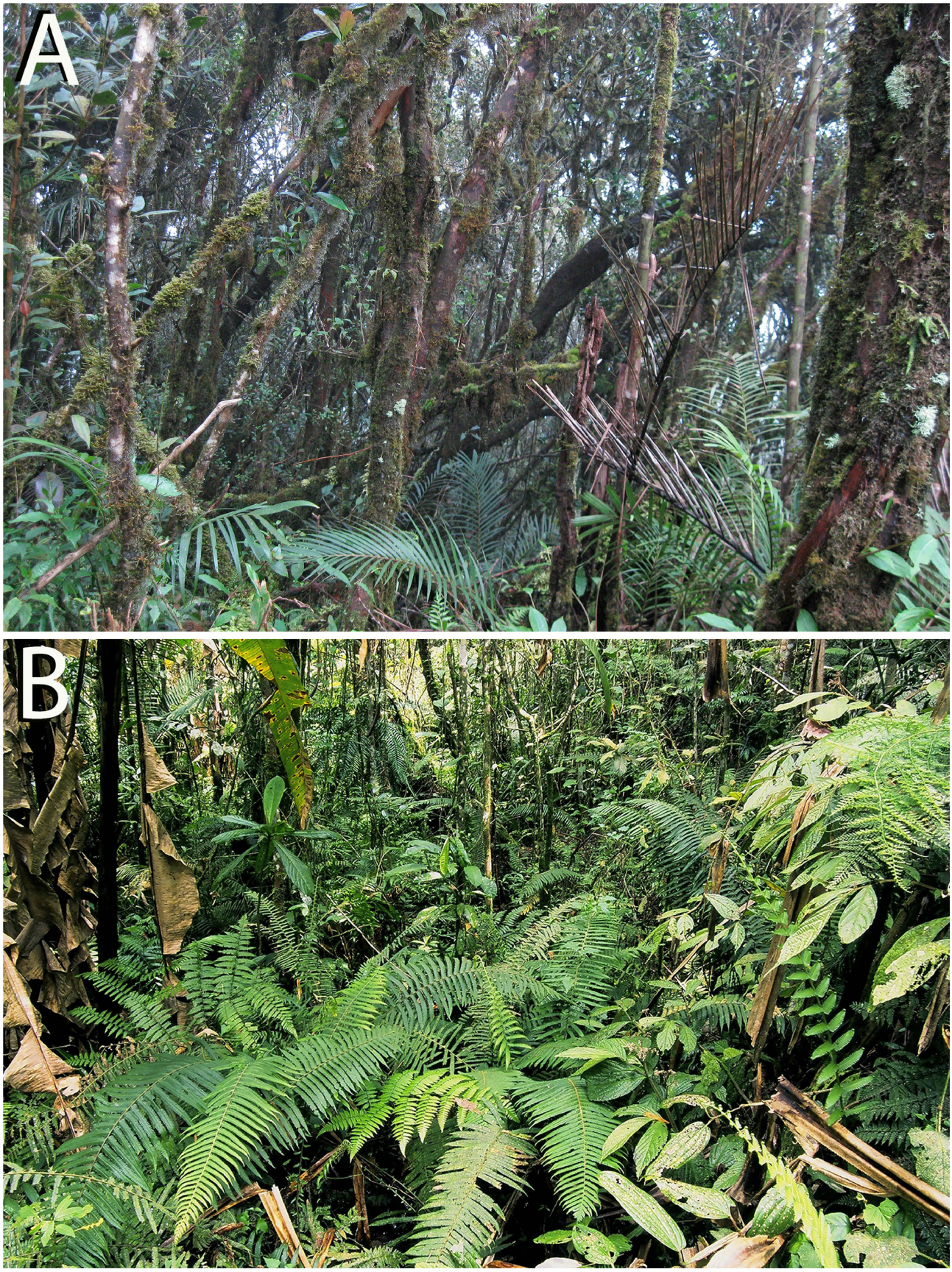

FIGURE 6. Appearance of typical habitat characteristics of *Platymantis navjoti* **sp. nov.** at the type locality. Photographs by ACD.

