ZooKeys 1002: 1–114 (2020)
doi: 10.3897/zookeys.1002.58017
https://zookeys.pensoft.net

RESEARCH ARTICLE

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The success story of *Labiobaetis* Novikova & Kluge in the Philippines (Ephemeroptera, Baetidae), with description of 18 new species

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Academic editor: L. Pereira-da-Conceicoa | Received 26 August 2020 | Accepted 16 October 2020 | Published 10 December 2020

http://zoobank.org/C9EAF9DC-D87D-402F-AC35-CC4983D2E142

Citation: Kaltenbach T, Garces JM, Gattolliat J-L (2020) The success story of *Labiobaetis* Novikova & Kluge in the Philippines (Ephemeroptera, Baetidae), with description of 18 new species. ZooKeys 1002: 1–114. https://doi.org/10.3897/zookeys.1002.58017

Abstract

Material collected between 1994 and 2020 in the Philippines, covering most main islands like Luzon, Mindoro, Palawan, Negros, Cebu, Leyte, and Mindanao and some smaller islands, substantially increased our knowledge of *Labiobaetis* Novikova & Kluge in this archipelago. Only three species were previously reported: *L. molawinensis* (Müller-Liebenau, 1982) and *L. sumigarensis* (Müller-Liebenau, 1982) from larvae and *L. boettgeri* (Ulmer, 1924) from adults. Eighteen new species have been identified using a combination of morphology and genetic distance (COI, Kimura 2-parameter). They are described and illustrated based on their larvae and a key to all species in the Philippines is provided. The total number of *Labiobaetis* in the Philippines has increased to 21 species. Additional diversity of *Labiobaetis* based on molecular evidence only is presented as Molecular Operational Taxonomic Units (MOTUs) without description. The interspecific K2P distances in the Philippines are between 15% and 27%, the intraspecific distances are usually between 0% and 3%. The total number of *Labiobaetis* species worldwide is augmented to 144.

Keywords

COI, genetic distance, integrated taxonomy, Molecular Operational Taxonomic Unit (MOTU), Southeast Asia

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Introduction

The family Baetidae has the highest species diversity among mayflies, comprising 1,070 species in 110 genera (Sartori and Brittain 2015; Jacobus et al. 2019), which is approx. one quarter of all mayfly species worldwide (Gattolliat and Nieto 2009; Jacobus et al. 2019). They have a cosmopolitan distribution except Antarctica and New Zealand. Investigations of the molecular phylogeny of the Order Ephemeroptera revealed the relatively primitive status of the family (Ogden and Whiting 2005; Ogden et al. 2009).

The genus *Labiobaetis* Novikova & Kluge (Novikova and Kluge 1987) is one of the richest genera of mayflies with 126 previously described species (Barber-James et al. 2013; Webb 2013; Kubendran et al. 2014, 2015; Shi and Tong 2014; Gattolliat et al. 2018; Kaltenbach and Gattolliat 2018, 2019, 2020). The distribution of *Labiobaetis* is nearly worldwide, except for the Neotropical realm, New Zealand and New Caledonia. The status and validity of the genus has often been a subject of controversy for a long time, but nowadays *Labiobaetis* is widely accepted as a valid genus (Gattolliat 2001; Fujitani et al. 2003; Fujitani 2008; McCafferty et al. 2010; Gattolliat and Staniczek 2011; Kluge and Novikova 2011, 2014, 2016; Kluge 2012; Webb 2013; Kubendran et al. 2014, 2015; Shi and Tong 2014). The history and concept of the genus *Labiobaetis* were recently summarized in detail (Shi and Tong 2014; Kaltenbach and Gattolliat 2018). Recently, Kluge and Novikova (2016) established a new tribe Labiobaetini including the genera *Labiobaetis* and *Pseudopannota* Waltz & McCafferty, 1987, based on a unique combination of imaginal and larval characters. All Oriental species previously transferred to *Pseudocloeon* (Lugo-Ortiz et al. 1999) were formerly reassigned to *Labiobaetis* by Shi and Tong (2014); the concept of *Pseudocloeon* is therefore limited to the type species *P. kraepelini* Klapálek, 1905 from Java. Molecular reconstructions indicated that the concept of *Labiobaetis* is probably at least diphyletic (Monaghan et al. 2005; Gattolliat et al. 2008).

Recently, integrative taxonomy was done on collections from the diverse and poorly explored Southeast Asia and New Guinea regions where 47 species were described and named (Kaltenbach and Gattolliat 2018, 2019, 2020). This contribution will focus on the Philippines archipelago, one of the highly diverse parts of the Oriental region.

The megadiversity of the Philippines is partly attributed to the complex biogeographic history and isolation of the archipelago. The discussion of the biogeographic history of the Philippine archipelago includes landmass movements, collisions between landmasses of different origin in Miocene, and temporary Pleistocene land bridges which were possible colonization pathways of species. Originally part of the Eurasian continent, the oldest landmasses of the current Philippines are parts of Palawan, Mindoro, Romblon and Panay. Whether these landmasses were entirely

submerged during the drift is still a matter of debate (Vane-Wright 1990; Turner et al. 2001; Hall 2002; Zamoras and Matsuoka 2004; Siler et al. 2012; Heaney et al. 2013), but undoubtedly these current islands are of different origin and age compared to the rest of the country which is of oceanic origin. Hence, it is expected that the adjacent areas (continental Southeast Asia, Taiwan, Borneo and Sulawesi) differ from most of the archipelago. Moreover, when the sea level was low during the Pleistocene, land bridges were formed interconnecting groups of Philippine islands, and the Sundaic landmasses with the western Philippine island (Greater Palawan) (Ong et al. 2002; Welton et al. 2014; Zettel and Freitag 2014; Freitag et al. 2016). This was the major basis of the intra-Philippine biogeographic region (Ong et al. 2002) and is subsequently reflected up to a certain extent on current species distribution (Siler et al. 2012; Zettel and Freitag 2014; Freitag et al. 2016), but not always (Heads 2013 and references therein). In his review of the biogeography of the Philippines, Heads (2013) outlined different species affinities and sister-group relationships of various taxa based on published records and available data – Philippine clades recovered sister to: Madagascar-Asia-Central America, Africa-Asia, Madagascar-Mascarenes-Asia, Indochina/China, Sundaland, Borneo, Sulawesi and further east. Several Philippine-endemic clades indeed have diverse sister groups with widespread intercontinental distributions, as opposed to simply coming from Borneo, Sulawesi or Taiwan as once previously thought. In addition, recent data suggest that even biogeographic regions previously categorized as one single unit (e.g., Greater Luzon) are in fact composed of distinct centres of endemism that correlate with tectonic features (Vallejo 2014), further exemplifying high endemism and niche specialization of species found in the country.

The diversity of *Labiobaetis* in the Philippines was poorly known, as only two species were previously reported from larvae (*L. molawinensis* and *L. sumigarensis* by Müller-Liebenau 1982) and one species from adults only (*L. boettgeri*). Here, we increase the total number of *Labiobaetis* species in the Philippines to 21, based on material collected between 1994 and 2020 on several islands (Figs 48, 49). We describe 18 new species of *Labiobaetis* based on larval stage only. The characters of some of the species groups are complemented based on the results of this study. Additionally, we have new reports of *L. molawinensis* and *L. sumigarensis*. We are also presenting cryptic diversity as Molecular Operational Taxonomic Units (MOTUs) based on molecular evidence only (COI), without description of species (Floyd et al. 2002; Blaxter et al. 2005; Morard et al. 2016).

Materials and methods

All specimens were collected between 1994 and 2020 by Dr. Hendrik Freitag and his team (Ateneo de Manila University) and preserved in 70%–96% ethanol.

The dissection of larvae was done in Cellosolve (2-Ethoxyethanol) with subsequent mounting on slides with Euparal liquid, using an Olympus SZX7 stereomicroscope.

The DNA of part of the specimens was extracted using non-destructive methods allowing subsequent morphological analysis (see Vuataz et al. 2011 for details). We amplified a 658 bp fragment of the mitochondrial gene cytochrome oxidase subunit 1 (COI) using the primers LCO 1490 and HCO 2198 (Folmer et al. 1994; see Kaltenbach and Gattolliat 2020 for details). Sequencing was done with Sanger's method (Sanger et al. 1977). The genetic variability between specimens was estimated using Kimura-2-parameter distances (K2P, Kimura 1980), calculated with the program MEGA 7 (Kumar et al. 2016, http://www.megasoftware.net).

The GenBank accession numbers are given in Table 1, nomenclature of gene sequences follows Chakrabarty et al. (2013).

The nomenclature used for Molecular Operational Taxonomic Units (MOTUs) is somewhat different as the one proposed by Morard et al. (2016).

Drawings were made using an Olympus BX43 microscope. To facilitate the determination of species and the comparison of important structures, we partly used a combination of dorsal and ventral aspects in one drawing. Explanations are given in Fig. 1.

Photographs of larvae were taken using a Canon EOS 6D camera and the Visionary Digital Passport imaging system (http://www.duninc.com) and processed with Adobe Photoshop Lightroom (http://www.adobe.com) and Helicon Focus version 5.3 (http://www.heliconsoft.com). Photographs were subsequently enhanced with Adobe Photoshop Elements 13.

The distribution maps were generated with SimpleMappr (https://simplemappr.net, Shorthouse 2010). Google Earth (http://www.google.com/earth/download/ge/) was used to attribute approximate GPS coordinates to sample locations of Müller-Liebenau (1982).

The taxonomic descriptions were generated with a DELTA (Dallwitz 1980; Dallwitz et al. 1999; Coleman et al. 2010) database containing the morphological states of characters of the *Labiobaetis* species of the Philippines.

The dichotomous key was elaborated with the support of DKey version 1.3.0 (http://drawwing.org/dkey, Tofilski 2018).

The terminology follows Hubbard (1995) and Kluge (2004). The character states of some of the characters are depicted in Fig. 2.

Abbreviations:

AdMU Ateneo de Manila University, Quezon City (Philippines)
MZL Musée de Zoologie Lausanne (Switzerland)
PCSD Palawan Council for Sustainable Development, Puerto Princesa, Palawan (Philippines)
PNM Museum of Natural History of the Philippine National Museum, Manila (Philippines)
ZSM Zoologische Staatssammlung München (Germany).

Table 1. Sequenced specimens.

Species	Species group	Locality	Specimens catalog #	GenBank # (COI)	GenSeq Nomenclature
L. dalisay sp. nov.	*dendrisetis* gr.	Philippines: Luzon	GBIFCH 00763649	MT830940	genseq-2 COI
L. acei sp. nov.	*numeratus* gr.	Philippines: Luzon	GBIFCH 00763643	MT830941	genseq-1 COI
			GBIFCH 00763645	MT830942	genseq-2 COI
			GBIFCH 00763651	MT830943	genseq-2 COI
L. aldabae sp. nov.	*numeratus* gr.	Philippines: Luzon	GBIFCH 00654913	MT830944	genseq-1 COI
			GBIFCH 00654908	MT830945	genseq-2 COI
			GBIFCH 00763646	MT830946	genseq-2 COI
			GBIFCH 00763648	MT830947	genseq-2 COI
		Philippines: Negros	GBIFCH 00654889	MT830948	genseq-2 COI
L. camiguinensis sp. nov.	*numeratus* gr.	Philippines: Camiguin	GBIFCH 00654915	MT830949	genseq-1 COI
L. lachicae sp. nov.	*numeratus* gr.	Philippines: Mindanao	GBIFCH 00654891	MT830950	genseq-1 COI
L. palawano sp. nov.	*numeratus* gr.	Philippines: Busuanga	GBIFCH 00763688	MT830987	genseq-1 COI
		Philippines: Palawan	GBIFCH 00763679	MT830988	genseq-2 COI
L. sabordoi sp. nov.	*numeratus* gr.	Philippines: Negros	GBIFCH 00654878	MT830951	genseq-2 COI
		Philippines: Romblon	GBIFCH 00763674	MT830952	genseq-2 COI
L. gamay sp. nov.	*operosus* gr.	Philippines: Mindoro	GBIFCH 00654922	MT830953	genseq-2 COI
			GBIFCH 00763637	MT830954	genseq-2 COI
			GBIFCH 00763639	MT830955	genseq-2 COI
		Philippines: Luzon	GBIFCH 00763655	MT830956	genseq-2 COI
			GBIFCH 00763657	MT830957	genseq-2 COI
			GBIFCH 00763658	MT830958	genseq-2 COI
L. pangantihoni sp. nov.	*operosus* gr.	Philippines: Palawan	GBIFCH 00763684	MT830959	genseq-2 COI
L. tagbanwa sp. nov.	*operosus* gr.	Philippines: Palawan	GBIFCH 00654885	MT830960	genseq-2 COI
			GBIFCH 00763681	MT830961	genseq-2 COI
			GBIFCH 00763680	MT830962	genseq-2 COI
L. valdezorum sp. nov.	*operosus* gr.	Philippines: Negros	GBIFCH 00654888	MT830963	genseq-1 COI
			GBIFCH 00654882	MT830964	genseq-2 COI
			GBIFCH 00654879	MT830965	genseq-2 COI
			GBIFCH 00654880	MT830966	genseq-2 COI
		Philippines: Cebu	GBIFCH 00763671	MT830967	genseq-2 COI
L. wantzeni sp. nov.	*operosus* gr.	Philippines: Camiguin	GBIFCH 00654898	MT830968	genseq-1 COI
			GBIFCH 00654897	MT830969	genseq-2 COI
			GBIFCH 00763641	MT830970	genseq-2 COI
			GBIFCH 00763642	MT830971	genseq-2 COI
			GBIFCH 00654896	MT830972	genseq-2 COI
			GBIFCH 00654900	MT830973	genseq-2 COI
L. baganii sp. nov.	*sumigarensis* gr.	Philippines: Mindanao	GBIFCH 00654895	MT830974	genseq-1 COI
		Philippines: Camiguin	GBIFCH 00654899	MT830975	genseq-2 COI
L. delocadoi sp. nov.	*sumigarensis* gr.	Philippines: Cebu	GBIFCH 00654886	MT830976	genseq-1 COI
		Philippines: Leyte	GBIFCH 00763668	MT830977	genseq-2 COI
L. freitagi sp. nov.	*sumigarensis* gr.	Philippines: Palawan	GBIFCH 00763677	MT830978	genseq-2 COI
			GBIFCH 00763678	MT830979	genseq-2 COI
			GBIFCH 00763682	MT830980	genseq-2 COI
			GBIFCH 00763683	MT830981	genseq-2 COI
L. pelingeni sp. nov.	*sumigarensis* gr.	Philippines: Negros	GBIFCH 00654901	MT830982	genseq-2 COI
		Philippines: Cebu	GBIFCH 00763672	MT830983	genseq-2 COI
L. giselae sp. nov.	*vallus* gr.	Philippines: Luzon	GBIFCH 00654911	MT830984	genseq-2 COI
L. mendozai sp. nov.	*vallus* gr.	Philippines: Mindanao	GBIFCH 00654894	MT830985	genseq-2 COI

