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Additions to Philippine Slender Skinks of the *Brachymeles bonitae* Complex (Reptilia: Squamata: Scincidae) I: a new species from Lubang Island

AARON D. GEHEBER[1], DREW R. DAVIS[2], JESSA L. WATTERS[3], MICHELLE L. PENROD[1], KATHRYN D. FELLER[4], CONNER S. DAVEY[1], ELYSE D. ELLSWORTH[1], RACHEL L. FLANAGAN[1], BRENDAN B. HEITZ[1], TANA MOORE[1], MARIE D. C. NGUYEN[1], AUSTYN ROBERTS[1], JOHN SUTTON[1], MARITES B. SANGUILA[5], CHARLES W. LINKEM[6], RAFE M. BROWN[7] & CAMERON D. SILER[1,3]

[1]*Department of Biology, University of Oklahoma, 730 Van Vleet Oval, Norman, OK 73019, USA. E-mails: aaron.d.geheber-1@ou.edu, michelle.l.penrod-1@ou.edu, conner.s.davey-1@ou.edu, elyse.d.ellsworth-1@ou.edu, rachelflanagan73@gmail.com, bheitz@ou.edu, tana.m.moore-1@ou.edu, marie.d.nguyen-1@ou.edu, austyn.m.roberts-1@ou.edu, john.d.sutton-1@ou.edu, camsiler@ou.edu*
[2]*Department of Biology, University of South Dakota, 414 East Clark Street, Vermillion, SD 57069, USA. E-mail: drew.davis@usd.edu*
[3]*Sam Noble Oklahoma Museum of Natural History, University of Oklahoma, 2401 Chautauqua Avenue, Norman, OK 73072, USA. E-mail: jwatters@ou.edu*
[4]*School of Biological Sciences, University of Bristol, Bristol, BS8 1TQ, UK. E-mail: kate.feller@gmail.com*
[5]*Father Saturnino Urios University, San Francisco St., 8600 Butuan City, Philippines. E-mail: tess.b.sanguila@gmail.com*
[6]*Department of Biology, University of Washington, Seattle, WA 98195, USA. E-mail: cwlinkem@gmail.com*
[7]*Biodiversity Institute and Department of Ecology and Evolutionary Biology, University of Kansas, 1345 Jayhawk Boulevard, Lawrence, KS 66045, USA. E-mail: rafe@ku.edu*

Abstract

A new species of slender skink is described from the Philippines. The species is endemic to Lubang Island, and is assigned to the *Brachymeles bonitae* Complex based on phenotypic and genetic data. Specimens were collected from Lubang Island between 1991 and 2012, and were examined based on morphological data (qualitative traits, meristic counts, and mensural measurements). Published genetic sequence data from phylogenetic studies of the genus reveal the new species to be highly divergent from congeners. *Brachymeles ligtas* **sp. nov.** is differentiated from other members of the genus based on a number of distinct morphological features, including small body size (SVL 60.7–79.6 mm), bidactyl fore-limbs, digitless hind limbs, high number of presacral vertebrae (50), and the absence of auricular openings. Additionally, the new species has diagnostic, distinct dorsal head scale patterns. This new species becomes the only member of the genus known to occur on the deep-ocean island of Lubang.

Key words: biodiversity, endemism, fossorial, limb reduction, non-pentadactyl, pentadactyl, Philippines

Introduction

Scientific exploration of Southeast Asia has a long fruitful history that has resulted in a number of newly described species of amphibians and reptiles, especially since the early 2000's (e.g., Bain *et al.* 2003; Brown *et al.* 2009, 2013; Siler *et al.* 2014; Amarasinghe *et al.* 2015). In the Philippines, an island nation in Southeast Asia composed of more than 7,100 islands, species discoveries occur quite frequently, and the known diversity of endemic amphibians and reptiles has increased exponentially over the last few decades (Brown *et al*. 2008, 2013; Brown & Stuart 2012; Diesmos *et al.* 2015). These species discoveries and subsequent descriptions are important because they result in greater taxonomic resolution for the region, fuel conservation efforts, and prompt greater understanding of amphibian and reptile evolution, ecology, and diversity within and among islands of the archipelago.

Members of the lizard family Scincidae contribute substantially to the reptile diversity of the Philippines. For

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more than a century, scientists have progressively documented the remarkable diversity of Philippine skinks (Brown & Alcala 1980) and placed species into the genera *Brachymeles* Duméril & Bibron (e.g., Taylor 1917; Brown & Rabor 1967; Siler *et al.* 2009, 2010a,b; Davis *et al.* 2014), *Dasia* Gray, *Emoia* Gray, *Eutropis* Fitzinger (Barley *et al.* 2013), *Insulasaurus* Taylor, *Lamprolepis* Fitzinger, *Lipinia* Gray, *Otosaurus* Gray, *Parvoscincus* Ferner, Brown & Greer (*e.g*., Linkem & Brown 2013), *Pinoyscincus* Linkem, Diesmos & Brown (Linkem *et al.* 2011), *Sphenomorphus* Fitzinger (Heyer 1972; Brown *et al.* 1995; Linkem *et al.* 2010), *Tropidophorus* Duméril & Bibron (Brown & Alcala 1980), and *Tytthoscincus* Linkem, Diesmos & Brown 2011. Of the scincid lizards that occur in the Philippines, the genus *Brachymeles* is of special interest due to its increasing species-level diversity and unique body form diversity (Hikida 1982; Siler & Brown 2010; Siler *et al*. 2011, 2012a,b; Davis *et al.* 2014). Because of the perceived cryptic diversity within the *Brachymeles* clade (for review, see Davis *et al.* 2014), the taxonomic diversity of this group is thought to be greater than what is recognized currently.

The genus *Brachymeles* is a phenotypically diverse group of lizards that range from small, slender and externally limbless, to elongate, robust and pentadactyl (Brown & Alcala 1980; Siler & Brown 2011; Davis *et al*. 2014). Currently, the genus is distributed across Southeast Asia, with one species occurring in Thailand (*B. miriamae* Heyer 1972), one in northern Borneo (*B. apus*, Hikida 1982), and the vast majority of species occurring in the Philippines (Davis *et al*. 2014). Among the 36 *Brachymeles* species that currently are known from the Philippines, 18 species are pentadactyl, 15 are non-pentadactyl with reduced limbs and number of digits, and three are entirely limbless (Davis *et al*. 2014). Although the clade possesses a wide spectrum of body forms, it is currently supported as monophyletic based on molecular data (Siler & Brown 2010, 2011; Siler *et al*. 2011). Recent studies have revealed that species historically recognized to have widespread distributions are complexes of morphologically and genetically unique lineages (Siler & Brown 2010; Siler *et al.* 2011, 2012a; Davis *et al*. 2014).