Coloration of holotype in life. In life, the holotype was bright iridescent emerald green with irregularly shaped tiny white dots, evenly spaced across all dorsal surfaces of head, body and limbs (Fig. 2). A thin white vertebral line was visible through the dorsum, to the interorbital region, but disappeared in sacral and rostral regions. Extremely faint and slightly darker blotches were evident on tibia but were absent on other leg segments and forearms. Dorsal surfaces of terminal disks of hands and feet lacked darker green pigment and appeared immaculate yellow, with white subarticular flaps. The concealed posterior surfaces of things and tibia possessed dark orange patches. Ventrolateral flank surfaces had brighter white and orange coloration scattered around low glandular surfaces, wrapping posteriorly on to the ventrum. Ventral body surfaces were creamy white. Ventral surfaces of pes and manus possessed light green homogenous color (lighter and lacking white spots of dorsum). The iris was creamy reddish to golden brown. Tympanic region is slightly darker green than that of dorsum.

Coloration of holotype in preservative. After three years in preservative, all dorsal surfaces pale yellow to white, with skeletal elements and organs (in particular, its dark liver and eyes) visible through skin; transverse limb bands absent; supraarticular flaps above digits white, digital tips slightly darker yellow; ventral surfaces pale yellow to white, and with organs and some skeletal elements (hyoid, pectoral girdle) visible through translucent skin.

Measurements of holotype. SVL 21.1; ED 3.6; TD 1.1; HL 8.5; SNL 3.9; END 2.5; IOD 2.8; HW 8.8; FL 12.3; TBL 13.3; TSL 7.6; ML 6.9; PL 10.8; FA 5.3; UAL 3.7; Toe4L 7.0; Fin1L 5.2; Fin3L 5.2; Fin3DW 1.6; Fin3PPW 0.8; Toe4DW 1.0; Toe4PPW 0.7.

Variation. Our small type series and photographs of live specimens indicate some notable color variation (Figs. 2, 3); however, this is common in many species of *Platymantis* across the Philippines, with numerous color patterns observed in populations of most species (ACD, RMB, and CDS, *personal observations*). Both female and male specimens of the new species showed some variation in coloration patterns. For some specimens, after three years in preservative, the body coloration has faded to immaculate pale yellow. The type series showed similar dorsal coloration patterns; however, variation was observed on the lateral surfaces of the body, where coloration varied between a green background with white mottling to a more distinct transition between green (dorsal) and white (ventral) background coloration with bright orange spots on the lateral sides of the body within the axilla–groin region (Fig. 2). In life, some specimens were immaculate green with tiny white dots like the holotype, others were darker green with enlarged black markings, others lime green dorsally with white and orange lateral spots, and others were varying shades of orange (Figs. 2, 3). Prominence of dark limb blotches varied, and iris color varied from pale silvery white to deep bronze or gold (Figs. 2, 3). Additional variation is summarized in Table 1.

Advertisement call and interspecific acoustic comparisons. The advertisement call of *Platymantis navjoti* **sp. nov.** (Fig. 5) is produced approximately every several minutes (inter-call intervals unrecorded) and call sequences start as the male buccal pumps to inflate its lungs fully, perches upright, then fully inflates its median subgular vocal sac, and repeatedly shuttles back and forth between the lungs and vocal sac. With each contraction of body wall musculature, males forcibly exhale air into the vocal sac, coincident with a brief note, consisting of a finely pulsed (amplitude modulated), complex (frequency modulated) "chirp." Extended calls of 8–14 chirps (mean = 12, n = 3) are produced as the animal remains upright, vocal sac extended, with repeated movement of air elastically recoiled by the vocal sac, then forced back out (producing each note) for upwards of 20–30 s. These frogs were then observed to lower their heads, and sit in silence for several minutes before assuming the upright posture and starting the buccal pump sequence again at the start of another call (= note group) vocalization.