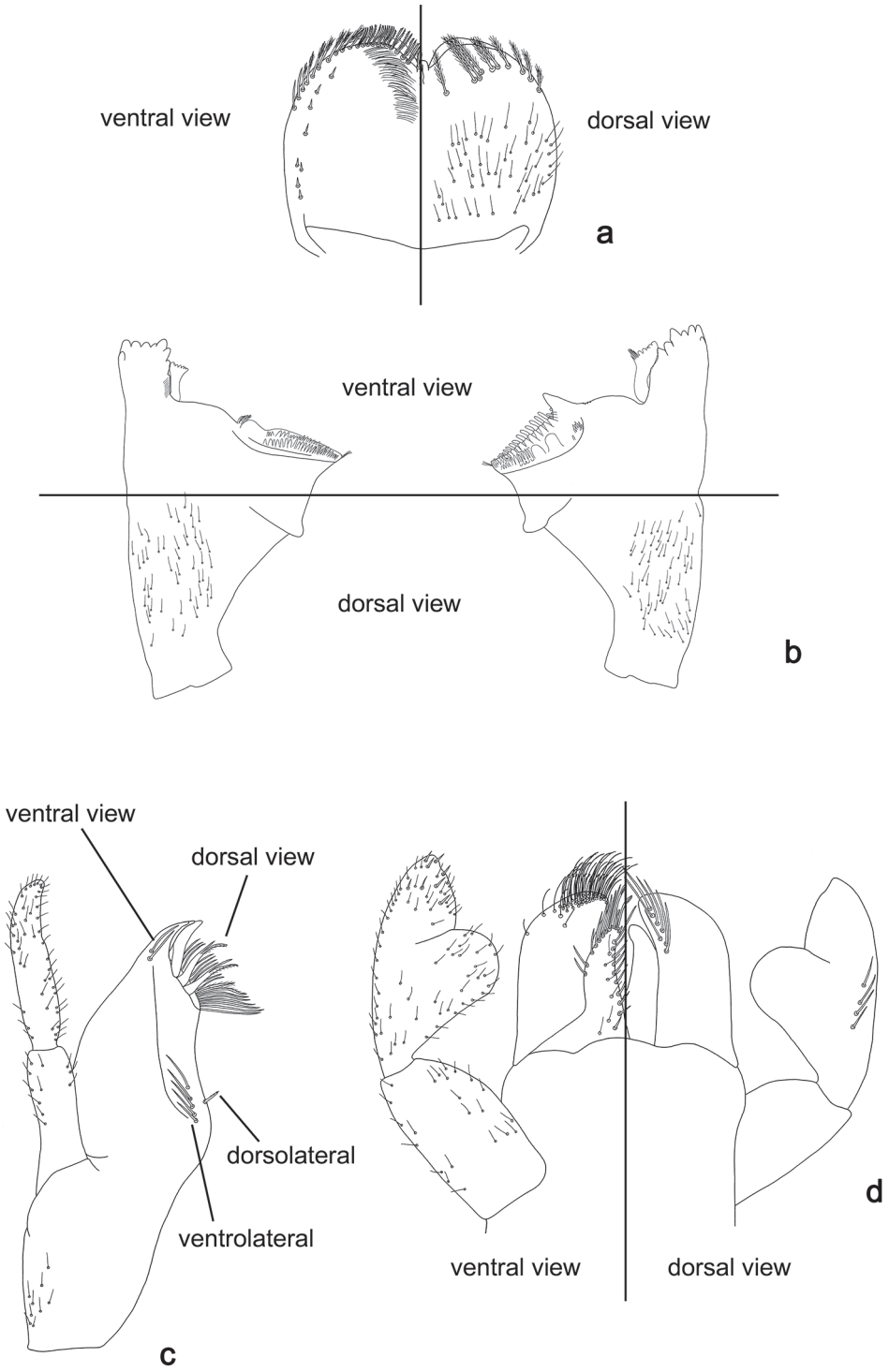

Figure 1. Explanation of drawings **a** labrum **b** mandibles **c** maxilla **d** labium.

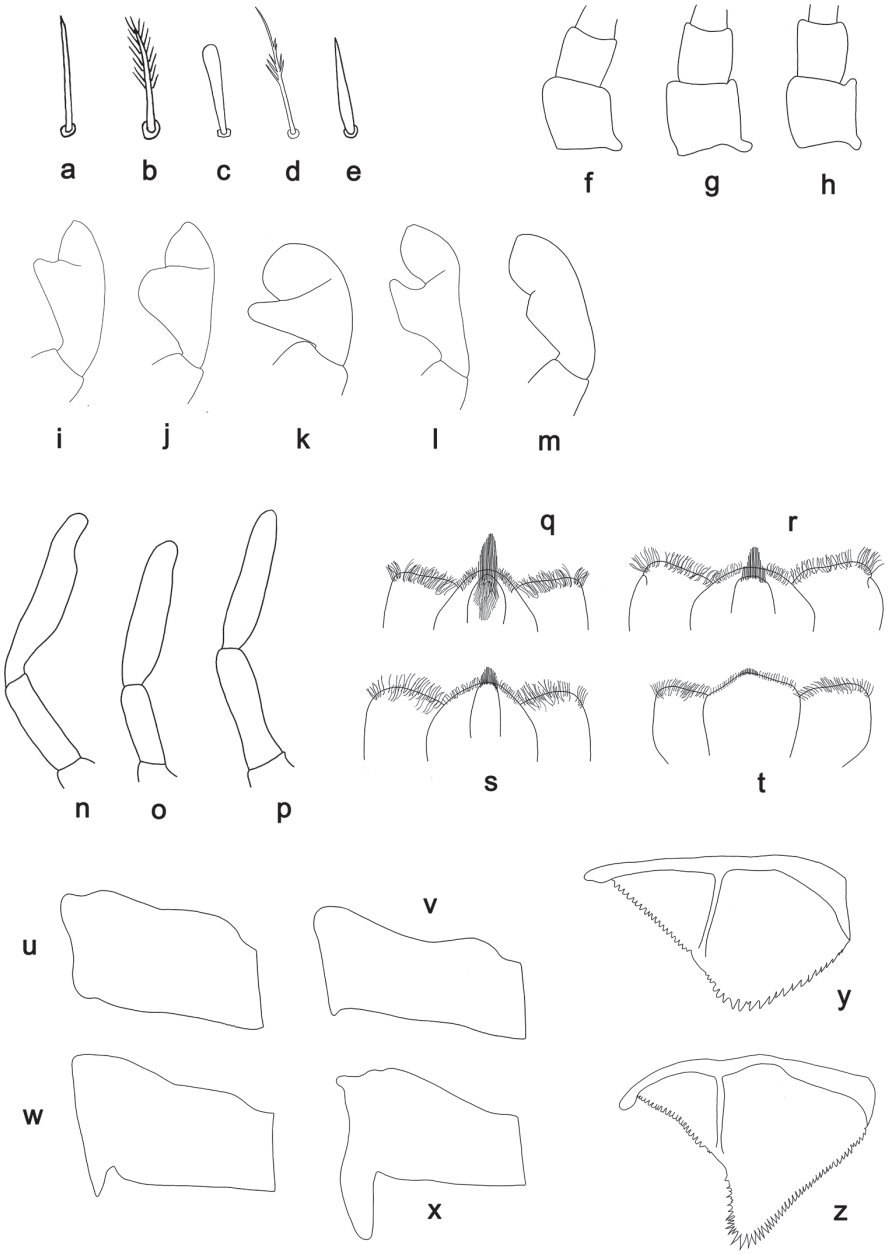

Figure 2. *Labiobaetis*, character states of selected characters **a–e** setae of the submarginal arc on the dorsal surface of the labrum: **a** simple **b** feathered **c** clavate **d** dendritic **e** lanceolate **f–h** distolateral process at scape of antenna: **f** absent **g** poorly developed **h** well developed **i–m** labial palp, distomedial protuberance of segment II: **i** thumb-like **j** broad thumb-like **k** slender thumb-like **l** hook-like **m** small thumb-like **n–p** distolateral excavation at maxillary palp segment II: **n** well developed **o** poorly developed **p** absent **q–t** hypopharynx, medial tuft of stout setae: **q** well developed, long **r** well developed, average length **s** well developed, short **t** poorly developed **u–x** hind protoptera: **u** absent **v** minute **w** small **x** well developed **y, z** paraproct: **y** distally not expanded **z** distally expanded.

Results

List of *Labiobaetis* species from the Philippines

dendrisetis group

1. *L. dalisay* sp. nov.

numeratus group

2. *L. acei* sp. nov.
3. *L. aldabae* sp. nov.
4. *L. camiguinensis* sp. nov.
5. *L. lachicae* sp. nov.
6. *L. palawano* sp. nov.
7. *L. sabordoi* sp. nov.

operosus group

8. *L. gamay* sp. nov.
9. *L. pangantihoni* sp. nov.
10. *L. tagbanwa* sp. nov.
11. *L. valdezorum* sp. nov.
12. *L. wantzeni* sp. nov.

sumigarensis group

13. *L. molawinensis* (Müller-Liebenau, 1982)
14. *L. sumigarensis* (Müller-Liebenau, 1982)
15. *L. baganii* sp. nov.
16. *L. delocadoi* sp. nov.
17. *L. freitagi* sp. nov.
18. *L. pelingeni* sp. nov.

vallus group

19. *L. giselae* sp. nov.
20. *L. mendozai* sp. nov.

Not assigned to a group

21. *L. boettgeri* (Ulmer, 1924), no further treatment in this study.

Labiobaetis dendrisetis group of species (new group of species)

Following combination of characters: A) dorsal surface of labrum with submarginal arc of dendritic setae; B) labial palp segment II slender or small thumb-like; C) labial palp segment III wide; D) maxillary palp shorter than galea-lacinia, rather thick; E) seven pairs of gills.

***Labiobaetis dalisay* sp. nov.**
http://zoobank.org/0CF1B9F8-0208-4EF9-BF95-379DBFAA2FF0
Figures 3, 4, 41a, 48b

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with 6–8 long, dendritic setae; B) labial palp segment II with a slender thumb-like distomedial protuberance, segment III subrectangular; C) right mandible without row of thin setae at inner margin of innermost denticle; D) fore femur length 3.4 × maximum width, dorsal margin with 10–19 curved, spine-like setae; E) hind protoptera well developed; F) paraproct distally not expanded, with ca. 15 stout, marginal spines.

Description. Larva (Figs 3, 4, 41a). Body length 4.8–6.5 mm. Cerci ca. ½ of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

***Colouration*.** Head, thorax, and abdomen dorsally brown with bright pattern as in Fig. 41a, fore protoptera light brown with darker striation. Head, thorax, and abdomen ventrally light brown. Legs light brown, femur basally and apically brown with a distomedial brown spot and a brown streak distomedially along dorsal margin, tibia basally with brown area, tarsus medially brown. Caudalii light brown with a brown band both at base and at ca. 1/3 of cerci length, cerci distally brown.

Antenna (Fig. 4g) with scape and pedicel subcylindrical, with well-developed distolateral process at scape.

Labrum (Fig. 3a, b). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of 6–8 long, dendritic setae. Ventrally with marginal row of setae composed of anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. six short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 3c, d, e). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle without a row of thin setae; denticles of both incisor and kinetodontium of unused mandibles with secondary dentation. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex. Tuft of setae at apex of mola present.

Left mandible (Fig. 3f, g). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola slightly convex. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins slightly convex. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 3h). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae poorly developed; distal half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

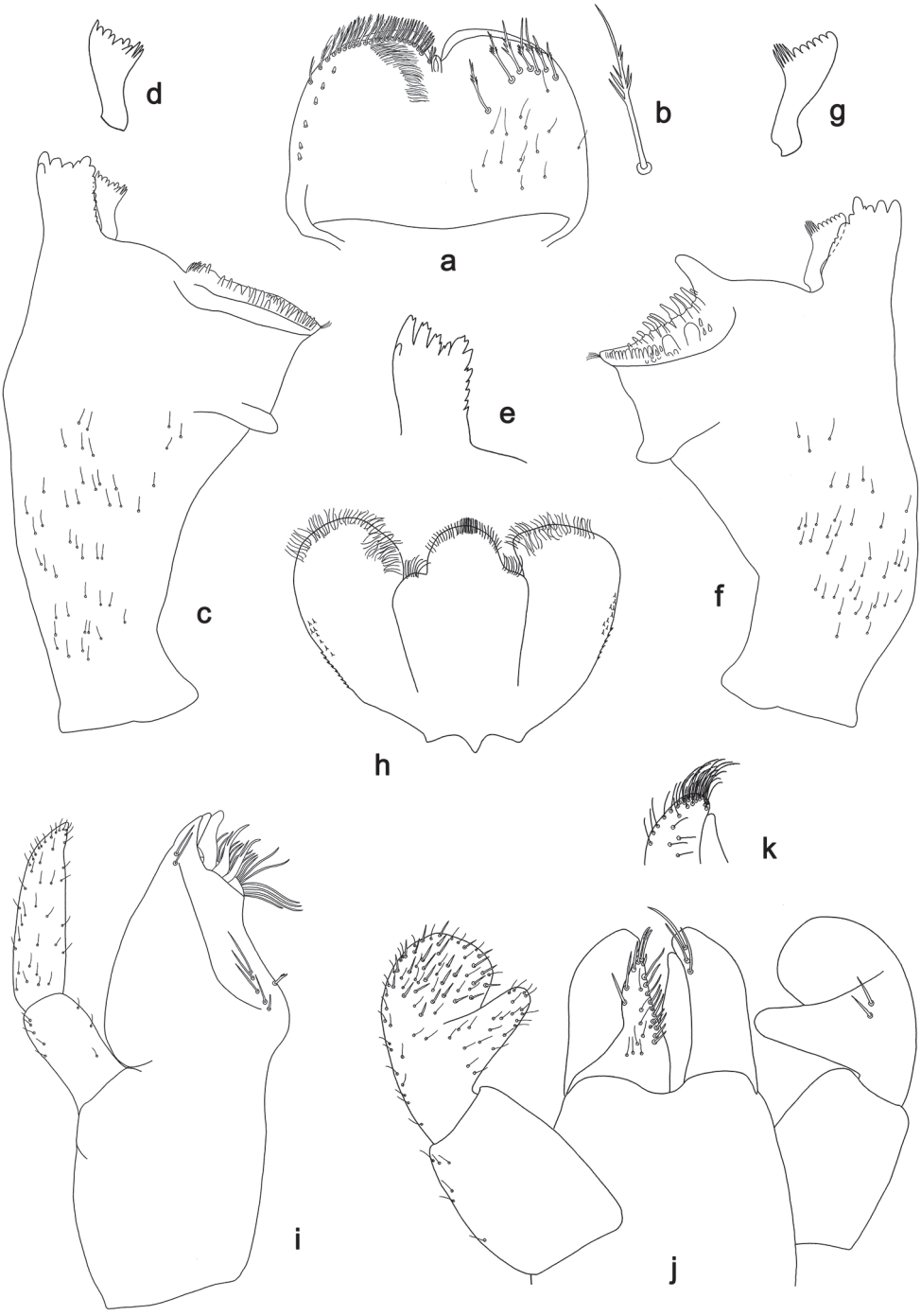

Figure 3. *Labiobaetis dalisay* sp. nov., larva morphology **a** labrum **b** seta of arc on dorsal surface of labrum **c** right mandible **d** right prostheca **e** right incisor and kinetodontium **f** left mandible **g** left prostheca **h** hypopharynx and superlinguae **i** maxilla **j** labium **k** apex of paraglossa.

