
Publisher's PDF, also known as Version of record

License (if available):
CC BY

Link to published version (if available):
10.11646/zootaxa.4132.1.1

Link to publication record in Explore Bristol Research

PDF-document

This is the final published version of the article (version of record). It first appeared online via Magnolia Press at http://www.mapress.com/j/zt/article/view/zootaxa.4132.1.1 Please refer to any applicable terms of use of the publisher.

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
http://www.bristol.ac.uk/pure/user-guides/explore-bristol-research/ebr-terms/
Additions to Philippine Slender Skinks of the Brachymeles bonitae Complex
(Reptilia: Squamata: Scincidae) I: a new species from Lubang Island

AARON D. GEHEBER¹, DREW R. DAVIS², JESSA L. WATTERS¹, MICHELLE L. PENROD¹,
KATHRYN D. FELLER⁴, CONNER S. DAVEY¹, ELYSE D. ELLSWORTH¹,
RACHEL L. FLANAGAN⁵, BRENDA B. HEITZ¹, TANA MOORE¹, MARIE D. C. NGUYEN⁴,
AUSTYN ROBERTS¹, JOHN SUTTON³, MARITES B. SANGUILA⁵,
CHARLES W. LINKEM⁶, RAFAEL M. BROWN⁷ & CAMERON D. SILER¹,³

¹Department 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, cansilter@ou.edu
²Department of Biology, University of South Dakota, 414 East Clark Street, Vermillion, SD 57069, USA. E-mail: drew.davis@usd.edu
³Sam Noble Oklahoma Museum of Natural History, University of Oklahoma, 2401 Chautauqua Avenue, Norman, OK 73072, USA. E-mail: jwatters@ou.edu
⁴School of Biological Sciences, University of Bristol, Bristol, BS8 1TQ, UK. E-mail: kate.feller@gmail.com
⁵Father Saturnino Urios University, San Francisco St., 8600 Butuan City, Philippines. E-mail: tess.b.sanguila@gmail.com
⁶Department of Biology, University of Washington, Seattle, WA 98195, USA. E-mail: cwlinkem@gmail.com
⁷Biodiversity 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
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* Ferrer, Brown & Greer (e.g., Linkem & Brown 2013), *Pinoscinclus* Linkem, Diesmos & Brown (Linkem et al. 2011), *Sphenomorphus* Fitzinger (Heyer 1972; Brown et al. 1995; Linkem et al. 2010), *Tropicophorus* Duméril & Bibron (Brown & Alcala 1980), and *Tythoscinus* 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/6hEkRmgM (Watters & Siler 2016).

**Taxonomic account**

*Brachymeles ligtas* sp. nov.  
(Figs. 2, 3)


**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 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 0.8–1.0) and a longer 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 presacral vertebrae (47 [*B. isangdaliri*] or 50 [*B. mapalanggaon*]); from *B. bonitae*, *B. isangdaliri*, and *B. tridactylus* 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 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 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 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 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 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 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 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 having fewer paravertebral scale rows (91–93 versus 103–110 [ *B. bonitae*], 97 [ *B. isangdaliri*], or 99–102 [ *B. mapalanggaon*]).

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).

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

**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 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, postriormost 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.

<table>
<thead>
<tr>
<th></th>
<th>bonitae (3 m, 1 f)</th>
<th>isangdaliri (1 f)</th>
<th>ligtas sp. nov. (3 m, 2 f)</th>
<th>mapalanggaon (3 m, 6 f)</th>
<th>tridactylus (12 m, 9 f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of digits</td>
<td>0/0(^1)</td>
<td>1/1</td>
<td>2/0</td>
<td>0/0</td>
<td>3/3</td>
</tr>
<tr>
<td>PSV</td>
<td>53</td>
<td>47</td>
<td>50</td>
<td>51</td>
<td>47</td>
</tr>
<tr>
<td>MBSR</td>
<td>21–24</td>
<td>22</td>
<td>22</td>
<td>22, 23</td>
<td>22–24</td>
</tr>
<tr>
<td>AGSR</td>
<td>83–90</td>
<td>73</td>
<td>74–76</td>
<td>80–84</td>
<td>72–79</td>
</tr>
<tr>
<td>SL</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6 (13)</td>
</tr>
<tr>
<td>IFL</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6 (8)</td>
<td>6 (13)</td>
</tr>
<tr>
<td>SC</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>SO</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Prefrontal contact</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Frontoparietal contact</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
<td>Point contact or Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>1st chin shield pair contact</td>
<td>Absent</td>
<td>Absent</td>
<td>Present or Absent</td>
<td>Absent</td>
<td>Present or Absent</td>
</tr>
<tr>
<td>2nd chin shield pair</td>
<td>Present</td>
<td>Absent</td>
<td>Present</td>
<td>Present or Absent</td>
<td>Present</td>
</tr>
<tr>
<td>Mental/1st IFL fusion</td>
<td>Present</td>
<td>Absent</td>
<td>Absent</td>
<td>Present or Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Enlarged nuchals</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Longitudinal rows of dark spots</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>

\(^1\)Observed for two individuals.