Within calls, repetition rate of pulsed chirps varied from 0.49 to 0.64 (mean = 0.55, n = 3) chirps. Individual chirps/notes consist of 3–5 subpulses, the first 75–85% of maximum amplitude, the next consistently highest amplitude, followed by one or two, which further decline to 60–40% maximum amplitude. Chirp duration averaged 190 ms (180–201, n = 8) for one male (not collected), 213 ms (209–219, n = 11) for another (the holotype) and 226 (222–230, n = 14) for a third male (not collected).

Individual chirps/notes begin with marked energy in two spectral call components. The lower frequency component (lasting no more than 75–150 ms) ranges from 0.99 to 1.77 kHz, with a peak frequency of 1.5 kHz. The second, higher frequency component, containing the majority of the call's energy (and lasting the full duration of each note) ranges from 2.2 kHz to 3.05 kHz, with a peak frequency of 2.6 kHz for one male (not collected), 2.7 ms for the holotype, and 2.4 for a third male (not collected). Faint harmonics of the fundamental are evident in some of our recordings at approximately 5.1–5.3, 7.8–8.1, and 10.0–10.2 kHz, respectively.

TABLE 1. List of selective diagnostic characters distinguishing *Platymantis navjoti* **sp. nov.** from other members of the phylogenetically distinct, monophyletic *Platymantis hazelae* Group of Philippine Forest Frogs (Brown *et al.* 1997a; Brown *et al.* 2015). Measurements of snout–vent length (SVL) include data from Brown (2004), Brown *et al.* (1997a), and specimens that we examined.

	navjoti **sp. nov.**	*polillensis*	*sierramadrensis*	*isarog*	*montanus*	*subterrestris*	*hazelae*	*panayensis*	*lawtoni*
Distribution	Leyte, Samar	Polillo, Luzon	Luzon	Luzon	Luzon	Luzon	Negros	Panay	Tablas
SVL (mm)									
Males (n)	21.1–26.6 (12)	20.2–24.9 (17)	22.7–25.2 (10)	23.3–27.7 (24)	23.9–27.7 (8)	24.2–27.6 (18)	21.6–28.2 (21)	25.4–28.0 (7)	31.2–33.4 (5)
Females (n)	26.4–28.8 (6)	25.5–26.2 (3)	25.7 (1)	27.0–34.6 (14)	26.0–28.5 (5)	24.1–29.2 (5)	25.2–36.2 (20)	28.4–32.2 (7)	39.2–44.2 (6)
Color	Iridescent green, orange, or yellow	Yellow to pale tan	Creamy white to pale yellow	Tan to brown, markings variable	Tan to brown, markings variable	White to light gray, with brown mottling	Yellow to brown, markings variable	Pale cream to brown, markings variable	Creamy white to pale yellow
Flank and groin areolation	–	–	–	+	+	+	+	+	+
Advertisement call note structure	chirp	chirp	tonal	chirp	chirp	chirp	tonal	tonal	tonal

The complex notes and slowly repeated overall "chirping" call structure of the new species sounds to the human ear like an insect (cricket or katydid) vocalization (Brown et al. 1997a). Similar call production (including behavior) has been observed in other species of *Tirahanulap* such as *P. isarog*, *P. montanus*, *P. polillensis*, *P. subterrestris*, including several undescribed species (ACD, RMB, *personal observations*). Others are species with lengthier note trains, more notes per call, notes of longer individual duration, with no frequency modulation (pure tones, or constant-frequency), with well-developed harmonic structure (sounding to the human ear like lengthy ringing small bells; e.g., *P. hazelae*, *P. lawtoni*, *P. panayensis*, *P. sierramadrensis*). In both temporal and spectral properties, the call of the new species is most similar to that of *P. polillensis*, a distantly allopatric species from Polillo and Luzon islands, northern Philippines (Inger 1954; Alcala & Brown 1999; Brown *et al.* 2012, 2013b).