Maxilla (Fig. 3i). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and five medium to long, simple setae. Maxillary palp approx. as long as length of galea-lacinia; 2-segmented; palp segment II 1.6 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment slightly pointed, with slight excavation at inner distolateral margin.

Labium (Fig. 3j, k). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. ten spine-like setae increasing in length distally; apex with two long, robust, pectinate setae and one short, robust seta; outer margin with three spine-like setae; ventral surface with fine, simple, scattered setae. Paraglossa subrectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and 4–6 medium, simple setae in anteromedial area; outer, anterolateral margin with some long, spine-like setae; dorsally with a row of three long, spine-like setae near inner margin. Labial palp with segment I 0.9 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with slender, thumb-like distomedial protuberance; distomedial protuberance 0.5 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with two or three spine-like, simple setae near outer margin. Segment III subrectangular; length 0.9 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 4h) well developed.

Foreleg (Fig. 4a–c). Ratio of foreleg segments 1.4:1.0:0.7:0.3. ***Femur***. Length ca. 3 × maximum width. Dorsal margin with a row of 10–19 curved, spine-like setae, apically rounded and sometimes with minute dentation; length of setae 0.13 × maximum width of femur. Apex rounded, with a pair of spine-like setae, apically rounded and sometimes with minute dentation and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch present. ***Tibia.*** Dorsal margin with two rows of short, spine-like setae. Ventral margin with a row of short, curved, spine-like setae, on apex some longer, partly bipectinate, spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 2/3 area. ***Tarsus.*** Dorsal margin with one or two rows of short, stout setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 13–15 denticles; distally pointed; with five or six stripes; subapical setae absent.

Terga (Fig. 4d). Surface with irregular rows of W-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular spines, longer than wide.

Gills (Fig. 4e). Present on segments I–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill I ca. 2/3 length of segment II. Gill IV as long as length of segments V and 2/3 VI combined. Gill VII as long as length of segments VIII and 1/3 IX combined.

Paraproct (Fig. 4f). Distally not expanded, with ca. 15 stout, marginal spines. Surface scattered with U-shaped scale bases and fine, simple setae. Cercotractor with numerous small, marginal spines.

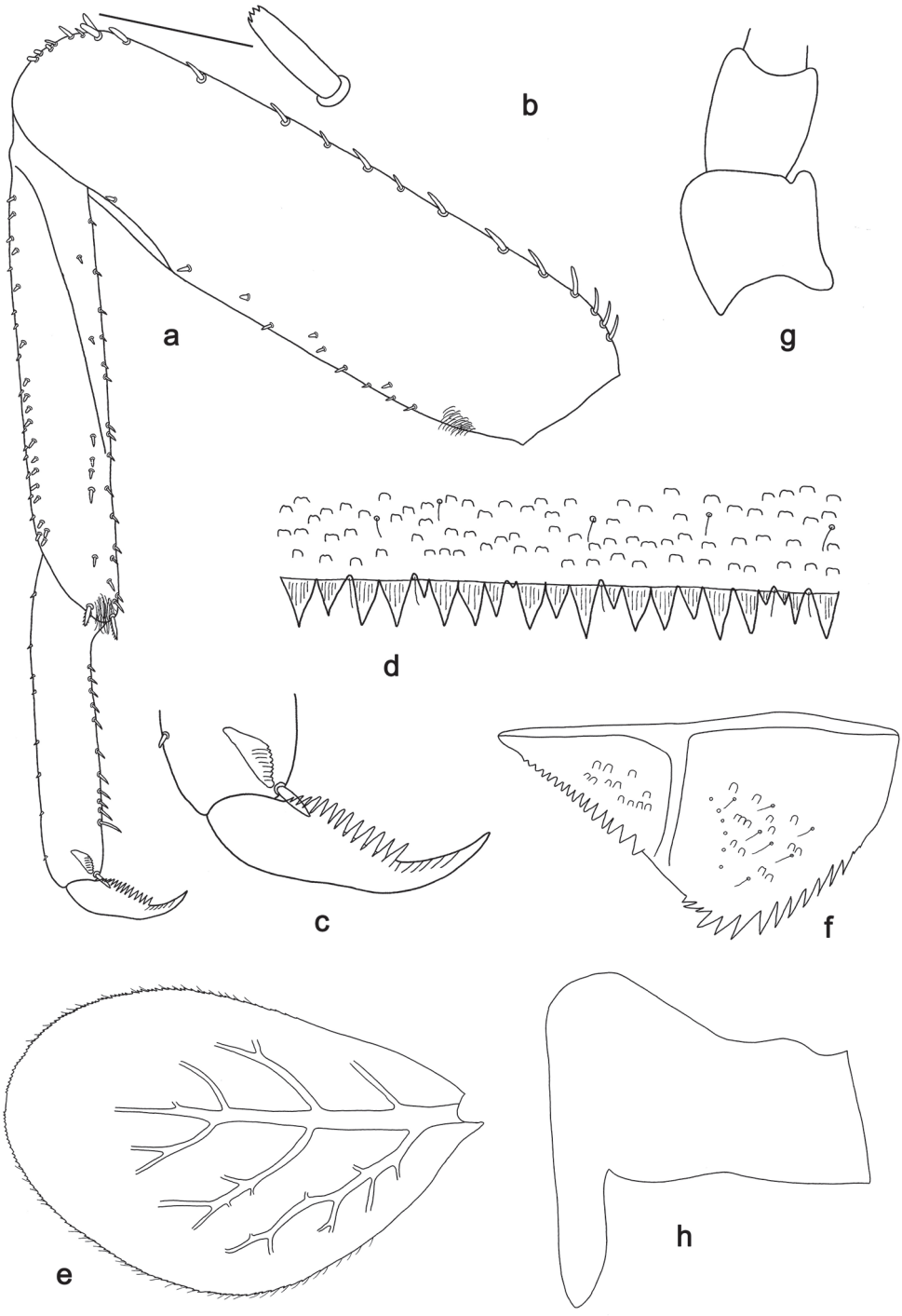

Figure 4. *Labiobaetis dalisay* sp. nov., larva morphology **a** foreleg **b** seta at apex of femur **c** fore claw **d** tergum IV **e** gill IV **f** paraproct **g** antennal scape **h** metanotum.

Etymology. Named after the Filipino word *dalisay* meaning pristine, which describes the localities where the species was collected.

Distribution. Philippines: Luzon (Fig. 48b).

Biological aspects. The specimens were collected at altitudes from 60 m to 400 m, mainly in pristine areas.

Type material. ***Holotype.*** Philippines • larva; Luzon, Maria Aurora, Wenceslao, Bingwangan River; 15°45'48"N, 121°25'21"E; 60 m; 05.II.1998; leg. Mendoza; on slide; GBIFCH 00592279; PNM. ***Paratypes.*** Philippines • larva; Luzon, Nueva Ecija, Pantabangan, Candaclan River; 15°46'48"N, 121°13'17"E; 240 m; 05.II.1998; leg. Mendoza; on slide; GBIFCH 00654909; ZSM • 6 larvae; Luzon, Benguet, Tuba, Taloy Sur; 16°21'33"N, 120°30'31"E; 400 m; XI. 1997; leg. Mey; 1 on slide; GenBank: MT830940; GBIFCH 00763649; AdMU; 5 in alcohol; GBIFCH 00515405; MZL.

Labiobaetis numeratus group of species (Kaltenbach and Gattoliat 2019)

Following combination of characters: A) dorsal surface of labrum with submarginal arc of simple setae, 1st and 2nd setae after submedian seta close together; B) labial palp segment II with thumb-like distomedial protuberance; C) glossae with robust setae at inner margin; D) paraglossae with setae at anterolateral and lateral outer margin; E) right mandible with a pronounced hump between prostheca and mola, thin setae at base of mola; F) left mandible with convex margin between prostheca and mola; G) maxillary palp segment II much longer vs. segment I, bent; H) superlinguae sclerotized along margins (Fig. 47d); I) six pairs of gills, mostly oblong; J) hind protoptera present, minute; K) distolateral process at scape absent; L) spines at posterior margin of tergum IV always partly merged, mostly rounded and wider than long; M) femur dorsal margin with a partial second row of spine-like setae; N) ventral margin of tibia with a longer, spine-like seta distally at patellotibial suture.

Labiobaetis acei **sp. nov.**

http://zoobank.org/256AE781-83A3-41C7-A109-78AB9EFA3906
Figures 5, 6, 41b, 46a, 48c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of six or seven long, simple setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III conical; C) left mandible with a comb-shaped structure at base of mola; D) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with 9–12 curved, spine-like setae and a partial second row near margin; E) tergum IV with rounded, partly fused spines at posterior margin, surface with irregular, dense rows of U-shaped scale bases; F) paraproct distally not expanded, with 29–34 stout, marginal spines.

Description. Larva (Figs 5, 6, 41b, 46a). Body length 4.2–10.3 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

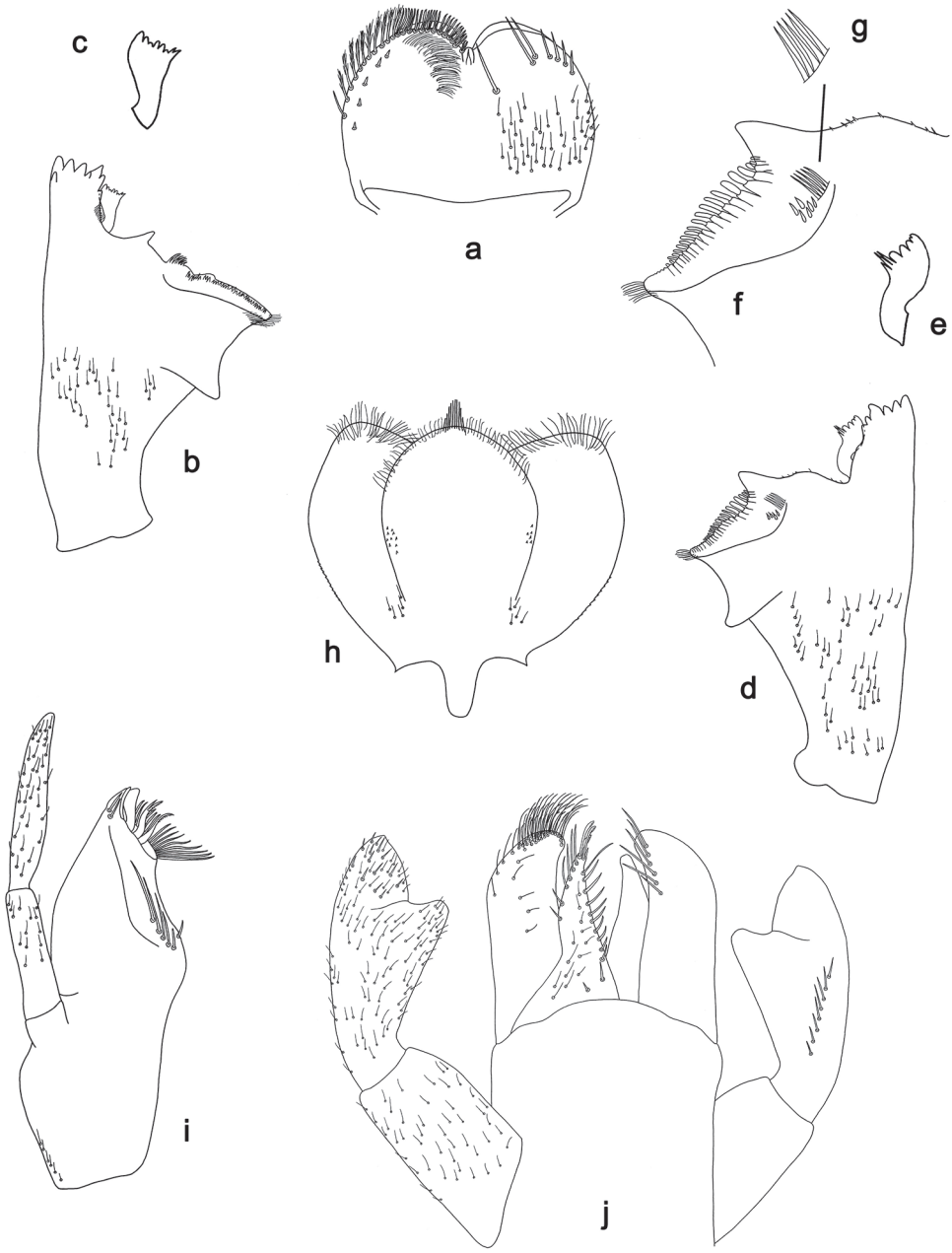

Figure 5. *Labiobaetis acei* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** detail of left mola **g** comb-shaped structure at left mola **h** hypopharynx and superlinguae **i** maxilla **j** labium.