Mental wider than long, in contact with first infralabials; postmentonal 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).
NEW SPECIES OF *BRACHYMELES* FROM LUBANG ISLAND

**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 shed, 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. lukhani* 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).

<table>
<thead>
<tr>
<th></th>
<th>bonitae</th>
<th>isangdaliri</th>
<th>ligtas sp. nov.</th>
<th>mapalanggaon</th>
<th>tridactylus</th>
</tr>
</thead>
<tbody>
<tr>
<td>bonitae</td>
<td>0.2–1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>isangdaliri</td>
<td>9.5–10.0</td>
<td><strong>0.0</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>ligtas sp. nov.</em></td>
<td>8.8–9.5</td>
<td>10.0</td>
<td><strong>0.7</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mapalanggaon</td>
<td>9.0–11.1</td>
<td>10.4–11.2</td>
<td>10.3–11.1</td>
<td><strong>2.6</strong></td>
<td></td>
</tr>
<tr>
<td>tridactylus</td>
<td>8.6–9.6</td>
<td>9.5–10.3</td>
<td>9.8–10.2</td>
<td>7.8–8.8</td>
<td><strong>0.1–5.0</strong></td>
</tr>
</tbody>
</table>

*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 congenic 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.

Acknowledgments

We thank the Biodiversity Management Bureau (BMB) of the Philippine Department of Environment and Natural Resources (DENR) for facilitating collecting and export permits necessary for this and related studies; we are particularly grateful to T. M. Lim, C. Custodio, A. Tagtag, and J. L. De Leon for their logistical support of this research. Fieldwork was conducted under the Memorandum of Agreement with the BMB of the Philippines (2009–2014), Gratuitous Permit to Collect No. 221, and KU IACUC Approval (158-01). Financial support for fieldwork was provided by a Panorama Fund grant from The University of Kansas Biodiversity Institute, travel funds from The University of Kansas Ecology and Evolutionary Biology department, a Madison and Lila Self Fellowship from the University of Kansas, a Fulbright Fellowship, a Fulbright-Hayes Fellowship, NSF DEB 0804115 and NSF IOS 1353683 to CDS, and NSF DEB 0743491 and EF-0334952 to RMB. For loans of specimens we thank D. Blackburn, J. Vindum, and A. Leviton (California Academy of Sciences), J. Barnes (Philippine National Museum), J. Ferner (Cincinnati Museum of Natural History), A. Resetar and H. Voris (Field Museum of Natural History), R. Crombie, K. de Queiroz (National Museum of Natural History, Smithsonian Institution), and D. Cannatella and T. LaDuc (Biodiversity Collections, University of Texas at Austin). For access to the Sam Noble Museum Invertebrate Paleontology Stacking Photography Lab we thank S. Westrop and R. Burkhalter. Critical reviews of the manuscript were provided by J. Vindum. CDS thanks the CAS Stearns Fellowship and the MCZ Ernst Mayr Fellowship for funding recent visits to examine comparative material. Both CDS and RMB extend a special thanks to A. Alcala for his continued support of our Philippine biodiversity research program.

References


http://www.biodiversitylibrary.org/part/44806


http://dx.doi.org/10.1655/09-037.1

http://dx.doi.org/10.1146/annurev-ecolsys-110411-160323


http://dx.doi.org/10.1670/13-173


http://dx.doi.org/10.5962/bhl.title.3184

http://dx.doi.org/10.2307/1444095


http://dx.doi.org/10.11646/zootaxa.3700.4.1

http://dx.doi.org/10.1016/j.ympev.2010.03.043

http://dx.doi.org/10.1111/j.1096-3642.2011.00747.x


http://dx.doi.org/10.1655/08-076.1


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


*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);
NEW SPECIES OF *BRACHYMELES* FROM LUBANG ISLAND

Zootaxa 4132 (1) © 2016 Magnolia Press · 13


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


Brachymeles tibolorum 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 Tubigon: 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 Calasi: (KU 307726–307736).


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