Ecology and Natural History. *Platymantis navjoti* **sp. nov.** is a direct developing species that inhabits lower- to upper-montane forest from 600 m to at least 1000 m elevation. At night, individuals were found perched on leaves of saplings, on fronds of rattan palms (genus *Calamus*), on dead leaves that were entangled atop vegetation, or in spaces of curled leaves, from 0.5–3 m above the forest floor. Egg clutches were observed on top of leaves, with egg number per clutch ranging from eight to 12 and males observed guarding clutches (Fig. 3). Sympatric anurans include *Kaloula picta* Günther, *K. conjuncta meridionalis* Inger, *K.* cf. *kalingensis* Taylor (undescribed), *Kurixalus appendiculatus* (Günther), *Limnonectes magnus* (Stejneger), *L. leytensis* (Boettger), *Megophrys stejnegeri* Taylor, *Nyctixalus spinosus* (Taylor), *Occidozyga laevis* (Günther), *Oreophryne* sp. Boettger, *Pelophryne brevipes* (Peters), *Philatus leitensis* (Boulenger), *Ph. poecilus* Brown & Alcala, *Ph. surdus* (Peters), *Platymantis corrugatus* Günther, *P. guentheri* Zweifel, *P. rabori* Brown, Alcala, Diesmos & Alcala, *Pulchrana grandocula* (Taylor), *Rhacophorus bimaculatus* Peters, *Sanguirana mearnsi* (Stejneger), and the introduced species *Rhinella marina* (Linnaeus), *Kaloula pulchra* Gray, and *Hylarana erythraea* (Schlegel). The latter three species are introduced and not native to the Philippines (Diesmos *et al.* 2015).

Distribution. *Platymantis navjoti* **sp. nov.** is thus far known from two localities on Nacolod mountain range in the southern region of Leyte Island and recently was encountered in mountains around Ormoc City at the northern part of the island. Additionally, recent field surveys on north-central Samar Island also recorded this species. We expect that *P. navjoti* **sp. nov.** will eventually be found from other mountainous regions on Leyte and Samar (if appropriate habitats are available and field surveys conducted during favorable atmospheric conditions; Fig. 1).

Etymology. The specific epithet is a patronym in the genitive singular, honoring the late Navjot Sodhi (National University of Singapore). A leader in the field of conservation science in Southeast Asia, Sodhi's contributions were unparalleled, and did not decline in impact until his untimely death in 2012. His role as a professor and graduate mentor extended to many students (including ACD and BRS) and his leadership by example will have a lasting and profound impact in the conservation of Southeast Asian biodiversity. Suggested common name: Navjot Sodhi's Cloud Frog.

Discussion

The description of *Platymantis navjoti* **sp. nov.** increases the known diversity of Philippine frogs of the genus *Platymantis* to 32 species (Brown 2007; Diesmos & Brown 2011; Diesmos *et al.* 2014). However, many additional new species of Philippine *Platymantis* have been identified and await taxonomic descriptions (Brown *et al.* 2008, 2013b). Contributing to the underestimate of species diversity within the genus is the considerable phenotypic variation that is observed within and among populations of recognized species. In extreme cases like populations of *P. corrugatus*, *P. dorsalis*, and *P. guentheri*, more than 15–20 color and color pattern morphotypes can be observed at a single site (RMB, CDS, & ACD personal observations). This situation has surely contributed to the recognition of many putatively widespread species in the country with distributions that span recognized faunal demarcations in the archipelago (Brown et al. 2013a). Many of these species are now known complexes of unique, divergent lineages worthy of taxonomic recognition; however, identifying suites of diagnostic features for such phenotypic variability in color and color patterns complicates revisionary work. Even in situations where species such as *P. navjoti* **sp. nov.** present exceptional coloration patterns distinct from all other known congeners, color variation within and among populations is significant (Figs. 2, 3).