Colouration. Head, thorax, and abdomen dorsally brown, with pattern as in Fig. 41b. Fore protoptera brown with dark brown striation. Head, thorax, and abdomen ventrally brown, abdominal segment IX ecru (Fig. 46a). Legs light brown, femur

with a distomedial brown spot and a brown apex. Caudalii light brown with a dark brown band at ca. 1/3 of cerci length.

Antenna (Fig. 6f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 5a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus six or seven long, simple setae, the first two setae after the submedian seta are close together. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. five short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 5b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola with a pronounced hump. Tuft of setae at apex of mola present and many thin setae distally at base of mola.

Left mandible (Fig. 5d–g). Incisor and kinetodontium fused. Incisor with three denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola slightly convex, with minute denticles toward subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present. Comb-shaped structure at base of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 5h). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 5i). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and 5–7 medium to long, simple setae. Maxillary palp 1.4 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.4 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment slightly pointed, without excavation at inner distolateral margin.

Labium (Fig. 5j). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. ten short, stout, spine-like setae plus distalmost one much longer, less robust, spine-like seta; apex with two long and one medium, robust, pectinate setae and one short, robust seta; outer margin with six spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and four or five medium, simple setae in anteromedial

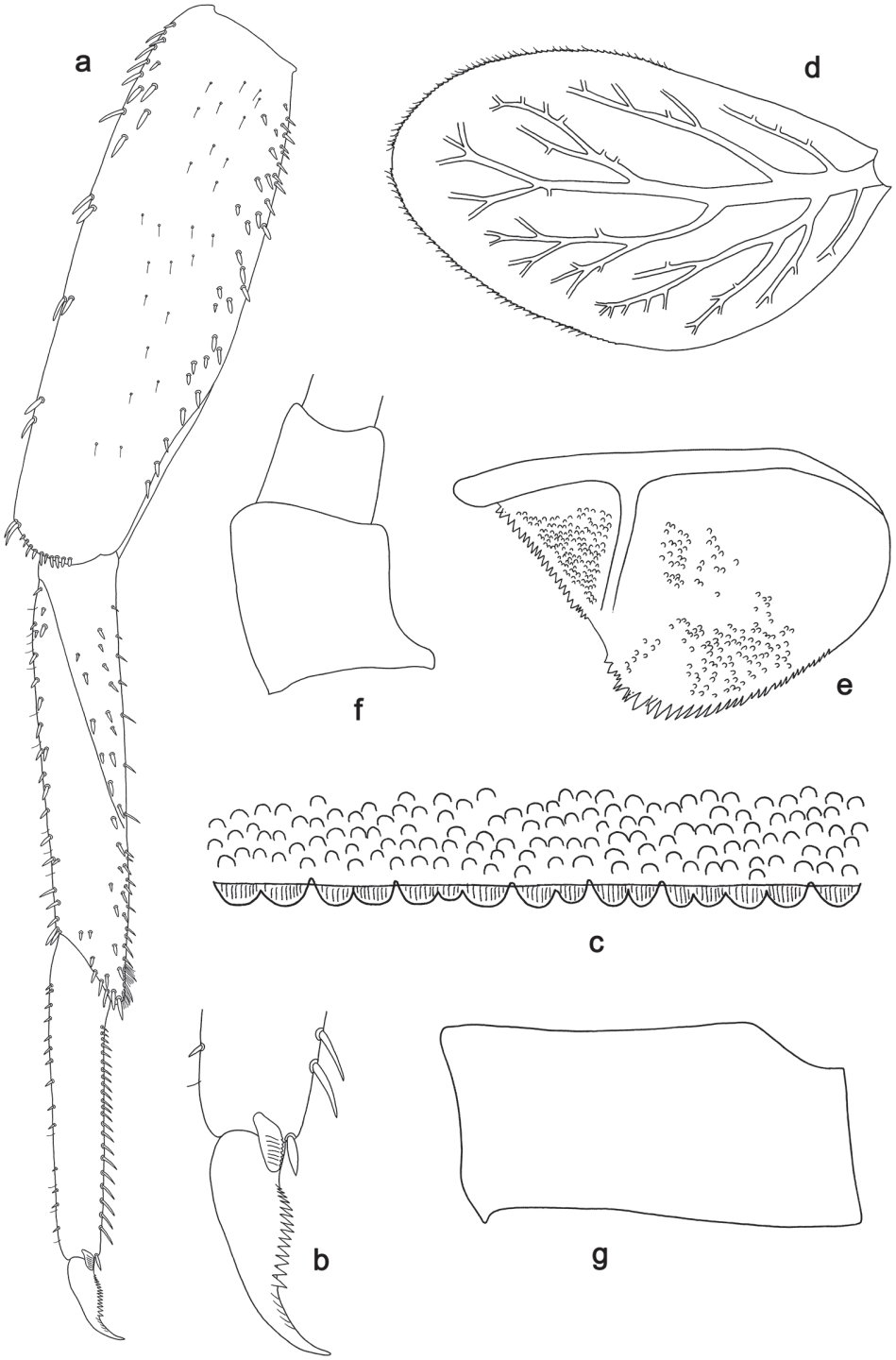

Figure 6. *Labiobaetis acei* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

area; outer margin with some long, spine-like setae; dorsally with a row of six long, spine-like setae near inner margin. Labial palp with segment I 0.7 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.5 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of 7–9 medium, spine-like, simple setae near outer margin. Segment III conical; apex slightly pointed; length 1.0 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 6g) minute.

Foreleg (Fig. 6a, b). Ratio of foreleg segments 1.4:1.0:0.8:0.2. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with a row of 9–12 curved, spine-like setae, a partial row of spine-like setae and some additional spine-like setae near margin; length of setae 0.16 × maximum width of femur. Apex rounded, with a pair of curved, spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short to medium, spine-like setae and fine, simple setae, on apex two longer, spine-like setae. Ventral margin with a row of short to medium curved, spine-like setae, distally of patellotibial suture one longer, curved, spine-like seta, on apex some longer, partly bipectinate, spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus.*** Dorsal margin with a row of short, spine-like setae and fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 12–14 denticles; distally pointed; with ca. five stripes; subapical setae absent.

Terga (Fig. 6c). Surface with dense, irregular rows of U-shaped scale bases. Posterior margin of tergum IV with rounded, partly fused spines, wider than long.

Gills (Fig. 6d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and VI combined. Gill VII as long as length of segments VIII and half of IX combined.

Paraproct (Fig. 6e). Distally not expanded, with 29–34 stout, marginal spines. Surface scattered with U-shaped scale bases. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Mr. Ace Kevin Amarga (Philippines/Taiwan), an outstanding collector and entomologist, for loaning some precious material to one of the authors (JG).

Distribution. Philippines: Luzon (Fig. 48c).

Biological aspects. The specimens were collected at altitudes of 1700 m and 1820 m, either on rock surface or bottom gravel in riffles or runs, or in root packs or grass bunches in riffles or runs.

Type material. ***Holotype.*** Philippines • larva; Luzon, Mountain Province, Bauko, mineral rich mountain creek; 17°03'53"N, 121°05'10"E; 1820 m; XI.1997; leg. Mey; on slide; GenBank: MT830941; GBIFCH 00763643; PNM. ***Paratypes.*** Philippines • 41 larvae; same data as holotype; 2 on slides; GBIFCH 00592360, GBIFCH

00592361; MZL; 13 in alcohol; GBIFCH 00515445; MZL; 25 in alcohol; GBIFCH 00515449; AdMU; 1 in alcohol; GBIFCH 00515452; MZL • 64 larvae; Luzon, Ifugao, Banaue, Sumigar Bridge; 16°59'37"N, 121°02'51"E; 1700 m; IX.1997; leg. Mey; 3 on slides; GenBank: MT830942, MT830943; GBIFCH 00592329, GBIFCH 00763645, GBIFCH 00763651; MZL; 31 in alcohol; GBIFCH 00515446, GBIFCH 00515447, GBIFCH 00515453; MZL; 30 in alcohol; GBIFCH 00515448, GBIFCH 00515450; AdMU.

***Labiobaetis aldabae* sp. nov.**
http://zoobank.org/9B9F4A30-2C5A-4B83-9649-175F52920FC1
Figures 7, 8, 41c, 46b, 48c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of 4–6 long, simple setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III conical; C) left mandible with a comb-shaped structure at base of mola; D) fore femur rather broad, length 3.4 × maximum width, with ca. nine curved, spine-like setae and a partial second row near margin; E) claw with 12–15 denticles; F) paraproct distally not expanded, with 18–21 stout, marginal spines.

Description. Larva (Figs 7, 8, 41c, 46b). Body length 4.1–5.4 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

Colouration. Head dorsally light brown, thorax and abdomen dorsally brown with bright pattern as in Fig. 41c. Fore protoptera light brown with darker and brighter striation. Head, thorax, and abdomen ventrally brown with bright pattern as in Fig. 46b. Femur with a distomedial brown spot and a distodorsal brown streak, apically brown, tibia partially light brown, tarsus light brown, apically darker. Caudalii light brown with a brown dark band at ca. 1/3 of cerci length, distal area of cerci brown.

Antenna (Fig. 8f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 7a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 4–6 long, simple setae, the first two setae after the submedian seta are close together. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. five short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 7b, c). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola with a pronounced hump. Tuft of setae at apex of mola present and many thin setae distally at base of mola.

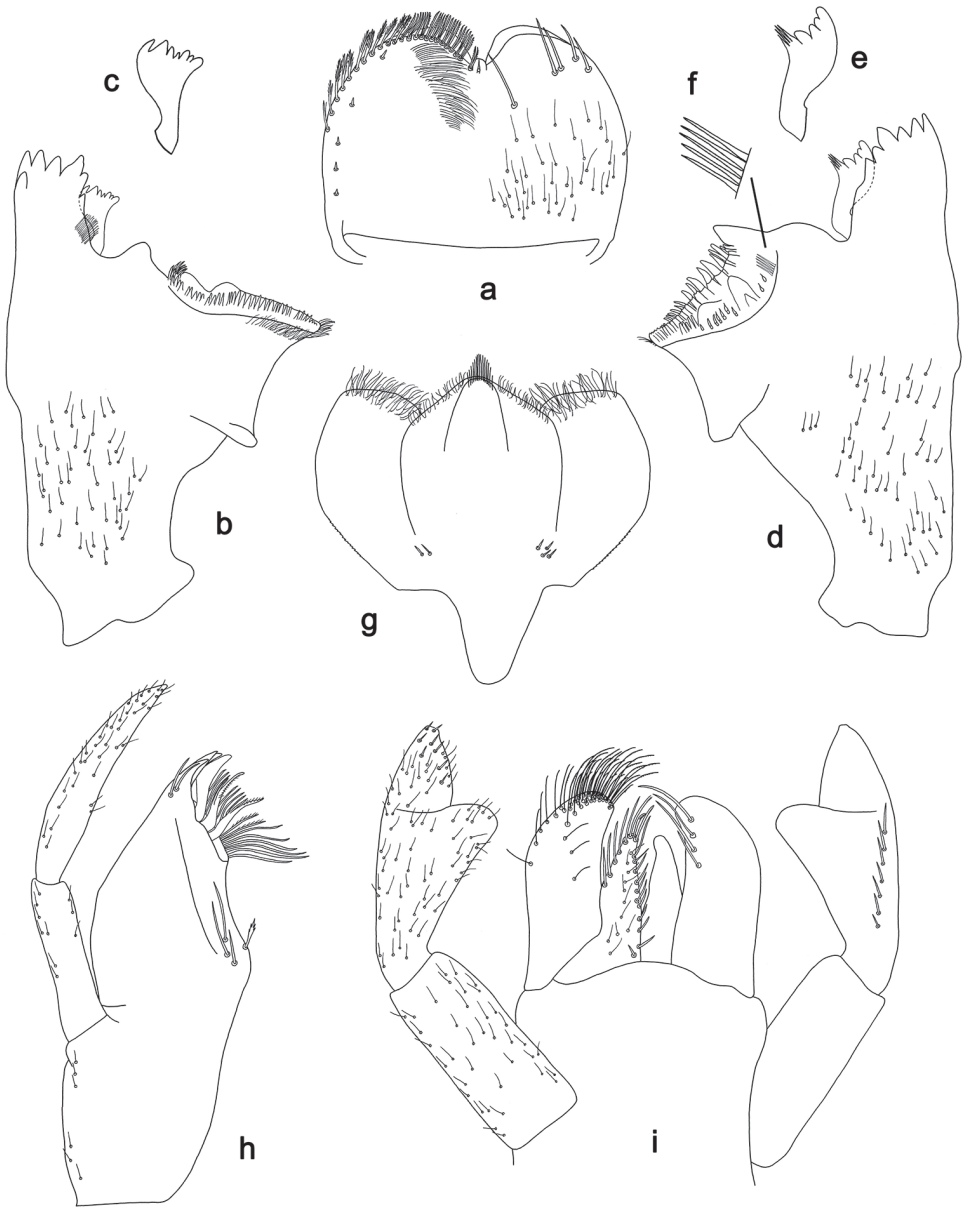

Figure 7. *Labiobaetis aldabae* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** comb-shaped structure at left mola **g** hypopharynx and superlinguae **h** maxilla **i** labium.

Left mandible (Fig. 7d–f). Incisor and kinetodontium fused. Incisor with three denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola convex. Subtriangular process long and slender, above level of area between prostheca and

mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present. Comb-shaped structure at base of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 7g). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half not expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 7h). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and three or four medium to long, simple setae. Maxillary palp 1.4 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.6 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment slightly pointed, without excavation at inner distolateral margin.

Labium (Fig. 7i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. ten short, stout, spine-like setae plus distalmost one much longer, less robust, spine-like seta; apex with two long and one medium, robust, pectinate setae; outer margin with five long, spine-like setae; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and two or three medium, simple setae in anteromedial area; outer margin with some long, spine-like setae; dorsally with a row of four long, spine-like, simple setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.7 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of six or seven long, spine-like, simple setae near outer margin. Segment III conical; apex slightly truncate; length 1.3 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 8g) minute.