Until recently, *B. bonitae* Duméril & Bibron was recognized as a single species spanning most of the central and northern islands in the Philippines (Duméril & Bibron 1938; Taylor 1917; Brown 1956; Siler & Brown 2010; Siler *et al.* 2011, 2012a); however, a recent systematic revision of the group resulted in the recognition of four distinct lineages within the *B. bonitae* Complex (Davis *et al*. 2014). In revising this species complex, Davis *et al*. (2014) recognized four species: *B. isangdaliri* Davis, Feller, Brown & Siler from Aurora Province on Luzon Island, *B. mapalanggaon* Davis, Feller, Brown & Siler from Masbate Island, *B. tridactylus* Brown from the central Western Visayan islands, and *B. bonitae* based on robust morphological data as well as the results of recently published phylogenetic studies (Siler & Brown 2010; Siler *et al.* 2011, 2012a). Furthermore, Davis *et al.* (2014) restricted the range of true *B. bonitae* to central Luzon and Polillo Island based on comparisons of freshly collected material with the original descriptions of the holotype of *B. bonitae* (Duméril & Bibron 1839; Brown 1956). However, with observed morphological and genetic diversity remaining among allopatric populations allied with the *B. bonitae* Complex, it is likely that additional species may warrant recognition (Davis *et al.* 2014).

From 1991 to 2012 CDS, RMB, and colleagues conducted herpetological field surveys covering much of the central and northern Philippines, resulting in novel, vouchered individuals of many species of *Brachymeles* from throughout their ranges. Importantly, these surveys resulted in improved sampling of island populations of *B. bonitae*, and led to the discovery of a unique lineage on the deep-ocean island of Lubang in the northwestern Philippines (Fig. 1). Based on distinct, diagnostic morphological characteristics, we confirm that this unique lineage can be set apart from other members of the genus *Brachymeles*. In this study we describe the new species and comment on its ecology, distribution, and conservation status.

Material and methods

Field work, sample collection, and specimen preservation. Fieldwork was conducted on Camiguin Norte, Catanduanes, Lubang, Luzon, Marinduque, Masbate, Mindoro, Polillo, Sibuyan, and Tablas islands, all in the Philippines (Fig. 1) between 1991 and 2012. Specimens were collected during the day, euthanized with MS-222, dissected for tissue samples (liver samples preserved in 95% ethanol), fixed in 10% formalin, and eventually (< 2 mo) transferred to 70% ethanol. Specimens were deposited in U.S. and Philippine museum collections (Acknowledgments and Specimens Examined). Museum abbreviations for specimens examined follow those from Sabaj Pérez (2014).

Morphological data. We examined fluid-preserved specimens (Appendix I) for variation in qualitative,

meristic (scale counts), and mensural (measurements) characters. Sex was determined by gonadal inspection, and measurements were taken to the nearest 0.1 mm with digital calipers by CDS. X-rays were taken with a company cabinet X-ray on Kodak MIN-R 2000 film exposed at 5 milliamperes and 30 volts for 1 minute 15 seconds.

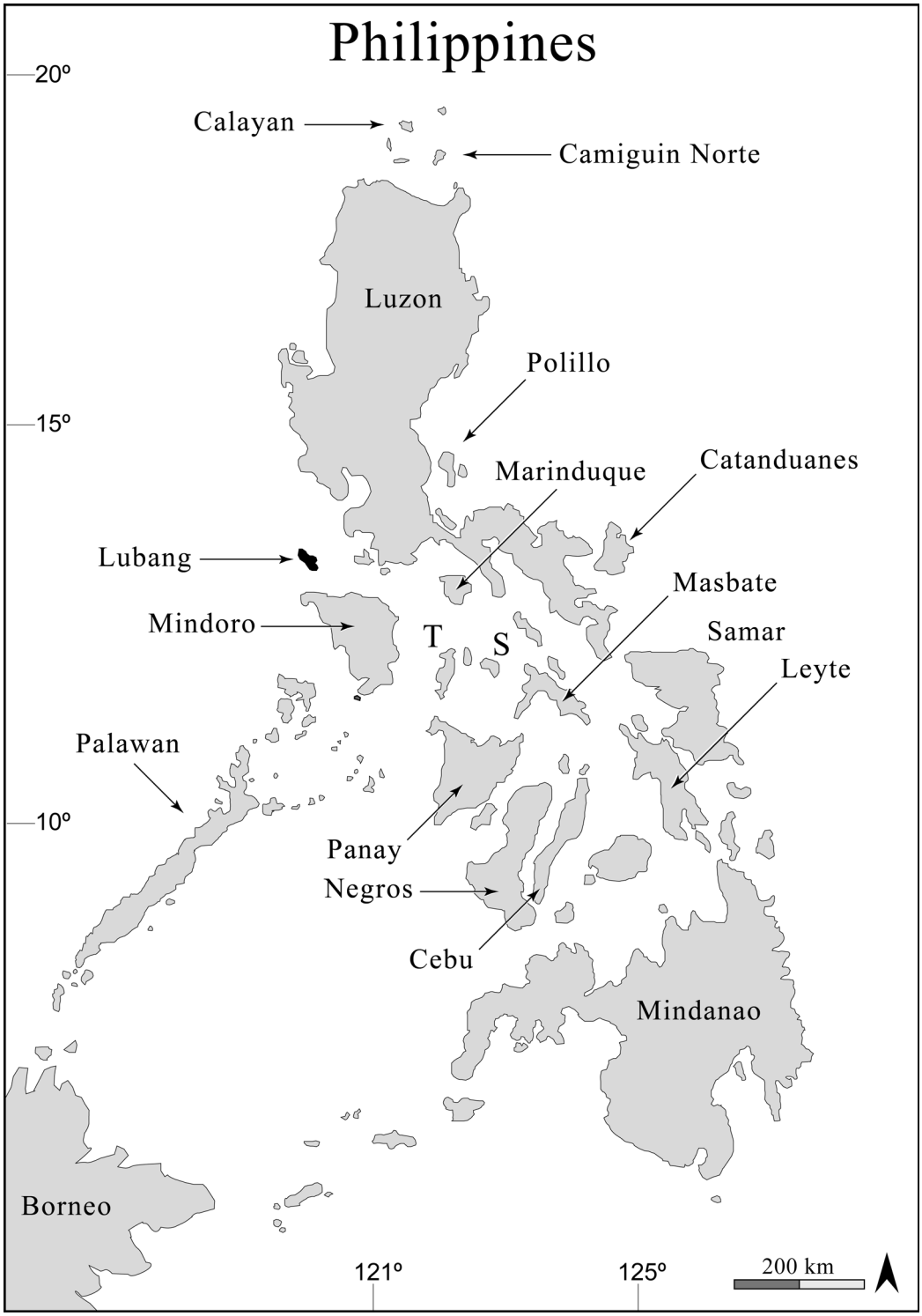

FIGURE 1. Map of the Philippine islands, with island labels provided for islands with representative samples used for this study. S = Sibuyan Island; T = Tablas Island.

Meristic and mensural characters were chosen based on Siler *et al*. (2009, 2010a,b): snout–vent length (SVL), axilla–groin distance (AGD), total length (TotL), midbody width (MBW), midbody height (MBH), tail length (TL), tail width (TW), head length (HL), head width (HW), snout–forearm length (SnFa), eye diameter (ED), eye–nares

distance (END), snout length (SNL), fore-limb length (FLL), hind limb length (HLL), midbody scale-row count (MBSR), paravertebral scale-row count (PVSR), axilla–groin scale-row count (AGSR), supralabial count (SL), infralabial count (IFL), supraciliary count (SC), and supraocular count (SO). Additionally, we counted the number of presacral vertebrae (PSV) from X-ray images of specimens. In the description, ranges are followed by mean ± standard deviation in parentheses.