Currently, *Platymantis navjoti* **sp. nov.** remains the only member of the subgenus *Tirahanulap* that has been identified from the East Visayan islands of Leyte and Samar, which are biologically affiliated to Mindanao faunal

region (Fig. 1). Why this monophyletic group (Brown 2004; Brown *et al.* 2015) is particularly species-rich in the Luzon faunal region (*P. isarog*, *P. montanus*, *P. polillensis*, *P. sierramadrensis*, *P. subterrestris*) and central islands of the Philippines (*P. hazelae*, *P. lawtoni*, *P. panayensis*) but is apparently lacking from the southern islands, has been the subject of some conjecture (Brown & Alcala 1970; Brown 1997; Brown *et al.* 1997a; Alcala & Brown 1999). This question will be addressed most appropriately within the historical and comparative context of a time-calibrated phylogeny (Brown *et al.* 2015).

The last decade's trend of new species discovery from unexplored or incompletely surveyed habitats underscores the manner in which Philippine biodiversity is underestimated; it also highlights the importance of protecting remaining natural habitats—including regenerating forests—wherever possible. This process of discovery (e.g., Siler *et al.* 2007, 2009, 2020; Diesmos *et al.* 2011, 2014) has included new species like the one described here, but also involved the rediscovery of previously considered "extinct" species (e.g., *P. spelaeus* Brown & Alcala, *P. insulatus* Brown & Alcala, *P. subterrestris*) that have been located in remnant forests, which are unprotected and are continuously being degraded. The conservation community's prevailing perception that forest patches are worthy of protection only if they include pristine and/or original vegetation is clearly an oversimplification (e.g., Mallari *et al.* 2001; Alcala *et al.* 2004, 2012a,b; Alcala & Alcala 2004; Posa *et al.* 2008; Brown *et al.* 2003, 2012a). Second growth and regenerating forest habitats are becoming an increasingly irreplaceable resource with utmost conservation value (Sodhi *et al.* 2004; Posa *et al.* 2008; Brown & Diesmos 2009; Diesmos *et al.* 2014).

Particularly susceptible to local population extirpation following forest removal, Cloud Frogs of the subgenus *Tirahanulap* are important indicator species for environmental and conservation assessments (Alcala *et al.* 2012a,b; Scheffers *et al.* 2013, 2014). Unlike terrestrial Forest Frogs of the genus *Platymantis* subgenera *Lupacolus* and *Platymantis* or arboreal Rain Frogs (members of subgenera *Tahananpuno* and *Lahatnanguri*), we have observed on many occasions the rarity of *Tirahanulap* Cloud Frogs in selectively logged forests (where canopy gaps allow ground layer temperatures to rise by penetration of sunlight) and their near or complete absence in logged-over forest (Diesmos 2008). The exception to this generalization is *P. polillensis*, a species that has persisted in its type locality (Polillo Island off northeast Luzon) despite heavy disturbance and removal of most original vegetation; this species is also common in forest gaps and along forest edges throughout most of northern and eastern Luzon (Brown *et al.* 2012b, 2013b). In contrast, we have observed that the majority of populations of Cloud Frog species of the subgenus *Tirahanulap* have high densities in intact, more pristine high elevation montane forests in the northern and central islands in the Philippines (ACD, BRS, & RMB, *personal observations*).