Foreleg (Fig. 8a, b). Ratio of foreleg segments 1.3:1.0:0.7:0.3. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with a row of ca. nine curved, spine-like setae, a partial row of spine-like setae near margin; length of setae 0.19 × maximum width of femur. Apex rounded, with a pair of curved, spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like setae and fine, simple setae, on apex one longer, spine-like seta. Ventral margin with a row of short to medium curved, spine-like setae, distally of patellotibial suture one longer, curved, spine-like seta, on apex some longer, partly bipectinate, spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus.*** Dorsal margin with a row of fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 12–15 denticles on Luzon Is-

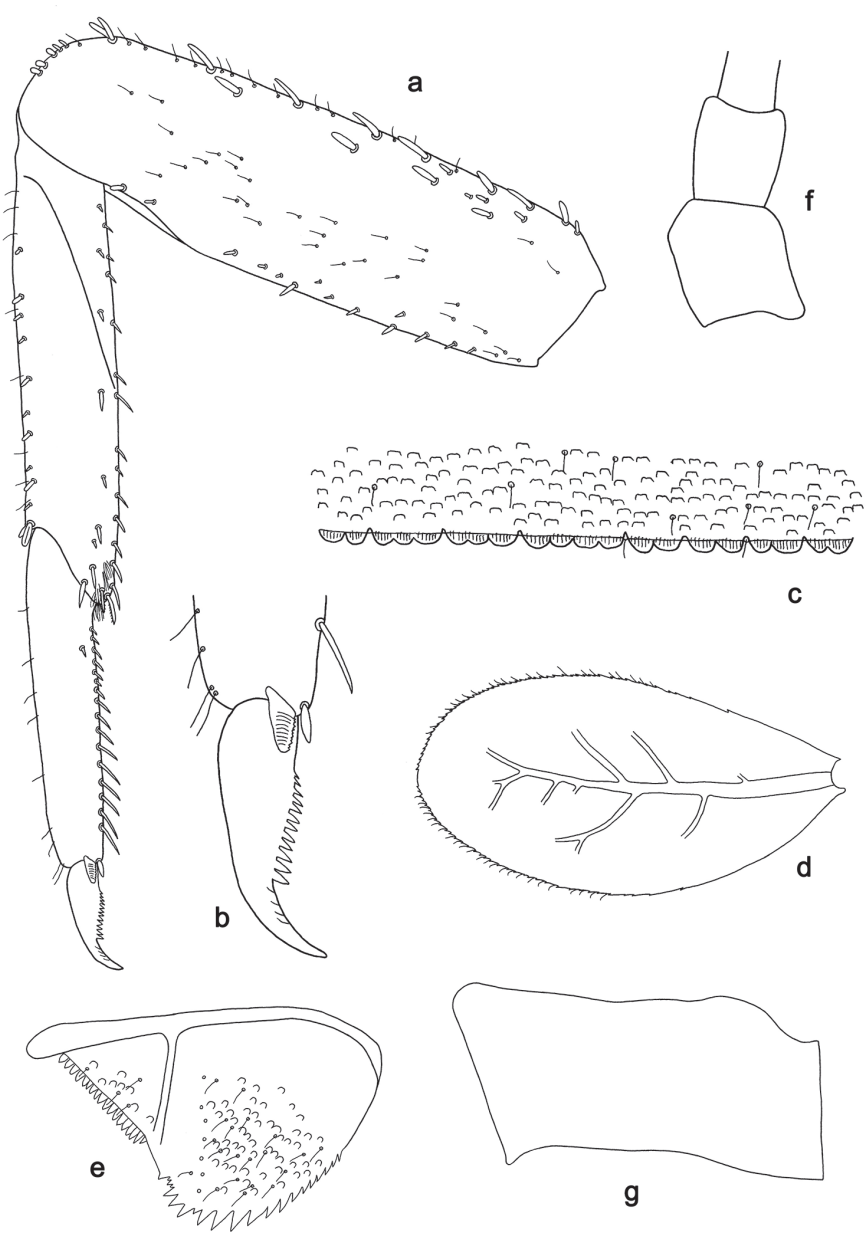

Figure 8. *Labiobaetis aldabae* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

land and ca. 17 denticles on Negros Island; distally pointed; with 4–7 stripes; subapical setae absent.

Terga (Fig. 8c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with rounded, partly fused spines, wider than long.

Gills (Fig. 8d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and 3/4 VI combined. Gill VII as long as length of segments VIII and ½ IX combined.

Paraproct (Fig. 8e). Distally not expanded, with 18–21 stout, marginal spines. Surface scattered with U-shaped scale bases and fine, simple setae. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Ms. Kyra Mari Dominique Aldaba (Philippines), member of the AdMU Biodiversity Laboratory.

Distribution. Philippines: Luzon and Negros (Fig. 48c).

Biological aspects. The specimens were collected at altitudes from 50 m to 1400 m, mainly in riverside pools, but also in root packs or grass bunches in the runs.

Type material. ***Holotype*****.** Philippines • larva; Luzon, Laguna, Samil River; 14°08'N, 121°31'E; 370 m; 27.VI.2018; leg. BIO-PHIL exped.; on slide; GenBank: MT830944; GBIFCH 00654913; PNM. ***Paratypes*****.** Philippines • 2 larvae; same data as holotype; 1 on slide; GBIFCH 00592273; ZSM; 1 in alcohol, GBIFCH 00515409; ZSM • 1 larva; Luzon, Nueva Ecija, Pantabangan, Candaclan River; 240 m, 15°46'48"N, 121°13'17"E; 240 m; 05.II.1998; leg. Mendoza; on slide; GenBank: MT830945; GBIFCH 00654908; ZSM • 39 larvae; Luzon, Benguet, Tuba, Taloy Sur; 16°21'33"N, 120°30'31"E; 400 m; XI.1997; leg. Mey; 1 on slide; GenBank: MT830947; GBIFCH 00763648; AdMU; 38 in alcohol; GBIFCH 00515443; ZSM • 126 larvae; Luzon, Benguet, Kabayan, Bongis Bridge; 16°34'11"N, 120°50'12"E; 1000 m; XI.1997; leg. Mey; 1 on slide; GenBank: MT830946; GBIFCH 00763646; AdMU; 66 in alcohol; GBIFCH 00515440; 59 in alcohol; GBIFCH 00515500, GBIFCH 00515464, GBIFCH 00515441; ZSM • 1 larva; Negros Oriental, Valencia, Malaunay, small river; 09°18'17"N, 123°10'07"E; 470 m; 01.IX.2019; leg. Garces and Pelingen; on slide; GenBank: MT830948; GBIFCH 00654889; ZSM.

Other material. Philippines • 27 larvae; Luzon, Ifugao, Tinoc; 16°40'58"N, 120°56'59"E; 1400 m; XI.1997; leg. Mey; in alcohol; GBIFCH 00515444; AdMU • 4 larvae; Luzon, Ilocos Sur, Suyo Municipality, Tagudin-Cervantes-Sabangan Road, Besang Pass Area; 16°57'17"N, 120°38'52"E; 1200 m; 15.IV.2019; leg. Freitag, Garces and Pangantihon; in alcohol; GBIFCH 00515442; ZSM.

Labiobaetis camiguinensis sp. nov.

http://zoobank.org/A5674916-368A-4191-8F11-898F6CB52162
Figures 9, 10, 42a, 46c, 47d, 48c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus four or five long, simple setae; B) labial palp segment II with thumb-like distomedial protuberance; C) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with ca. ten curved, spine-like setae and a partial second row near margin; D) claw with 14 or 15 denticles; E) paraproct distally not expanded, with 15–17 stout, marginal spines.

Description. Larva (Figs 9, 10, 42a, 46c, 47d). Body length 3.6–3.9 mm; antenna: approx. twice as long as head length.

Colouration. Head dorsally light brown, thorax and abdomen dorsally brown with bright pattern as in Fig. 42a. Fore protoptera light brown with brown striation. Head, thorax, and abdomen ventrally brown with bright pattern as in Fig. 46c. Femur ecru with distomedial brown spot, apex with brown spot, tibia and tarsus light brown. Caudalii light brown, with a brown band at ca. 1/3 of cerci.

Antenna (Fig. 10f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 9a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus four or five long, simple setae, the first two setae after the submedian seta are close together. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. five short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 9b, c). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola with a pronounced hump. Tuft of setae at apex of mola present and many thin setae distally at base of mola.

Left mandible (Fig. 9d, e). Incisor and kinetodontium fused. Incisor with three denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola convex. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Figs 9f, 47d). Lingua approx. as long as superlinguae. Lingua approx. as broad as long; medial tuft of stout setae well developed, short; distal half not expanded. Superlinguae distally rounded; lateral margin angulate; fine, long, simple setae along distal margin.

Maxilla (Fig. 9g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and three or four medium to long, simple setae. Maxillary palp 1.4 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.8 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment slightly pointed, without excavation at inner distolateral margin.

Labium (Fig. 9h). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. seven short, stout, spine-like setae plus distalmost one much longer, less robust, spine-like seta; apex with two long and one medium, robust,

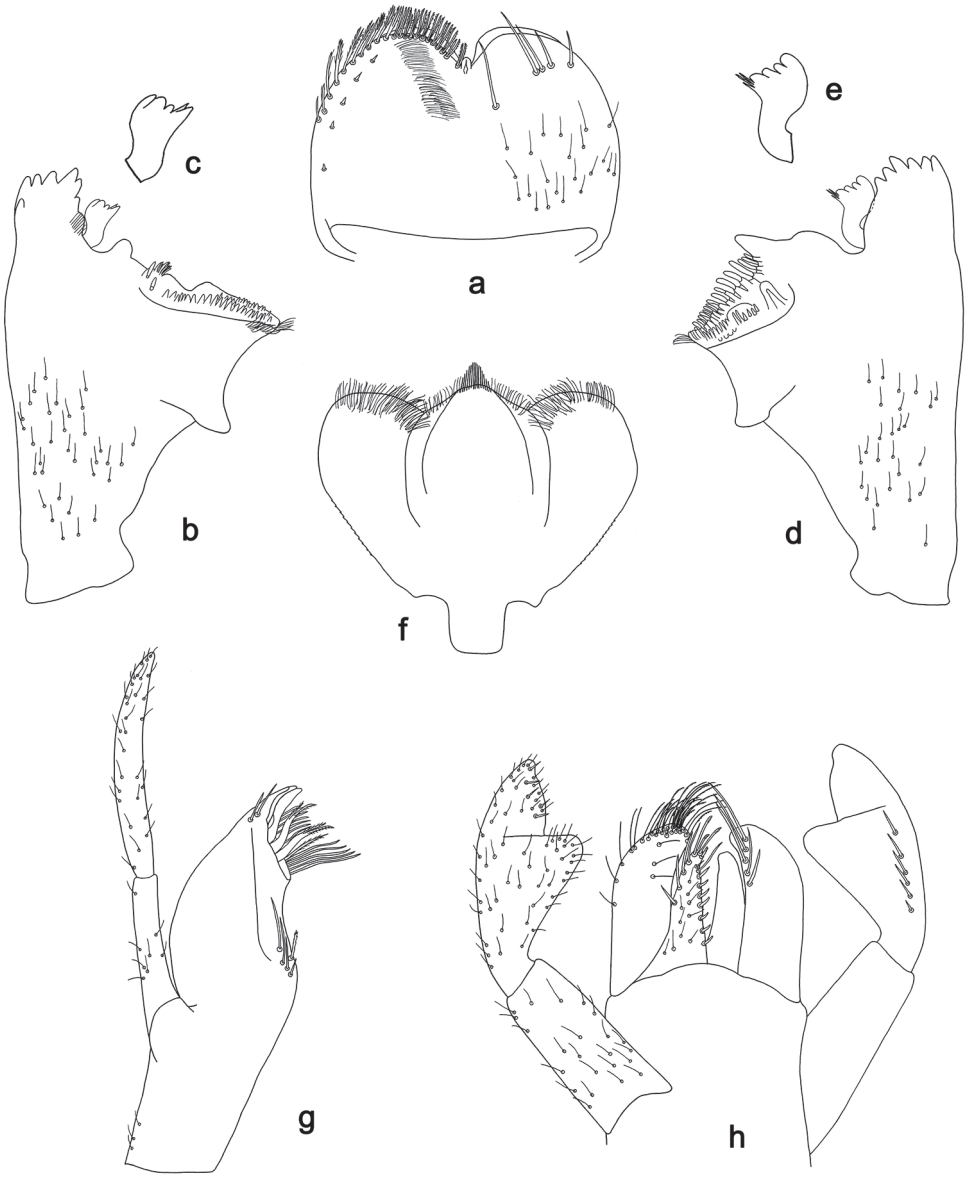

Figure 9. *Labiobaetis camiguinensis* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium.

pectinate setae and one short, robust seta; outer margin with four spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and a row of three medium, simple setae in anteromedial area; outer margin with some long, spine-like setae; dorsally with a row of five long,

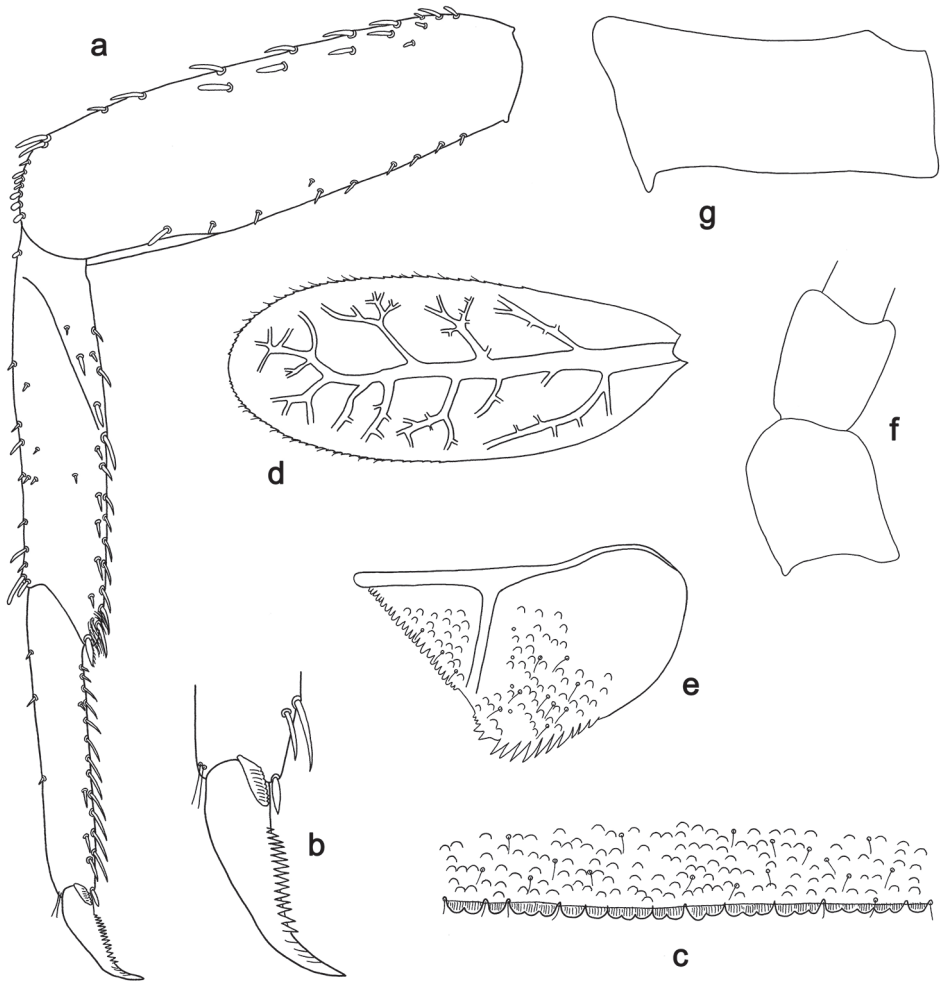

Figure 10. *Labiobaetis camiguinensis* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

spine-like, simple setae near inner margin. Labial palp with segment I 0.7 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.6 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of six short to medium, spine-like, simple setae near outer margin. Segment III conical; apex rounded; length 1.2 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 10g) minute.