Species Concept. We feel that the General Lineage Concept of species (de Queiroz 1998, 1999) is best suited for *Brachymeles*. For this study, we consider phenotypically divergent populations as distinct lineages, especially if such populations are allopatric. In this study we diagnose a new species based on character differences in non-overlapping morphological character states.

Research experience in the undergraduate classroom. As part of the Spring 2015 Herpetology Course (BIOL 4083) taught by CDS at the University of Oklahoma, students took part in a semester long, small group writing assignment, with each group assigned a distinct lineage of *Brachymeles* to describe under a structured writing and mentoring program (Siler *et al.* unpublished data). Detailed description of this course project has been made freely available at http://www.webcitation.org/6hEkRmogM (Watters & Siler 2016).

Taxonomic account

Brachymeles ligtas sp. nov.

(Figs. 2, 3)

Brachymeles bonitae Duméril & Bibron 1839; Taylor 1917; Brown 1956:5; Brown & Rabor 1967:526; Brown & Alcala 1970; Brown & Alcala 1980:20; Davis *et al.* 2014.

Holotype. PNM 9818 (CDS Field No. 3886, formerly KU 320472), adult female, collected on 26 April 2009 (14:00 h) in Sitio Dangay, Barangay Vigo, Municipality of Lubang, Occidental Mindoro Province, Lubang Island, Philippines (13.79995° N, 120.163930° E; WGS 84; 45 m elev. elevation), by J. Fernandez and CDS.

Paratypes (Paratopotypes). Four paratopotypes were also collected in Sitio Dangay, Barangay Vigo, Municipality of Lubang, Occidental Mindoro Province, Lubang Island, Philippines (13.79995° N, 120.163930° E; WGS 84; 45 m elev.), by J. Fernandez and CDS. One adult male (KU 320470) was collected on 24 April 2009 at 14:00 h, two adult females (KU 320471, 320473) were collected on 26 April 2009 at 14:00 h, and one juvenile (KU 320474) was collected on 29 April 2009 at 14:00 h.

Paratypes. One adult male (KU 307755) was collected on 8 December 2005 in Barangay Vigo, Municipality of Lubang, Occidental Mindoro Province, Lubang Island, Philippines (13.826552° N, 120.120514° E; WGS 84; 27 m elev.), by RMB, CDS, and CWL.

Diagnosis. Following recent taxonomic revisions of *Brachymeles* (Siler *et al.* 2011; Davis *et al.* 2014) the new species is assigned to the *B. bonitae* Complex based on the following suite of morphological characters: (1) limbs present, (2) non-pentadactyl, (3) fore-limbs with 0–3 fingers, (4) hind limbs with 0–2 toes, (5) paravertebral scale rows ≥ 91, (6) presacral vertebrae 47–53, (7) supraoculars four, (8) enlarged, differentiated nuchals present, (9) longitudinal rows of dark spots around the body absent, and (10) auricular opening absent.

Brachymeles ligtas **sp. nov.** can be distinguished from congeners by the following combination of characters: (1) body size small (SVL 60.7–79.6 mm), (2) fore-limbs bidactyl, (3) hind limbs digitless, (4) limb length short, (5) supralabials six, (6) infralabials six, (7) supraciliaries five, (8) supraoculars four, (9) midbody scale rows 22, (10) axilla–groin scale rows 74–76, (11) paravertebral scale rows 91–93, (12) prefrontal contact absent, (13) frontoparietal contact present, (14) enlarged chin shields in three pairs, (15) nuchals enlarged, (16) auricular opening absent, (17) presacral vertebrae 50, and (18) uniform body color (Tables 1, 2).

Comparisons. *Brachymeles ligtas* **sp. nov.** can be distinguished from other species in the *B. bonitae* Complex (*B. bonitae*, *B. isangdaliri*, *B. mapalanggaon, B. tridactylus*), by the number of presacral vertebrae (50 *versus* 53 [*B. bonitae*], 51 [*B. mapalanggaon*], 47 [*B. isangdaliri*, *B. tridactylus*]), and by having bidactyl fore-limbs and digitless hind limbs (*versus* bidactyl fore-limbs and unidactyl hind limbs [*B. bonitae*], digitless [*B. bonitae*, *B. mapalanggaon*], unidactyl [*B. isangdaliri*], or tridactyl [*B. tridactylus*]; Table 2); further, from *B. bonitae* by having a greater number of infralabials (6 *versus* 5) and absence (*versus* presence) of a fused mental and first chin shield; from *B. isangdaliri* by having fewer supraciliaries (5 *versus* 6) and the presence (*versus* absence) of a third chin

shield pair; from *B. mapalanggaon* by having a longer fore-limb length (1.2–1.4 mm *versus* 0.8–1.0) and a longer hind limb length (1.6–2.0 mm *versus* 1.2–1.6); from *B. tridactylus* by having a shorter fore-limb length (1.2–1.4 mm *versus* 1.5–2.5); from *B. isangdaliri* and *B. tridactylus* by having a greater number of presacral vertebrae (50 *versus* 47 [*B. isangdaliri*, *B. tridactylus*]) and a shorter hind limb length (1.6–2.0 mm *versus* 2.2 [*B. isangdaliri*] or 2.6–3.6 [*B. tridactylus*]); from *B. bonitae* and *B. mapalanggaon* by having fewer presacral vertebrae (50 *versus* 53 [*B. bonitae*] or 51 [*B. mapalanggaon*]), fewer axilla–groin scale rows (74–76 *versus* 83–90 [*B. bonitae*] or 80–84 [*B. mapalanggaon*]); from *B. bonitae*, *B. isangdaliri*, and *B. mapalanggaon* by having fewer paravertebral scale rows (91–93 *versus* 103–110 [*B. bonitae*], 97 [*B. isangdaliri*], or 99–102 [*B. mapalanggaon*]); from *B. bonitae*, *B. isangdaliri*, and *B. tridactylus* by the presence of frontoparietals in contact (*versus* not in contact). Finally, *Brachymeles ligtas* **sp. nov.** can be distinguished from all limbless species of *Brachymeles* by having limbs, and from all pentadactyl species of *Brachymeles* by having bidactyl fore-limbs and digitless hind limbs.