Recent estimates of the forest cover of Leyte Island indicate an unprecedented rate of degradation followed by deforestation particularly of the lower-montane and lowland forests (Mallari *et al.*, 2013). From 2007 to 2010, there has been a decrease of 15% (41,060 ha) of pristine lowland and montane forest, a corresponding decrease of 57% (55,637 ha) of degraded lowland forest, and an 18% (48,232 ha) increase in the extent of non-forested areas (Mallari *et al.*, 2013). Because *P. navjoti* **sp. nov.** is a forest-obligate species, the continuing trend of forest degradation in the east Visayan islands of Leyte and Samar is anticipated to have a detrimental impact on this species and other endemic taxa, which have high exclusivity to forest habitats. A serious redesign of protected areas on Leyte and Samar must be undertaken to arrest the alarming trend of deforestation on these islands.

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APPENDIX I. Specimens examined

Platymantis banahao (20 specimens): LUZON ISLAND, Quezon Province, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: TNHC 61968–71, PNM 9248–49; CAS 201003–10, 201210, 201231, 201531–32, 202544 (paratypes).

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 (62 specimens): LUZON ISLAND, Cagayan Province, "Tagat Forest Reserve near Santa Praxedes Town:" PNM 7564, 7578, 7496–99, 7506, 7608, 7526; Municipality of Gonzaga, Barangay Magrafil, Mt. Cagua: KU 330300–326; Ilocos Norte Province, Municipality of Adams, Barangay Adams, Mt. Pao: KU 329594–620.

Platymantis cornutus (100 specimens): LUZON ISLAND, Kalinga Province, *Municipality of Balbalan*, Barangay Balbalan: CAS 231498, 231501, CMNH 8128; Cagayan Province, *Municipality of Gonzaga*, Barangay Magrafil, Mt. Cagua: KU 330362–392; Ilocos Norte Province, *Municipality of Adams*, Barangay Adams, Mt. Pao: KU 329621–28; 329630–76; Aurora Province, *Municipality of Maria Aurora*, Barangay Villa Aurora, Aurora Memorial National Park, "Siete" area, Mt. Dayap: KU 322051–64.

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: KU 300350, 300352–54; NEGROS ISLAND, Negros Oriental Province, *Municipality of Valencia*, Barangay Bongbong, Camp Lookout, Cuernos de Negros Mt. Range, Mt. Talinis: 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 (78 specimens): NEGROS ISLAND, Negros Oriental Province, *Municipality of Valencia*, Barangay Bongbong, Sitio Tagaytay, Mt. Talinis: KU 300356−300377; LUZON ISLAND, Bulacan Province, *Municipality of Norzagaray*, Barangay San Lorenzo, Angat Dam: KU 328721–22; *Municipality of Dona Remedios Trinidad*, Barangay Kabayunan, Sitio Langud, Langud River, Angat Watershed: KU 329042–60; Laguna Province, *Municipality of Los Banos*, Barangay Bagong Silang, Mt. Makiling Forest Reserve, Camp Malaboo: KU 330964–89; Macajoyong River, Area="Bilog:" KU 333939–40; Quezon Province, *Municipality of Polillo*, Polillo Town: KU 303545–56.

Platymantis guentheri (88 specimens): DINAGAT ISLAND, Surigao Province, *Municipality of Loreto*, Barangay Esperanza: KU 306320–23, 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; LEYTE ISLAND, Leyte Province, *Municipality of Baybay*, Barangay Pilim, San Vicente: KU 311022–29; MINANAO ISLAND, Agusan del Sur Province, *Municipality of San Francisco*, Barangay Bagusan II, Mt. Magdiwata: KU 319609–26; Barangay Lunga, Mt. Talinus: KU 306738–43; Negros Occidental Province, Barangay Patag; city of Silay; Mt. Bungol: 323712–53.

Platymantis indeprensus (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 (9 specimens): LUZON ISLAND, Camarines Sur Province, *Naga City*, Barangay Panicuason, Mt. Isarog National Park, Mt. Isarog: TNHC 61961–67; CAS 197218 (Holotype); *Municipality of Pili*: CAS-SU 21837 (paratype).