Foreleg (Fig. 10a, b). Ratio of foreleg segments 1.4:1.0:0.8:0.3. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with ca. ten curved, spine-like setae, proximally and medially a partial second row of spine-like setae near margin; length of setae

0.18 × maximum width of femur. Apex rounded, with a pair of spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short to medium, spine-like setae, on apex two longer, spine-like setae. Ventral margin with a row of medium, curved, spine-like setae, distally of patellotibial suture one long, curved, spine-like seta, on apex some longer, partly bipectinate, spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus.*** Dorsal margin with some short, stout setae. Ventral margin with a row of curved, spine-like setae and some spine-like setae near margin. Claw with one row of 14 or 15 denticles; distally pointed; with 4–6 stripes; subapical setae absent.

Terga (Fig. 10c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with rounded, partly fused spines, wider than long.

Gills (Fig. 10d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and VI combined. Gill VII as long as length of segments VIII and IX combined.

Paraproct (Fig. 10e). Distally not expanded, with 15–17 stout, marginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Refers to the island Camiguin, where the specimens were collected.

Distribution. Philippines: Camiguin (Fig. 48c).

Biological aspects. The specimens were collected at altitudes of 30 m and 900 m, mainly on bottom gravel.

Type material. ***Holotype.*** Philippines • larva; Camiguin, Sagay, Bonbon, lower Binangawan River; 09°06'39"N 124°43'45"E; 30 m; 09.XII.2018; leg. Freitag and Wantzen; on slide; GenBank: MT830949; GBIFCH 00654915; PNM. ***Paratypes.*** Philippines • 2 larvae; same data as holotype; 1 on slide; GBIFCH 00592308; ZSM; 1 in alcohol; GBIFCH 00515489; ZSM • 1 larva; Camiguin, Mt. Mabajao Sagay, upstream Binangawan Falls; 09°09'25"N, 124°43'57"E; 900 m; 09.XII.2018; leg. Freitag; in alcohol; GBIFCH 00515454; AdMU.

Labiobaetis lachicae sp. nov.

http://zoobank.org/60DC83D6-32F6-4181-B224-1A890EF26245
Figures 11, 12, 42b, 47a, 48c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus 5–7 long, simple setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III conical; C) left mandible without setae at apex of mola; D) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with 10–12 curved, spine-like setae and a partial second row near margin; E) claw with 15–17 denticles; F) paraproct distally not expanded, with ca. 13 stout, marginal spines.

Description. Larva (Figs 11, 12, 42b, 47a). Body length 3.6–3.7 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

Colouration. Head dorsally light brown, thorax and abdomen dorsally brown, with bright pattern as in Fig. 42b. Fore protoptera light brown with distinct brown striation. Head, thorax, and abdomen ventrally brown with bright pattern as in Fig. 47a. Legs ecru, femur with two partly merged distomedial brown spots, apex with brown spot, tibia with distomedial brown area. Caudalii light brown, with a brown band at ca. 1/3 of cerci, cerci brown in distal part.

Antenna (Fig. 12f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 11a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 5–7 long, simple setae, the first two setae after the submedian seta are close together. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. six short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 11b, c). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola with a pronounced hump. Tuft of setae at apex of mola present and many thin setae distally at base of mola.

Left mandible (Fig. 11d, e). Incisor and kinetodontium fused. Incisor with three denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola convex. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola absent.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 11f). Lingua shorter than superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half laterally expanded. Superlinguae distally rounded; lateral margin angulate; fine, long, simple setae along distal margin.

Maxilla (Fig. 11g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and four medium to long, simple setae. Maxillary palp 1.3 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.6 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment slightly pointed, without excavation at inner distolateral margin.

Labium (Fig. 11h, i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. nine short, stout, spine-like setae plus distalmost one much longer, less robust, spine-like seta; apex with two long and one medium, robust,

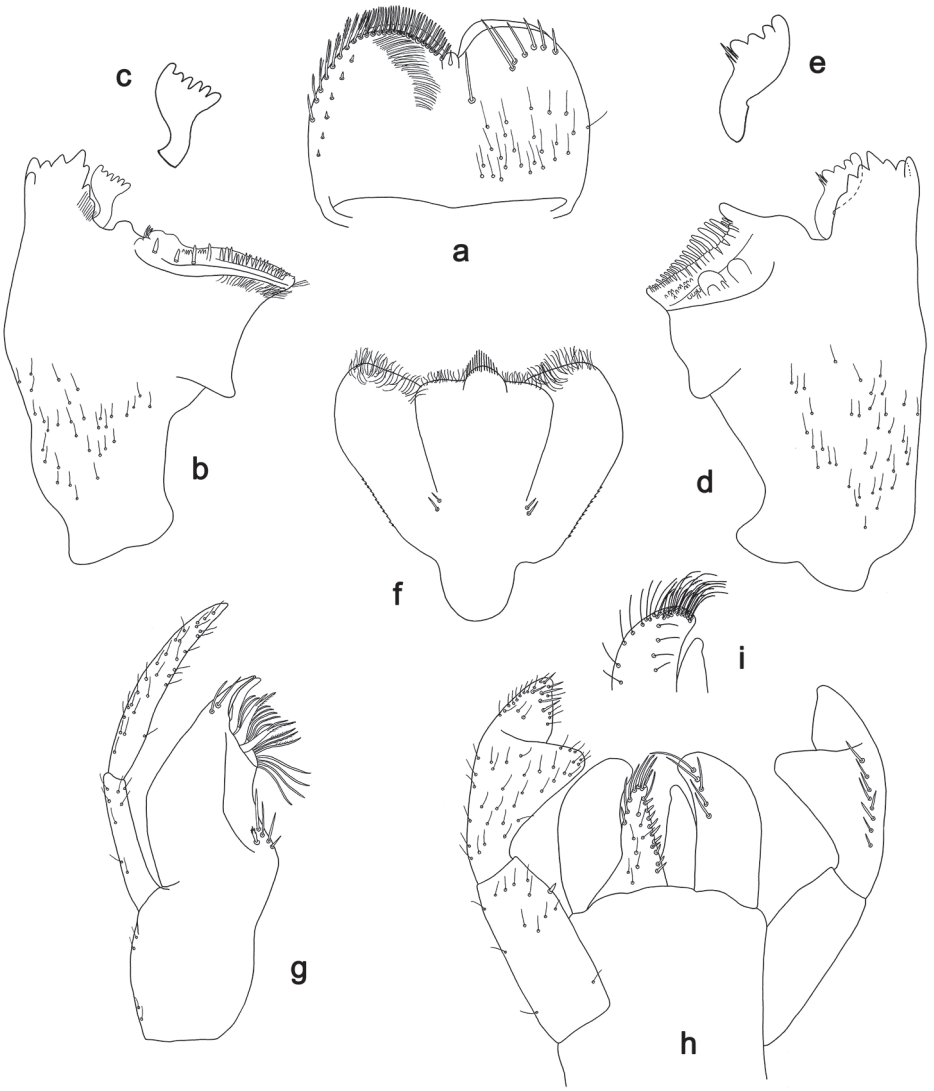

Figure 11. *Labiobaetis lachicae* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium **i** apex of paraglossa.

pectinate setae; outer margin with four spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and four medium, simple setae in anteromedial area; outer margin with some long, spine-like setae; dorsally with a row of five long, spine-like, simple setae near inner margin. Labial palp with segment I 0.9 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae and one short, stout, simple seta at inner margin. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.8 × width of base of segment III; ventral surface with short, fine, simple

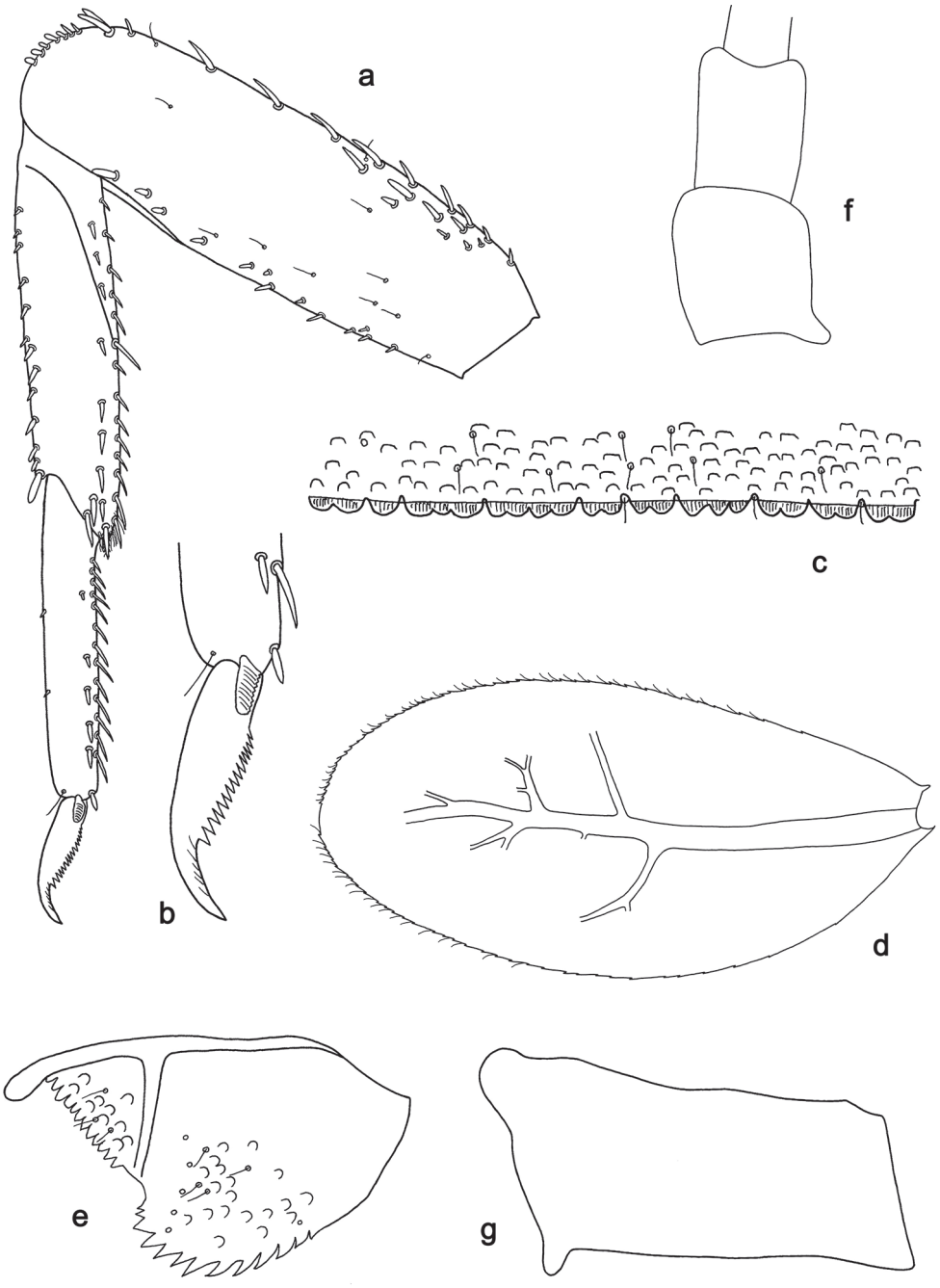

Figure 12. *Labiobaetis lachicae* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

setae; dorsally with a row of 6–8 medium, spine-like, simple setae near outer margin. Segment III conical; apex rounded; length 1.1 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 12g) minute.

Foreleg (Fig. 12a, b). Ratio of foreleg segments 1.4:1.0:0.8:0.3. ***Femur*.** Length ca. 3 × maximum width. Dorsal margin with 10–12 curved, spine-like setae, proximally and medially a partial second row of spine-like setae and some additional stout setae near margin; length of setae 0.23 × maximum width of femur. Apex rounded, with a pair of spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia*.** Dorsal margin with a row of short to medium, spine-like setae, on apex one longer, spine-like seta. Ventral margin with a row of medium, curved, spine-like setae, distally of patellotibial suture one long, curved, spine-like seta, on apex some longer, partly bipectinate, spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus*.** Dorsal margin with some short, stout setae. Ventral margin with a row of curved, spine-like setae and some spine-like setae near margin. Claw with one row of 15–17 denticles; distally pointed; with ca. six stripes; subapical setae absent.

Terga (Fig. 12c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae and micropores. Posterior margin of tergum IV with rounded, partly fused spines, wider than long.