TABLE 1. Summary of mensural characters among species of the *Brachymeles bonitae* Complex. Sample size, body length and total length among males and females, and general geographical distribution (PAIC = Pleistocene Aggregate Island Complexes, sensu Brown & Diesmos [2002]) are included for reference (SVL, TotL, FLL, and HLL given as range over mean ± standard deviation; all body proportions given as percentage over mean ± standard deviation).

	bonitae (3 m, 1 f)	*isangdaliri* (1 f)	*ligtas* **sp. nov.** (3 m, 2 f)	*mapalanggaon* (3 m, 6 f)	*tridactylus* (12 m, 9 f)
Range	Luzon & Polillo islands	Luzon Island	Lubang Island	Masbate Island	West Visayan PAIC
SVL (f)	69.4	59.5	60.7–69.2 (65.0 ± 6.0)	61.7–75.8 (67.2 ± 5.4)	59.9–82.3 (71.4 ± 6.9)
SVL (m)	69.7–78.4 (72.8 ± 4.8)	N/A	69.4–79.6 (74.5 ± 5.1)	65.1–72.7 (68.4 ± 3.9)	60.7–77.6 (69.0 ± 6.0)
TotL (f)	N/A	106.1	119.4	120.2	133.6[1]
TotL (m)	122.0	N/A	160.6	112.6–118.6 (115.6 ± 4.3)	120.9–154.1 (136.0 ± 9.8)
TL/SVL	73	78	97–102 (99 ± 4)	67–84 (78 ± 9)	85–112 (95 ± 10)
FLL	1.0–1.7 (1.3 ± 0.3)	1.3	1.2–1.4 (1.3 ± 0.1)	0.8–1.0 (0.9 ± 0.1)	1.5–2.5 (2.0 ± 0.3)
FLL/SVL	1–2 (2 ± 0)	2	2–2 (2 ± 0)	1–2 (1 ± 0)	2–4 (3 ± 0)
HLL	1.5–2.3 (1.9 ± 0.3)	2.2	1.6–2.0 (1.8 ± 0.1)	1.2–1.6 (1.4 ± 0.1)	2.6–3.6 (3.1 ± 0.3)
HLL/SVL	2–3 (3 ± 0)	4	2–3 (3 ± 0)	2–2 (2 ± 0)	3–6 (5 ± 1)

Description of holotype. Adult female, body small, slender, SVL 79.6 mm; head weakly differentiated from neck (Fig. 2, 3), nearly as wide as body, HW 5.7% SVL, 96.0% HL; HL 34.2% SnFa; SnFa 17.3% SVL; snout rounded in dorsal and lateral profile, SNL 56.0% HL; ear completely hidden by scales; eyes small, ED 21.3% HL, 50.9% END, pupil subcircular; body slightly depressed, nearly uniform in thickness, MBW 124.7% MBH; scales smooth, glossy, imbricate; longitudinal scale rows at midbody 22; paravertebral scale rows 93; axilla–groin scale rows 76; limbs short, diminutive, bluntly rounded, with digits reduced to two small digit growths on fore-limbs; hind limb digits absent; finger lamellae absent; FLL 2.2% AGD, 1.7% SVL; HLL 3.1% AGD, 2.5% SVL; tail not as wide as body, gradually tapered towards end, TW 88.9% MBW, TL 101.7% SVL.

Rostral projecting onto dorsal snout to level in line with midline of nasal, wider than long, in contact with frontonasal; frontonasal wider than long; nostril ovoid, in anteroventral corner of single trapezoidal nasal, longer axis directed posterodorsally and anteroventrally; supranasals present; postnasals absent; prefrontals moderately separated; frontal roughly diamond-shaped, its anterior margin in moderate contact with frontonasal, in contact with first two anterior supraoculars, 5× wider than anterior supraocular; supraoculars four; frontoparietals moderate, in narrow contact, each contacts supraoculars two and three; interparietal moderate, its length roughly

equal to 1.5× midline length of frontoparietal, longer than wide, diamond-shaped, wider anteriorly, pineal eyespot ovoid, visible in center; parietals broader than frontoparietals, in moderate contact behind interparietal; enlarged nuchals present; loreals two, anterior loreal longer and slightly higher than posterior loreal; preocular one; presubocular one; supraciliaries five, the anteriormost contacting prefrontal and separating posterior loreal from first supraocular, posteriormost extending to midline of fourth supraocular; subocular scale row complete, in contact with supralabials; lower eyelid with one row of scales; supralabials six, first twice the width of others, third, fourth and fifth subocular; infralabials six (Fig. 2).

TABLE 2. Summary of meristic and qualitative diagnostic characters (present, absent) among species of the *Brachymeles bonitae* Complex. The pairs of enlarged scales posterior to the postmental scale are abbreviated as chin shield pairs with reference to the 1st, 2nd, and 3rd pairs (when present). In cases of scale count variation within species, numbers of individuals showing specific counts are given in parentheses.

	bonitae (3 m, 1 f)	*isangdaliri* (1 f)	*ligtas* **sp. nov.** (3 m, 2 f)	*mapalanggaon* (3 m, 6 f)	*tridactylus* (12 m, 9 f)
Number of digits (fingers/toes)	0/0[1] 2/1[1]	1/1	2/0	0/0	3/3
PSV	53	47	50	51	47
MBSR	21–24	22	22	22, 23	22–24
AGSR	83–90	73	74–76	80–84	72–79
PVSR	103–110	97	91–93	99–102	90–98
SL	6	6	6	6	6 (13) 7 (8)
IFL	5	6	6	5 (8) 6 (1)	6 (13) 7 (8)
SC	5	6	5	5	5
SO	4	4	4	4	4
Prefrontal contact	Absent	Absent	Absent	Absent	Absent
Frontoparietal contact	Absent	Absent	Present	Point contact or Absent	Absent
1st chin shield pair contact	Absent	Absent	Present or Absent	Absent	Present or Absent
3rd chin shield pair	Present	Absent	Present	Present or Absent	Present
Mental/1st IFL fusion	Present	Absent	Absent	Present or Absent	Absent
Enlarged nuchals	Present	Present	Present	Present	Present
Longitudinal rows of dark spots	Absent	Absent	Absent	Absent	Absent

[1]Observed for two individuals.

Mental wider than long, in contact with first infralabials; postmental single, enlarged, its width greater than width of mental; followed by three pairs of enlarged chin shields, first and second pairs moderately separated by single medial scale, second pair largest followed by first pair, third pair smallest, separated by four medial scales (Fig. 2). Scales on limbs smaller than body scales.

Variation. All specimens examined in this series match the holotype closely except one individual (KU 307755) that has the first chin shield pair in contact.

Coloration of holotype in life. (Fig. 3) The dorsal, and lateral portions of the trunk and tail are solid pink-like Beige (Color 254; Köhler 2012). Just above the orbit, a single splotch of Pratt's Payne's Gray (Color 293; Köhler 2012) can be seen on the dorsal and lateral portions of the head, as well as Cinnamon-Drab on the snout (Color 50; Köhler 2012).

Coloration of holotype in preservative. The dorsal, lateral, and ventral portions of the trunk and tail are a solid Prout's Brown (Color 47; Köhler 2012). Just above the orbit, a single splotch of Fuscous (Color 283; Köhler 2012) can be seen on the dorsal and lateral portions of the head. The ventral portion of the head is the same background color as the trunk (Prout's Brown; Color 47; Köhler 2012).