Platymantis lawtoni (8 specimens): TABLAS ISLAND, Romblon Province, *Municipality of San Agustin*, Mt. Progreso: CAS 135733; *Municipality of Calatrava,* Barangay Balogo: Sitio Piqueno: KU 315280–86.

Platymantis levigatus (28 specimens): SIBUYAN ISLAND, Romblon Province, *Municipality of Magdiwang*, Barangay Talaba, Mt. Guiting-Guiting Natural Park: KU 300416–30; *Municipality of Calatrava,* Barangay Balogo: Sitio Piqueno: KU 315287–99.

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 (23 specimens): LUZON ISLAND, Quezon Province, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: TNHC 62149–58; CAS 200998–1000; Mt. Banahao, "Hasaan" area: KU 326217–27.

Platymantis naomiae (11 specimens): LUZON ISLAND, Quezon Province, *Municipality of Tayabas*, Barangay Lalo, Mt. Banahao: TNHC 62169–71, CAS 201009–11, 201184, 201197–99, (paratypes), 204746 (holotype).

Platymantis navjoti **sp. nov.** (18 specimens): See taxonomic account.

Platymantis negrosensis (23 specimens): NEGROS ISLAND, Negros Oriental Province, Cuernos de Negros Mountain Range, Mt. Talinis: KU 300439–45; *Municipality of Sibulan,* Lake Balinsasayao: CAS 128900, 128902–12, 128914 (paratypes); Cuernos de Negros, N slope of Mt Talinis, Dayungan: CAS 133899 (paratype); NW side of Bunyan River, ridge NW of Mt Talinis, Dayungan: CAS 133900 (paratype); Negros Occidental Province Bagtik River Valley: CAS 89804.

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*, Baragany Lalo, Mt. Banahao: KU 207455–57, 207459 (Paratypes).

Platymantis pygmaeus (20 specimens): LUZON ISLAND, Cagayan Province, *Municipality of Claveria*, Barangay Mabnang, Mabnang Falls: PNM 7523, 9528–31; Nueva Vizcaya Province, *Municipality of Quezon*, Barangay Maddiangat, Sitio Parola: KU 325642, 325648, 325691; Bulacan Province, *Municipality of Doña Remedios Trinidad*, Barangay Kabayunan, Sitio Langud, Langud River, Angat Watershed: KU 329003–08; Ilocos Norte Province, Municipality of Adams, Barangay Adams, Mt. Pao: KU 329756–61.

Platymantis rabori (18 specimens): MINDANAO ISLAND, New Bataan Province, Mt. Puting Bato: CMNH 2305, 2350; Davao Del Sur Province, *Municipality of Toril*, Barangay Baracatan, Sitio Upper Baracatan: CMNH 1462; *Municipality of Calinan*, Barangay Malagos: PNM 9504–05; AGUSAN DEL NORTE PROVINCE, Municipality of Remedios T. Romualdez, "May Impit" area, Mt. Hilong-Hilong: KU 334330–35; SAMAR ISLAND, Eastern Samar Province, *Municipality of Taft*, Barangay San Rafael: KU 309121–27.

Platymantis sierramadrensis (26 specimens): LUZON ISLAND, Aurora Province, *Municipality of San Luis*, Dipiningan branch of the Kobatangan River drainage: CMNH 5678–79, 5904; Barangay Villa Aurora, Aurora Memorial National Park, "Siete" area, Mt. Dayap: KU 322134–56; Isabela Province, *Municipality of Palanan*, Barangay Didian, Sitio Natap Dukan, Northern Sierra Madre National Park: 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: KU 300435–38.

Platymantis subterrestris (5 specimens): LUZON ISLAND, Mountain Province, Mt Data: CAS 204319–204321; Ifugao Province: FMNH 173165, 172392

Platymantis taylori (4 specimens): LUZON ISLAND, Isabela Province, *Municipality of Palanan*, Barangay Didian, Sitio Natapdukan: CAS 207443–207446 (Paratypes).