Gills (Fig. 12d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae partly extending from main trunk towards outer and inner margins. Gill IV as long as length of segments V and VI combined. Gill VII as long as length of segments VIII and IX combined.

Paraproct (Fig. 12e). Distally not expanded, with ca. 13 stout, marginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with small, marginal spines.

Etymology. Dedicated to Ms. Maria Kenosis Lachica (Philippines/Japan), friend of the AdMU Biodiversity Laboratory.

Distribution. Philippines: Mindanao (Fig. 48c).

Biological aspects. The specimens were collected at altitudes from sea level to 120 m, in root packs, grass bunches or submerged wood in riffles or runs.

Type material. ***Holotype*.** Philippines • larva; Mindanao, Agusan del Sur, San Francisco, Bayogan, Tagkunayan Creek; 08°28'N, 125°59'E; 120 m; 05.II.1998; leg. Mendoza; on slide; GenBank: MT830950; GBIFCH 00654891; PNM. ***Paratypes*.** Philippines • 2 larvae; same data as holotype; 1 on slide; GBIFCH 00592269; AdMU; 1 on slide; GBIFCH 00592310; ZSM. **Other material.** Philippines • 1 larva; Mindanao, Surigao del Sur, Tandag, middle Tandag River; 30 m; 09°03'33"N, 126°05'57"E; 04.XII.2018; leg. Pangantihon; in alcohol; GBIFCH 00515332; AdMU • 1 larva; Mindanao, Surigao del Sur, Tandag, Pangi, Pangi River; 09°06'18"N, 126°08'53"E; 10 m; 30.XI.2018, leg. Pangantihon; on slide; GBIFCH 515520; ZSM.

***Labiobaetis palawano* sp. nov.**
http://zoobank.org/9E057916-4F3E-43F3-9AB7-B89D1A001EEA
Figures 13, 14, 42c, 47b, 48c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus seven long, simple setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III conical; C) mola of right mandible proximally beginning with a double hump; D) hypopharynx with medial tuft of stout setae poorly developed; E) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with 10–13 curved, spine-like setae and a partial second row near margin; F) claw with 15–17 denticles; G) posterior margin of tergum IV with rounded spines, wider than long.

Description. Larva (Figs 13, 14, 42c, 47b). Body length 3–4 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. 2.5 × as long as head length.

***Colouration*.** Head, thorax, and abdomen dorsally brown, with dark brown markings as in Fig. 42c. Fore protoptera light brown with brown striation. Head, thorax, and abdomen ventrally brown. Legs light brown, femur with a distomedial brown spot, apically brown. Caudalii light brown, with a brown band at ca. 1/3 of cerci.

Antenna (Fig. 14f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 13a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus seven long, simple setae, the first two setae after the submedian seta are close together. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. eight short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 13b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola with a pronounced hump, mola proximally beginning with a double hump. Tuft of setae at apex of mola present and many thin setae distally at base of mola.

Left mandible (Fig. 13d–f). Incisor and kinetodontium fused. Incisor with three denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola convex, with minute denticles toward subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted and partly with minute secondary dentation at the tips. Tuft of setae at apex of mola present. Comb-shaped structure at base of mola present.

Both mandibles with lateral margins slightly convex. Basal half with fine, simple setae scattered over dorsal surface.

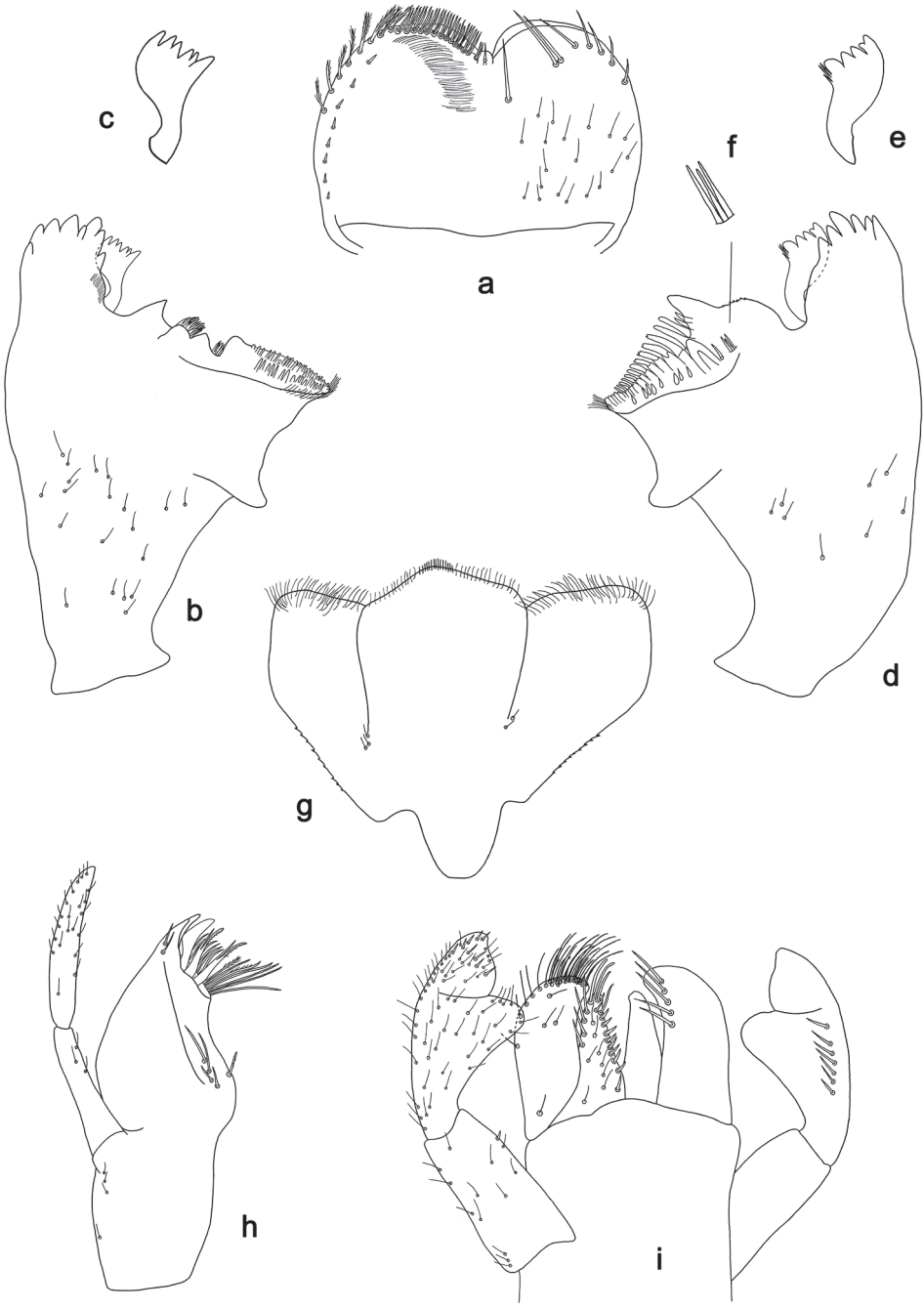

Figure 13. *Labiobaetis palawano* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** comb-shaped structure at left mola **g** hypopharynx and superlinguae **h** maxilla **i** labium.

Hypopharynx and superlinguae (Fig. 13g). Lingua longer than superlinguae. Lingua longer than broad; medial tuft of stout setae poorly developed; distal half not expanded. Superlinguae distally straight; lateral margin angulate; fine, long, simple setae along distal margin.

Maxilla (Fig. 13h). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and four or five long, simple setae. Maxillary palp 1.2 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.4 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment slightly pointed, without excavation at inner distolateral margin.

Labium (Fig. 13i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. nine short, stout, spine-like setae plus distalmost one much longer, less robust, spine-like seta; apex with two long, one medium and one short, robust, pectinate setae; outer margin with four spine-like setae; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and 3–5 medium, simple setae in anteromedial area and one fine, simple seta in proximomedial area; outer margin with some long, spine-like setae; dorsally with a row of five long, spine-like, simple setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae and one short, stout, simple seta at inner margin. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.6 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of seven medium, spine-like, simple setae near outer margin. Segment III conical; apex slightly truncate; length 1.0 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 14g) minute.

Foreleg (Fig. 14a, b). Ratio of foreleg segments 1.4:1.0:0.8:0.3. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with a row of 10–13 curved, spine-like setae in different length, and a partial second row of spine-like setae near margin; length of setae 0.28 × maximum width of femur. Apex rounded, with a pair of curved, spine-like setae and some short, stout, apically rounded setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like setae, on apex one longer, spine-like seta. Ventral margin with a row of short to long, curved, spine-like setae, distally of patellotibial suture one long, curved, spine-like seta, on apex some longer, curved, partly bipectinate spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus.*** Dorsal margin with a row of short, stout setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 15–17 denticles; distally pointed; with 5–8 stripes; subapical setae absent.

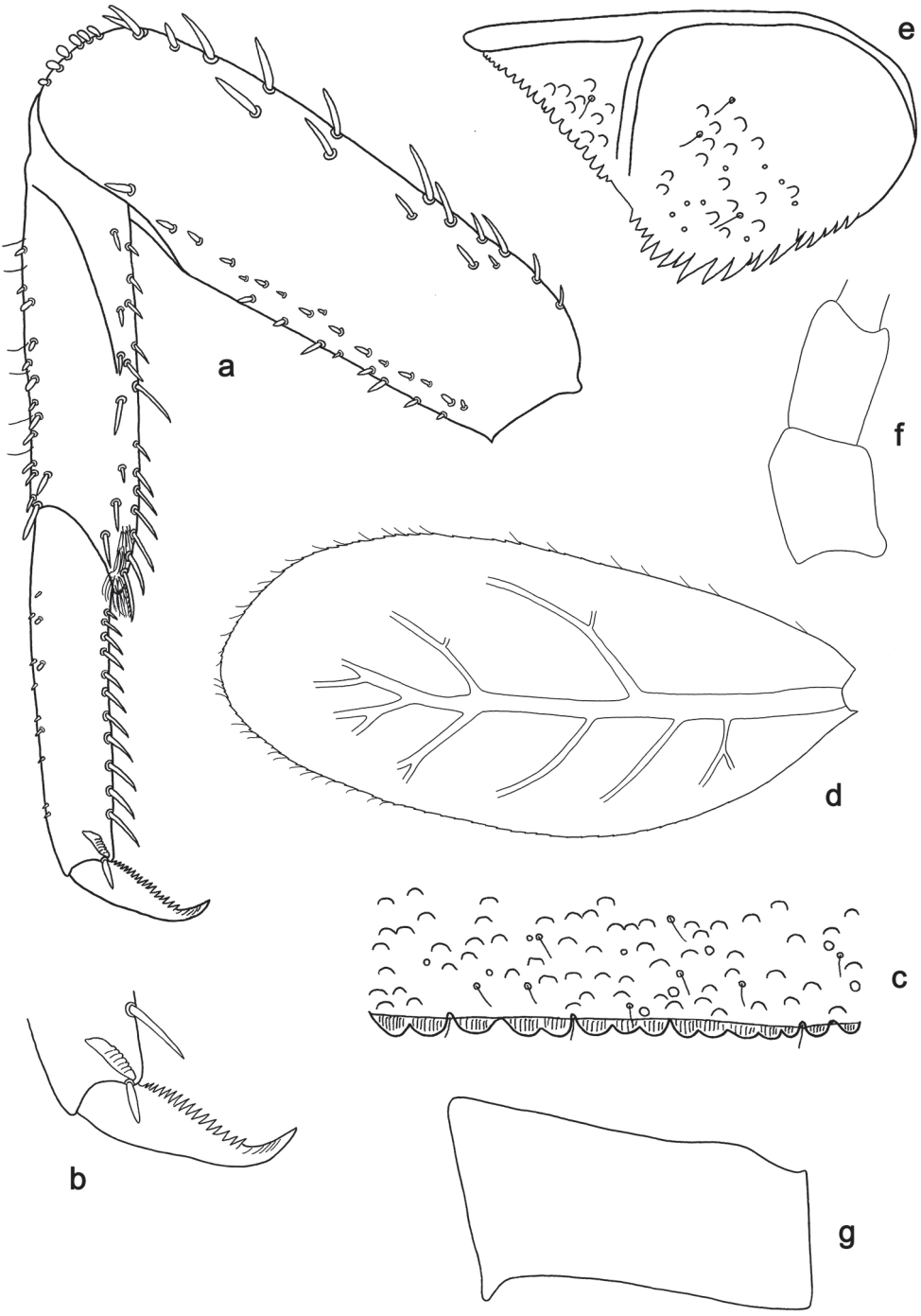

Figure 14. *Labiobaetis palawano* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

Terga (Fig. 14c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae and micropores. Posterior margin of tergum IV with rounded, partly fused spines, wider than long.

Gills (Fig. 14d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and ½ VI combined. Gill VII as long as length of segments VIII and 1/3 IX combined.

Paraproct (Fig. 14e). Distally not expanded, with ca. 17 stout, marginal spines and some submarginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to the indigenous Palawano people of Palawan.

Distribution. Philippines: Palawan (incl. Busuanga) (Fig. 48c).

Biological aspects. The specimens were collected at altitudes below 100 m, partly on rock surface in riffles or runs.

Type material. ***Holotype*.** Philippines • larva; Palawan, P. Princesa, Bindujan, Talabigan River; 10°01'26"N, 119°04'37"E; 10 m; 27.VII.2019; leg. Freitag and Molls; on slide; GenBank: MT830987; GBIFCH 00763688; PNM. ***Paratypes*.** Philippines • 2 larvae; Palawan, Busuanga, Coron, 4 km E San Nicolas; 12°03'46"N, 120°13'25"E; 25.XII.2019; leg. Freitag; 1 in alcohol; GBIFCH 00515519; ZSM, temporarily stored in AdMU; 1 in alcohol; MT830988; GBIFCH 00763679; PNM • 1 larva; Busuanga, 5 km NW Coron town; Mabintangen R., small mount. riv.; 12°01'45"N, 120°12'19"E; 50 m; 02.II.2020; leg. Freitag; on slide; GBIFCH 00515521; AdMU • 1 larva; Palawan, P. Princesa Cabayugan District, Cabayugan River, near Nagsatayan Creek, S of Martarpi; 10°09'47"N, 118°50'37"E; 37 m; 05.VIII.2000; leg. Freitag; on slide; GBIFCH 00592355; ZSM, temporarily stored in AdMU.