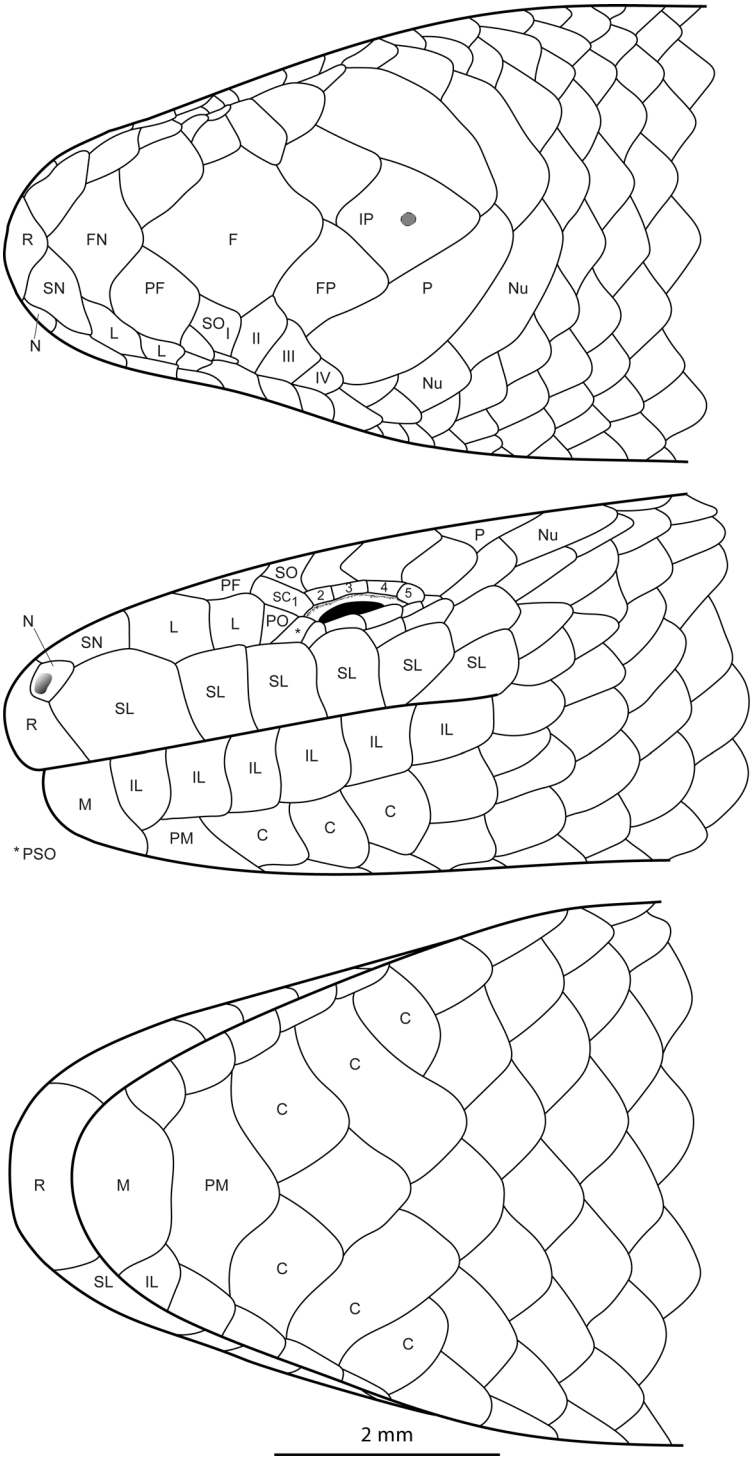

FIGURE 2. Illustration of head scale patterns of the holotype of *Brachymeles ligtas* **sp. nov.** (PNM 9818) in dorsal, lateral, and ventral views. Taxonomically diagnostic head scales are labeled as follows: C, chin shield; F, frontal; FN, frontonasal; FP, frontoparietal; IL, infralabial; IP, interparietal; L, loreal; M, mental; N, nasal; Nu, nuchal; P, parietal; PF, prefrontal; PM, postmental; PO, preocular; PSO, presubocular; R, rostral; SC, supraciliary; SL, supralabial; SN, supranasal; and SO, supraocular. Roman numerals indicate scales in the supraocular series, with Arabic numbers indicating scales in the supraciliary series. Illustrations by MLP and CDS.

Etymology. The specific epithet is derived from the Tagalog (Filipino) term "nakaligtas," meaning "survivor" and "ligtas," meaning "salvation." We name this species in honor of the people of Lubang Island who endured nearly three decades of violence and guerrilla warfare, from 1945 to 1974, led by the Imperial Japanese Army intelligence officer Hiroo Onoda, and four Japanese soldiers. After being driven into the jungle of Lubang Island

by allied forces near the end of World War II, Onoda resisted surrender for 29 years believing the war was not yet over. Onoda would finally surrender in 1974, allowing the communities of Lubang to move on from the hardships faced during this time period, including the loss of over 30 lives and injuries to dozens more. Suggested common name: Lubang Slender Skink.

FIGURE 3. Photograph of holotype in life of *Brachymeles ligtas* **sp. nov.** (PNM 9818). Note: Individual is about to shead, resulting in lighter scale coloration. Photograph taken by CDS.

Distribution. *Brachymeles ligtas* **sp. nov.** is currently known only from Lubang Island (Fig. 1) and we expect it is found on several smaller nearby landmasses.

Natural history. *Brachymeles ligtas* **sp. nov.** likely once occurred in low- to mid-elevation primary forest habitats. As most primary forest on Lubang Island has been destroyed, the recent observations of this species have occurred in secondary growth forest habitats. In contrast to the other members of the *B. bonitae* Complex, this species appears to be relatively common in secondary growth forest fragments on the island. To date, no other congeners have been documented on Lubang Island.

We have evaluated this species against the International Union for Conservation of Nature (IUCN) criteria for classification and find that it does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened status. Although *B. ligtas* **sp. nov.** is known from a single island only, the species appears relatively common in secondary growth forest on Lubang, and until additional data are presented to support otherwise, we classify this species as Least Concern (LC; IUCN 2015).

Discussion

To date, it appears that *Brachymeles ligtas* **sp. nov.** is endemic to Lubang Island, Philippines. Previous studies have suggested that the *B. bonitae* Complex likely includes a number of cryptic but distinct evolutionary lineages (Davis *et al.* 2014). Although populations of *B. ligtas* **sp. nov.** were included previously in this complex, the Lubang Island population is a genetically and morphologically distinct evolutionary lineage (Table 3). Percent divergences

for available mitochondrial data (Davis *et al.* 2014) demonstrate that *B. ligtas* **sp. nov.** is distinguished from congeners by levels of genetic divergence greater than those between previously defined species—*B. cebuensis* Brown & Rabor, *B. minimus* Brown & Alcala, *B. lukbani* Siler, Balete, Diesmos & Brown (Table 3; Siler *et al*. 2011). Our description of *B. ligtas* **sp. nov.** increases the known species diversity of the genus in the Philippines to 37, and future examination of other allopatric populations of the *B. bonitae* Complex may reveal additional diversity (Davis *et al.* 2014).

TABLE 3. Uncorrected pairwise sequence divergence (%) for mitochondrial data for focal species of the *Brachymeles bonitae* Complex (*B. bonitae*, *B. isangdaliri*, *B. ligtas* **sp. nov.**, *B. mapalanggaon*, and *B. tridactylus*). Percentages on the diagonal represent intraspecific genetic diversity (bolded for emphasis). Data based on Siler *et al.* (2011a) and Davis *et al.* (2014).

	bonitae	*isangdaliri*	*ligtas* **sp. nov.**	*mapalanggaon*	*tridactylus*
bonitae	**0.2–1.5**				
isangdaliri	9.5–10.0	**0.0**			
ligtas **sp. nov.**	8.8–9.5	10.0	**0.7**		
mapalanggaon	9.0–11.1	10.4–11.2	10.3–11.1	**2.6**	
tridactylus	8.6–9.6	9.5–10.3	9.8–10.2	7.8–8.8	**0.1–5.0**

Brachymeles ligtas **sp. nov.** is unique in having bidactyl fore-limbs and digitless hind limbs, which distinguish it from all other species in the genus. All *Brachymeles* share a relatively conserved body plan, although there is a relationship between body elongation, limb reduction, and digit loss (Siler & Brown 2011). It is possible that correlations between body length, limb size, and limb structure may play some role in ecological function. A comparative study of body plan variation indicated that multiple evolutionary shifts in body size, limb reduction, and digit loss has occurred in the evolutionary history of the genus (Siler & Brown 2011). This suggests that body plan is important or adaptive for locomotion in specialized habitats (i.e., certain body plans may be more or less beneficial depending on forest type, substrate, topography, etc.), which could explain why certain features have been lost and gained multiple times across the clade. Therefore, the small body size and short limbs of *B. ligtas* **sp. nov.** could be functionally important, and future work should assess the ecomorphology of this species, and congeneric lineages in order to better understand potential adaptive qualities of these morphologies.

Like other species in the genus, *B. ligtas* **sp. nov.** are semi-fossorial skinks that specialize by living in leaf litter, rotting logs, and loose soil (Siler & Brown 2010; Siler *et al.* 2011). Besides this generalization of habitat use among members of the genus, little is known as to whether *B. ligtas* **sp. nov.** has ecological preferences at the microhabitat scale. Although secondary growth forest is not likely a historically accurate depiction of the preferred habitat of *B. ligtas* **sp. nov.**, populations can still be readily encountered in such disturbed habitats.

The Philippine radiation of *Brachymeles* constitutes a remarkable model system for understanding biogeography, processes of diversification, evolution of morphological novelty, and phylogenetic patterns of local community structure (Siler & Brown 2011; Siler *et al.* 2011; Brown *et al.* 2013). *Brachymeles ligtas* **sp. nov.** is the only species in the genus to occur on Lubang Island. Historical dispersal events of *Brachymeles* throughout the archipelago have been hypothesized as a mechanism behind the archipelago-wide distribution of the genus (Siler *et al.* 2011). Dispersal between islands may have been mediated by chance oversea rafting events on mats of vegetation, topsoil, and logs (Siler *et al.* 2011), and it seems plausible that such a scenario was responsible for the colonization of *B. ligtas* **sp. nov.** on Lubang Island. Despite the widespread occurrence of the genus across the Philippines, the one exception is the western island of Palawan, where no populations of *Brachymeles* have ever been documented. Interestingly, on this island, two species of *Lygosoma* Hardwicke & Gray (*L. quadrupes* Linnaeus and *L. bowringii* Günther) occupy microhabitats typical of species of *Brachymeles* (Brown & Alcala 1980; ACD, *personal observations*).

Species descriptions within this complex, like that of the present study, will lead to a greater understanding of speciation patterns and processes within this system by providing a more refined measure of diversity, and in turn lead to more directed and effective conservation efforts. Habitat preservation must be a critical focus of researchers and policy makers alike in order to conserve *Brachymeles* diversity. The semi-fossorial habitat of this unique radiation of skinks has made it difficult for researchers to estimate population densities and assess microhabitat

affinities (Siler *et al.* 2011, 2012a). In the absence of such estimates, long-term impacts of deforestation on populations of endemic Philippine species have yet to be studied (Siler *et al.* 2012a). This should be addressed in the near future, as habitat preservation is essential to protecting the unique species diversity in the Philippines. Specifically, survey efforts are lacking in poorly understood regions of the Philippines (*i.e.*, Mindanao, Samar, parts of northern Luzon), and are needed to assist in long-term strategic conservation planning. Without such surveys, other distinct lineages of *Brachymeles* will remain undescribed and unprotected (Siler *et al.* 2011, 2012a; Davis *et al.* 2014). Finally, additional surveys on Lubang Island, as well the three geographically proximate islands of Ambil, Cabra, and Golo, are warranted to document the full geographic distribution of *B. ligtas* **sp. nov.** and to determine appropriate strategies for conserving suitable habitat at local scales.

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Author contributions

CDS conceived the idea; CDS, ADG, and JLW carried out assignment instruction and mentoring; MBS, CWL, RMB, and CDS participated in fieldwork; MLP and KDF created scientific illustrations; CSD, EDE, RLF, BBH, TM, MDCN, AR, and JS compiled and analyzed the dataset; CSD, EDE, RLF, BBH, TM, MDCN, AR, and JS led the writing; ADG, DRD, JLW and CDS assisted in finalizing the manuscript for publication; ADG, DRD, JLW, MLP, KDF, CSD, EDE, RLF, BBH, TM, MDCN, AR, JS, MBS, RMB, and CDS edited drafts of the manuscript.

APPENDIX I. Additional specimens examined.

Numbers in parentheses indicate the number of specimens examined. With the exception of *Brachymeles apus* and *B. miriamae*, all specimens examined are from the Philippines. Several sample sizes are greater than those observed in the description due to the examination of sub-adult specimens which were excluded from morphometric analyses.

Brachymeles apus (1). BORNEO: MALAYSIA: *Sabah*: (SP 06915).

Brachymeles bicolandia Siler, Fuiten, Jones, Alcala & Brown (20). LUZON ISLAND: ALBAY PROVINCE: *Municipality of Malinao*: Paratypes (CAS 140065, 152025, 152026); *Municipality of Tabaco City*: Holotype (PNM 9756), Paratopotypes (KU 324005–324011, 324015, 324016, 323087, PNM 9757–9760); CAMARINES SUR PROVINCE: *Municipality of Pili*: Paratypes (CAS-SU 24173, 24413).

Brachymeles bicolor Gray (24). LUZON ISLAND: AURORA PROVINCE: *Municipality of Maria Aurora*: (KU 323149–323152); CAGAYAN PROVINCE: *Municipality of Baggao*: (CAS 186111, USNM 140847, 498829, 498830, 498833); ISABELA PROVINCE: (KU 324097–324099, PNM 5785, 9568–9577); KALINGA PROVINCE: (FMNH 259438).

Brachymeles boholensis Brown & Rabor (39). BOHOL ISLAND: BOHOL PROVINCE: *Municipality of Sierra Bullones*: Holotype (CAS-SU 24528), Paratypes (CAS-SU 24502–24504, 24518, 24520–24525, 24541, 24543), (CAS-SU 18709, 18717, 24867, 25443, 25444, 25447, KU 323944, 323948, 323949, 323952–323956, 323960, 323962, 323963, 323966, 323970, 323972, 323975, 323976, 323981, 323982, 323990, 324001).

Brachymeles bonitae (9). LUZON ISLAND: CAVITE PROVINCE: *Municipality of Ternate*: (KU 326090); LAGUNA PROVINCE: *Municipality of Los Baños*: (CAS 62578, MCZ 26585); QUEZON PROVINCE: *Municipality of Tayabas*: (KU 326089);

MINDORO ISLAND: MINDORO ORIENTAL PROVINCE: *Municipality of Calapan*: (MCZ 26584); POLILLO ISLAND: QUEZON PROVINCE: *Municipality of Polillo*: (CAS 62278, 62279, 62575, KU 307747).

Brachymeles brevidactylus Siler, Fuiten, Jones, Alcala & Brown (3). LUZON ISLAND: SORSOGON PROVINCE: *Municipality of Irosin*: Holotype (PNM 9764), Paratypes (PNM 4856, TNHC 62469).

Brachymeles cebuensis (8). CEBU ISLAND: CEBU PROVINCE: *Municipality of Carcar*: Holotype (CAS-SU 24400), Paratypes (CAS 102405, CAS-SU 24396, 24397, 24399, 24401, 24403); *Municipality of Cebu City*: Paratype (CAS-SU 27537).

Brachymeles cobos Siler, Fuiten, Jones, Alcala & Brown (10). CATANDUANES ISLAND: CATANDUANES PROVINCE: *Municipality of Virac*: Holotype (PNM 9761), Paratopotypes (KU 306311, 308077, 324019–324021, 324025, 324026, PNM 9762, 9763).

Brachymeles elerae Taylor (5). LUZON ISLAND: KALINGA PROVINCE: *Municipality of Balbalan*: (CAS 61499, 61500, PNM 9563, 9564), Paratype (CM 1717).

Brachymeles gracilis Fischer (69). MINDANAO ISLAND: DAVAO DEL SUR PROVINCE: (FMNH 52642–52644, 52646, 52647, 52662, 52669, 52670); *Municipality of Davao City*: (CAS 124803, 124804, 139293–139295, 139301–139305); *Municipality of Davao City Digos City*: (CAS 124806–124808, 139296–139300); *Municipality of Kiblawan*: (KU 326096, 326098–326108, 326298, 326299); *Municipality of Malalag*: (CAS-SU 24158–24165, 24171, CAS 124809–124812, 139306–139311); *Municipality of Toril*: (CMC 12170, 12171); SOUTH COTABATO PROVINCE: (MCZ 26539, 26541, 26543, 26544, 26546, 26548–26550).

Brachymeles hilong Brown & Rabor (28). MINDANAO ISLAND: AGUSAN DEL NORTE PROVINCE: *Municipality of Cabadbaran*: Holotype (CAS-SU 24407), Paratypes (CAS-SU 102406, 133578, CAS-SU 24411, 133577, 133579, 133581, 133582, 133609, 133612, 133692, 133693, 133703–133706, 133743, 133745–133747); AGUSAN DEL SUR PROVINCE: *Municipality of San Francisco*: (KU 319934–319940); SURIGAO DEL SUR PROVINCE: *Municipality of Lanuza*: Paratype (CAS-SU 24315).

Brachymeles isangdaliri (2). LUZON ISLAND: AURORA PROVINCE: *Municipality of Baler*: Holotype (PNM 9791), Paratopotype (KU 323085).

Brachymeles kadwa Siler & Brown (141). CALAYAN ISLAND: CAGAYAN PROVINCE: *Municipality of Calayan*: Paratypes (KU 304875, 304897, 304900, 304902, 304903, 304905, 304906, 304915, 304929, 304941, 304908, 304899, 304907, 304909, 304921, 304941); CAMIGUIN NORTE ISLAND: CAGAYAN PROVINCE: *Municipality of Calayan*: Paratypes (KU 304559, 304575, 304593, 304708, 304754, 307984, 307996, 307998, 308011, 304558, 304562–304565, 304569, 304571–304574, 304627–304630, 304643, 304647, 304696–304699, 304704–304707, 304709–304712, 304714, 304753, 304755–59, 307965, 307966, 307985, 307986, 307997, 307999–308003, 308006–308010, 308012–308015, 308017, 308018); LUZON ISLAND: AURORA PROVINCE: *Municipality of Baler*: Holotype (PNM 9721), Paratopotypes (KU 323092, 323094–323096, 323100, 323104, 323106, 323090, 323093, 323097–323099, 323101–323103, 323105, 323107); *Municipality of Casiguran*: (KU 323108–48); *Municipality of San Luis*: (KU 322320).

Brachymeles libayani Siler, Fuiten, Jones, Alcala & Brown (45). LAPINIG CHICO ISLAND: BOHOL PROVINCE: *Municipality of President Carlos P. Garcia*: Paratypes (CAS-SU 27556, 28454, 28455); LAPINIG GRANDE ISLAND: BOHOL PROVINCE: *Municipality of President Carlos P. Garcia*: Holotype (PNM 9749), Paratopotypes (KU 320428–320430, 320435–320463, 320467, PNM 9750–9755), Paratype (CAS-SU 28453); POLONG DAKO ISLAND: BOHOL PROVINCE: *Municipality of President Carlos P. Garcia*: Paratype (CAS-SU 27554).

Brachymeles ligtas **sp. nov.** (5). LUBANG ISLAND: MINDORO OCCIDENTAL PROVINCE: *Municipality of Lubang*: Holotype (PNM 9818), Paratopotypes (KU 320470, 320471, 320473), Paratype (KU 307755).

Brachymeles lukbani (14). LUZON ISLAND: CAMARINES NORTE PROVINCE: *Municipality of Labo*: Holotype (PNM 9567), Paratopotypes (PNM 9589–9592, KU 313597–313599, 313601, 313603, 313604, 313606, 313608, FMNH 270191).

Brachymeles makusog Siler, Diesmos & Brown (17). CATANDUANES ISLAND: CATANDUANES PROVINCE: *Municipality of Gigmoto*: Holotype (PNM 9565), Paratopotypes (PNM 9583, 9584, KU 308126, 308128, 308136, 308208); LUZON ISLAND: CAMARINES NORTE PROVINCE: *Municipality of Labo*: Paratypes (KU 313612–313614, 313616, 313617, PNM 9585–9588, FMNH 270200).

Brachymeles mapalanggaon (8). MASBATE ISLAND: MASBATE PROVINCE: *Municipality of Masbate City*: Holotype (PNM 9792), Paratopotype (KU 323938); *Municipality of Mobo*, Paratypes (CAS 144223, 144236, 144237, 144239, 144270, 144340).

Brachymeles mindorensis Brown & Rabor (34). MINDORO ISLAND: MINDORO OCCIDENTAL PROVINCE: *Municipality of Paluan*: (KU 304351–304355, 304412, 304413, 304488, 307739–307742, 308404, 308447, 308448, 308534); MINDORO ISLAND: MINDORO ORIENTAL PROVINCE: *Municipality of Naujan*: Holotype (CAS-SU 24487), Paratypes (CAS-SU 24549–24554, 24561, 24562, 24564; 24566, 24568, 24570, 24573, 24574, 24577–24579).

Brachymeles minimus (6). CATANDUANES ISLAND: CATANDUANES PROVINCE: *Municipality of Gigmoto*: (KU 308129–308131, 308210–308212).

Brachymeles miriamae (2). THAILAND: NAKHON RATCHASIMA PROVINCE: *Wang Nam Khieo District*: (KU 327692, 327693).

Brachymeles muntingkamay Siler, Rico, Duya & Brown (17). LUZON ISLAND: NUEVA VIZCAYA PROVINCE: *Municipality of Quezon*: Holotype (PNM 9566), Paratopotypes (PNM 9578–9582, KU 308865, 308866, 308900–308906, 308908, 308953).

Brachymeles orientalis Brown & Rabor (48). BOHOL ISLAND: BOHOL PROVINCE: *Municipality of Sierra Bullones*: Holotype (CAS-SU 24436), Paratypes (CAS-SU 18702, 24428, 24434, 24437, 24458, 24442, 24446–24451, CAS 102404), (CAS-

SU 25452, 25460); CAMIGUIN SUR ISLAND: CAMIGUIN PROVINCE: *Municipality of Catarman*: (CAS 110976–110983); LEYTE ISLAND: Leyte PROVINCE: *Municipality of Baybay*: (KU 311231–311235, 311241); MINDANAO ISLAND: AGUSAN DEL NORTE PROVINCE: *Municipality of Cabadbaran*: (CAS-SU 133301, 133616, 133749, 133752, 133754); SAMAR ISLAND: EASTERN SAMAR PROVINCE: *Municipality of Taft*: (KU 305470, 310734–310736, 310739, 310942–310946, 310949, 310951, 310955).

Brachymeles paeforum Siler, Fuiten, Jones, Alcala & Brown (13). LEYTE ISLAND: LEYTE PROVINCE: *Municipality of Burauen*: Paratypes (CAS-SU 26110, 26112, 26115, 26120–26123); *Municipality of Baybay City*: Holotype (PNM 9746), Paratopotypes (KU 311224, 311225, 311224, PNM 9747, 9748).

Brachymeles pathfinderi Taylor (40). MINDANAO ISLAND: SARANGANI PROVINCE: *Municipality of Glan*: (KU 324057–324096).

Brachymeles samad Siler, Jones, Diesmos, Diesmos & Brown (45). SAMAR ISLAND: EASTERN SAMAR PROVINCE: *Municipality of Taft*: Holotype (PNM 9767), Paratopotypes (KU 310730, 310731, 310820–310827, 310829–310839, 310928–310935, 310937, 310941); LEYTE ISLAND: LEYTE PROVINCE: *Municipality of Baybay City*: Paratypes (KU 311216, 311218, 311220, 311221, 311223, PNM 9768–9775).

Brachymeles samarensis Brown (7). SAMAR ISLAND: EASTERN SAMAR PROVINCE: *Municipality of Taft*: (KU 310849–310852, 311294–311296).

Brachymeles schadenbergi Fischer (34). BASILAN ISLAND: BASILAN PROVINCE: *Municipality of Maluso*: (CAS 60493); MINDANAO ISLAND: MISAMIS OCCIDENTAL PROVINCE: (CAS-SU 23468, 23469, 23471, 23479–23481, 23484, 23485); ZAMBOANGA DEL NORTE PROVINCE: *Municipality of Rizal*: (CAS-SU 23494–23496); ZAMBOANGA CITY PROVINCE: *Municipality of Pasonanca*: (KU 314967, 314969, 314970–314978, 314980, 314984, 314985, 314988–314992, 314994, 314996, 314997).

Brachymeles suluensis Taylor (2). BASILAN ISLAND: BASILAN PROVINCE: *Municipality of Isabela City*: (CAS 60365, 60366).

Brachymeles talinis Brown (31). NEGROS ISLAND: NEGROS ORIENTAL PROVINCE: *Municipality of Valencia*: Holotype (CAS-SU 18358), Paratype (CAS-SU 89813), (CAS 133871); *Municipality of Dumaguete City*: Paratype (CAS-SU 12225); *Municipality of Siaton*: (CAS-SU 22311, 22312; 22317, 22323); INAMPULAGAN ISLAND: GUIMARAS PROVINCE: *Municipality of Sibunag*: (CAS-SU 27972, 27996, 27997); PANAY ISLAND: ANTIQUE PROVINCE: *Municipality of San Remigio*: (KU 306756–306760, 306762–306767, 306769, 306770–306776, 306786).

Brachymeles taylori Brown (34). NEGROS ISLAND: NEGROS OCCIDENTAL PROVINCE: *Municipality of Silay City*: (KU 324044–324056); NEGROS ORIENTAL PROVINCE: *Municipality of Valencia*: Holotype (CAS-SU 18615), Paratypes (CAS-SU 18641, 18649, 18656, 18657, 18748), (CAS-SU 21873, 21877, 21880, 21883, 21884, 22355, 22356); CEBU ISLAND: CEBU PROVINCE: *Municipality of Carcar*: (CAS 154671, 154673, 154678–154682, 154686).

Brachymeles tiboliorum Siler, Jones, Diesmos, Diesmos & Brown (3). MINDANAO ISLAND: SOUTH COTABATO PROVINCE: *Municipality of Tampakan*: Holotype (PNM 9777), Paratopotype (PNM 9776); MISAMIS ORIENTAL PROVINCE: *Municipality of Tubigan*: Paratype (KU 326109).

Brachymeles tridactylus (20). NEGROS ISLAND: NEGROS OCCIDENTAL PROVINCE: *Municipality of La Castellana*: (CAS-SU 19424, 19426, 19427, 19429, 19452, 19458, 27082, 27083); NEGROS ORIENTAL PROVINCE: *Municipality of Manjuyod*: Holotype (CAS-SU 18354); PANAY ISLAND: ANTIQUE PROVINCE: *Municipality of Culasi*: (KU 307726–307736).

Brachymeles tungaoi Siler & Brown (12). MASBATE ISLAND: MASBATE PROVINCE: *Municipality of Masbate City*: Holotype (PNM 9722), Paratopotypes (KU 323934–323936); *Municipality of Mobo*: Paratypes (CAS 144229, 144230, 144290, 144306, 144307, 144313, 144341, 144342).

Brachymeles vermis Taylor (5). JOLO ISLAND: SULU PROVINCE: *Municipality of Jolo*: Paratype (CAS-SU 62489), (CAS-SU 60720–60722, 60857).

Brachymeles vindumi Siler & Brown (4). JOLO ISLAND: SULU PROVINCE: *Municipality of Jolo*: Holotype (CAS 60724), Paratypes (CAS 60723, 60725, MCZ 26577).

Brachymeles vulcani Siler, Jones, Diesmos, Diesmos & Brown (20). CAMIGUIN SUR ISLAND: CAMIGUIN SUR PROVINCE: *Municipality of Mambajao*: Holotype (PNM 9766), Paratypes (CAS-SU 26142, 26144–26146, 26165, 26166, 26184, 26185, 26231, 26236, 26294, 26295, CAS 139031); *Municipality of Catarman*: Paratypes (CAS-SU 28199, 28314, 28329, 28331, 28358, 28359).

Brachymeles wrighti Taylor (2). LUZON ISLAND: BENGUET PROVINCE: *Municipality of La Trinidad*: Holotype (MCZ 26589), (USNM 140756).