Labiobaetis sabordoi sp. nov.

http://zoobank.org/007986FB-400B-4665-9113-F1A130E70527
Figures 15, 16, 42d, 47c, 48c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus five or six long, simple setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III conical; C) mola of right mandible proximally beginning with a double hump; D) hypopharynx with medial tuft of stout setae poorly developed; E) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with 11–14 curved, spine-like setae and a partial second row near margin; F) claw with 16–18 denticles; G) posterior margin of tergum IV with triangular spines, wider than long.

Description. Larva (Figs 15, 16, 42d, 47c). Body length 3–3.5 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

***Colouration*.** Head dorsally light brown with brown markings, thorax and abdomen dorsally brown with bright pattern as in Fig. 42d. Fore protoptera light brown with distinct

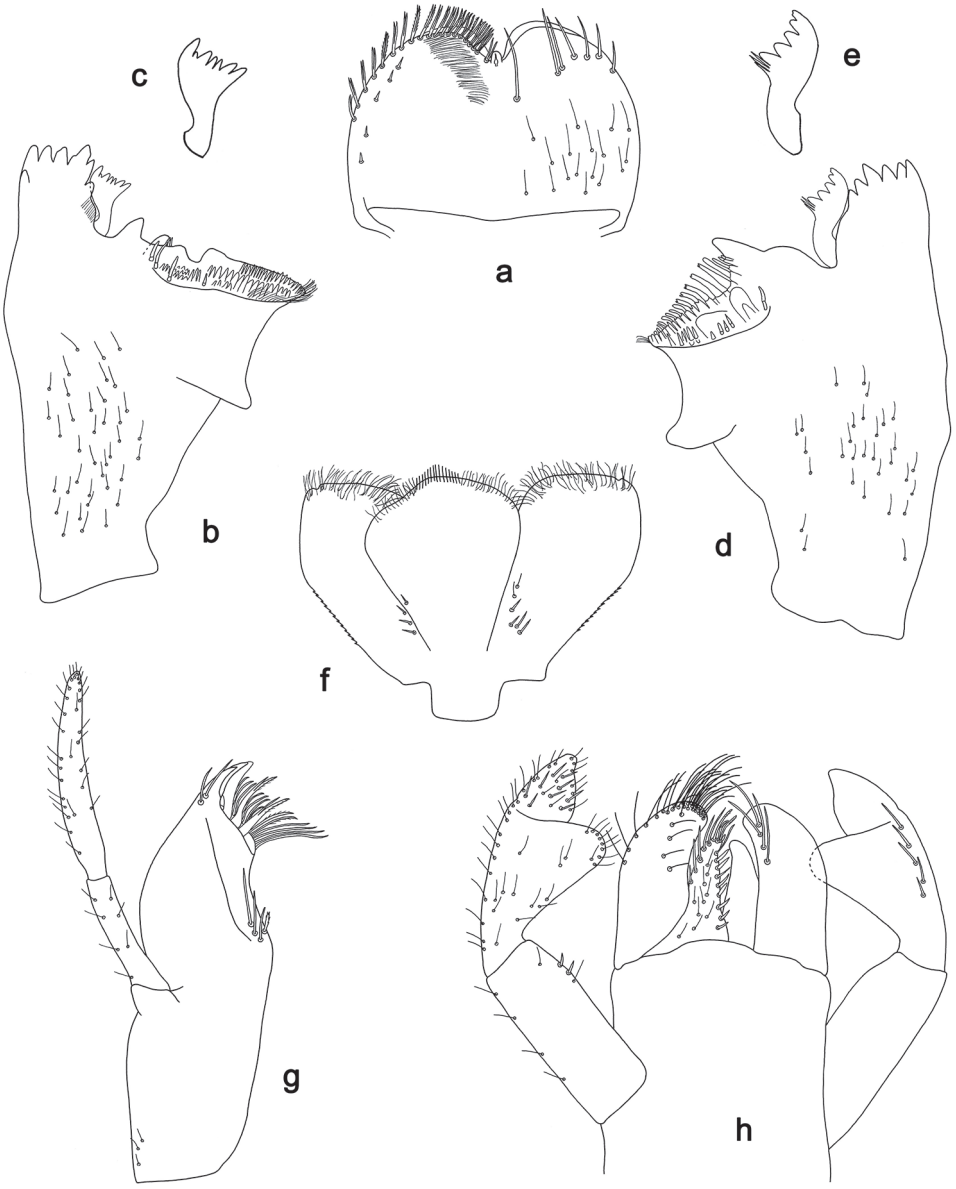

Figure 15. *Labiobaetis sabordoi* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium.

brown striation. Head, thorax, and abdomen ventrally brown with bright pattern as in Fig. 47c. Legs light brown, femur with two connected brown spots, apically brown. Caudalii light brown, with a brown band at ca. 1/3 of cerci length, distal area of cerci brown.

Antenna (Fig. 16f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 15a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus five or six long, simple setae, the first two setae after the submedian seta are close together. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. five short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 15b, c). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola with a pronounced hump, mola proximally beginning with a double hump. Tuft of setae at apex of mola present and many thin setae distally at base of mola.

Left mandible (Fig. 15d, e). Incisor and kinetodontium fused. Incisor with three denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola convex. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted and partly with minute secondary dentation at the tips. Tuft of setae at apex of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 15f). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae poorly developed; distal half laterally expanded. Superlinguae distally straight; lateral margin angulate; fine, long, simple setae along distal margin.

Maxilla (Fig. 15g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and three or four medium to long, simple setae. Maxillary palp 1.4 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.7 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment slightly pointed, without excavation at inner distolateral margin.

Labium (Fig. 15h). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. eight short, stout, spine-like setae plus distalmost one much longer, less robust, spine-like seta; apex with two long and one medium, robust, pectinate setae and one short, robust seta; outer margin with five spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and four medium, simple setae in anteromedial area; outer margin with some long, spine-like setae; dorsally with a row of four long, spine-like, simple setae near inner margin. Labial palp with segment I 0.9 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae and one or two short, stout, simple setae at inner margin. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.7 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of five or six me-

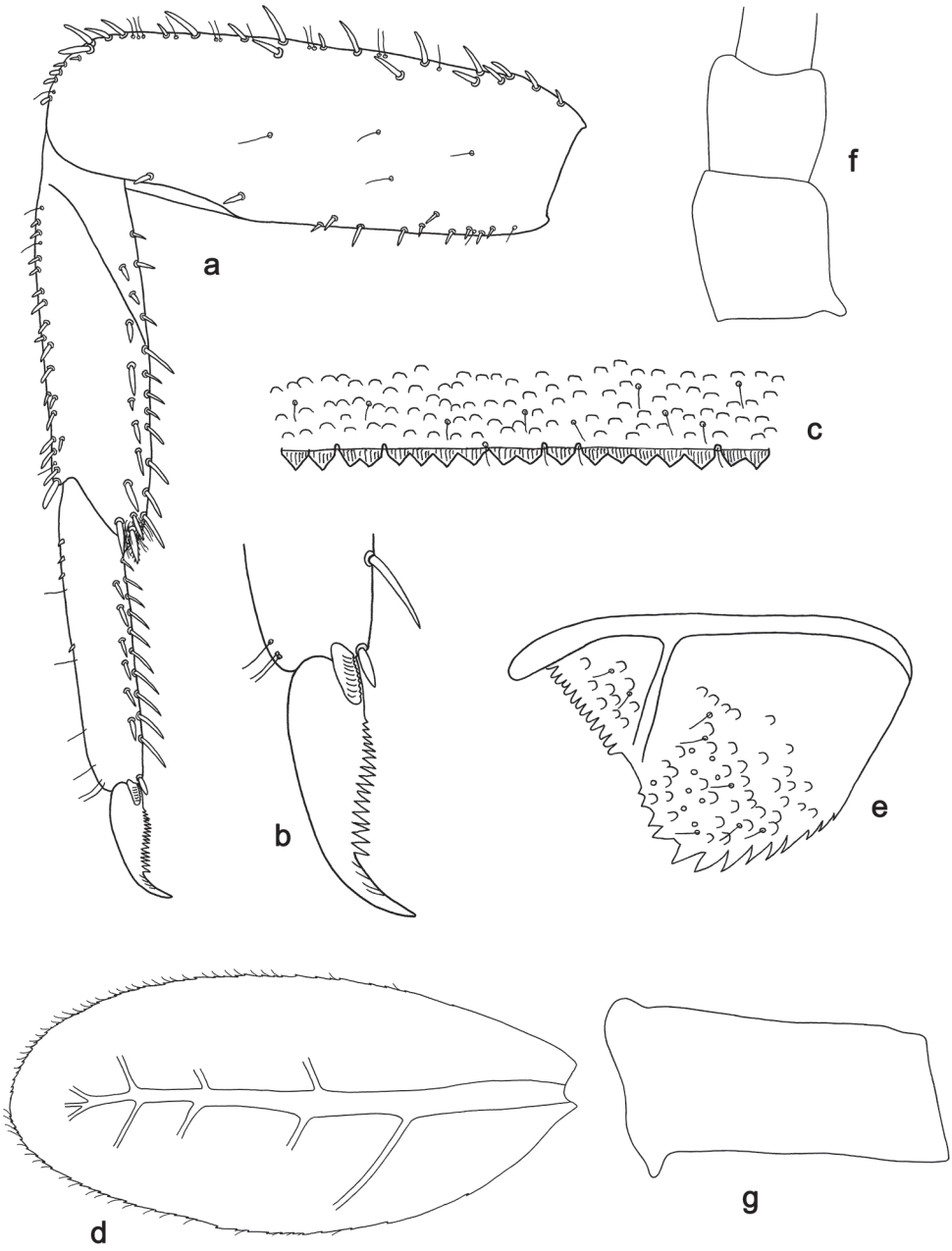

Figure 16. *Labiobaetis sabordoi* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

dium, spine-like, simple setae near outer margin. Segment III conical; apex slightly truncate; length 1.2 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 16g) minute.

Foreleg (Fig. 16a, b). Ratio of foreleg segments 1.4:1.0:0.8:0.3. ***Femur*.** Length ca. 3 × maximum width. Dorsal margin with a row of 11–14 curved, spine-like setae in different length, proximally and medially a partial second row of spine-like setae near margin; length of setae 0.22 × maximum width of femur. Apex rounded, with a pair of curved, spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia*.** Dorsal margin with a row of short, spine-like setae, on apex one longer, spine-like seta. Ventral margin with a row of short to long, curved, spine-like setae, distally of patellotibial suture one long, curved, spine-like seta, on apex some longer, partly bipectinate, spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus*.** Dorsal margin with some short, stout and some fine, simple setae. Ventral margin with a row of curved, spine-like setae and some spine-like setae near margin. Claw with one row of 16–18 denticles; distally pointed; with ca. four stripes; subapical setae absent.

Terga (Fig. 16c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular, partly fused spines, wider than long, sometimes apically rounded.

Gills (Fig. 16d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae partly extending from main trunk towards outer and inner margins. Gill IV as long as length of segments V and VI combined. Gill VII as long as length of segments VIII and IX combined.

Paraproct (Fig. 16e). Distally not expanded, with 13–23 stout, marginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Mr. Marc Ryan Sabordo (Philippines), collector and project assistant of the AdMU Biodiversity Laboratory.

Distribution. Philippines: Negros, Sibuyan and Tablas (Fig. 48c).

Biological aspects. The specimens were collected at altitudes from sea level to 480 m, partly in leaf litter.

Type material. ***Holotype*.** Philippines • larva; Negros Oriental, Valencia, Casaroro River downstream; 09°18'N, 123°14'E; 150 m; 01.IX.2019; leg. Garces and Pelingen; on slide; GBIFCH 00592270; PNM. ***Paratypes*.** Philippines • 1 larva; same data as holotype; on slide; GenBank: MT830951; GBIFCH 00654878; ZSM • 2 larvae; Romblon, Tablas, S of San Agustin; 12°33'38"N, 122°07'19"E; 40 m; 14.I.2019; leg. Freitag; 1 on slide; GenBank: MT830952; GBIFCH 00 763674; ZSM; 1 in alcohol; GBIFCH 00515334; ZSM • 2 larvae; Romblon, Sibuyan, Cajidiocan, Cambijang; 12°20'40"N, 122°40'37"E; 5 m; 16.I.2019; leg. Freitag; in alcohol; GBIFCH 00515333; AdMU.

Labiobaetis operosus group of species (Kaltenbach and Gattolliat 2019)

Following combination of characters: A) dorsal surface of labrum with submarginal arc of feathered setae; B) labial palp segment II with thumb-like or lobed distomedial

protuberance; C) seven pairs of gills; D) hind protoptera well developed; E) distolateral process at scape well developed; F) fore tarsus with thin setae at ventrodistal margin.

***Labiobaetis gamay* sp. nov.**
http://zoobank.org/8FB0BC17-3C57-4B66-A271-95FA834C5FAC
Figures 17, 18, 43a, 49a

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus 7–9 feathered setae with strongly reduced feathers; B) labial palp segment II with a broad, thumb-like distomedial protuberance; segment III conical; C) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with 10–14 curved, spine-like setae; D) hind protoptera well developed; E) paraproct distally not expanded, with 19–22 stout marginal spines.

Description. Larva (Figs 17, 18, 43a). Body length 4.6–5.2 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

Colouration. Head, thorax, and abdomen dorsally grey-brown, with bright pattern as in Fig. 43a, abdominal tergites I, VII, and X mainly light brown. Fore protoptera light brown with darker striation. Head, thorax, and abdomen ventrally ecru, frons and genae grey-brown, abdominal sternites VIII and IX grey-brown. Legs ecru, femur with two sometimes merged grey-brown distomedial spots, tarsus distally grey-brown. Caudalii light brown, with a grey- brown band at ca. 1/3 of cerci, cerci distally grey-brown.

Antenna (Fig. 18f) with scape and pedicel subcylindrical, with well-developed distolateral process at scape.

Labrum (Fig. 17a, b). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 7–9 long, feathered setae with strongly reduced feathers. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. five short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 17c, d). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex. Tuft of setae at apex of mola present.

Left mandible (Fig. 17e, f). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight, with few minute denticles. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

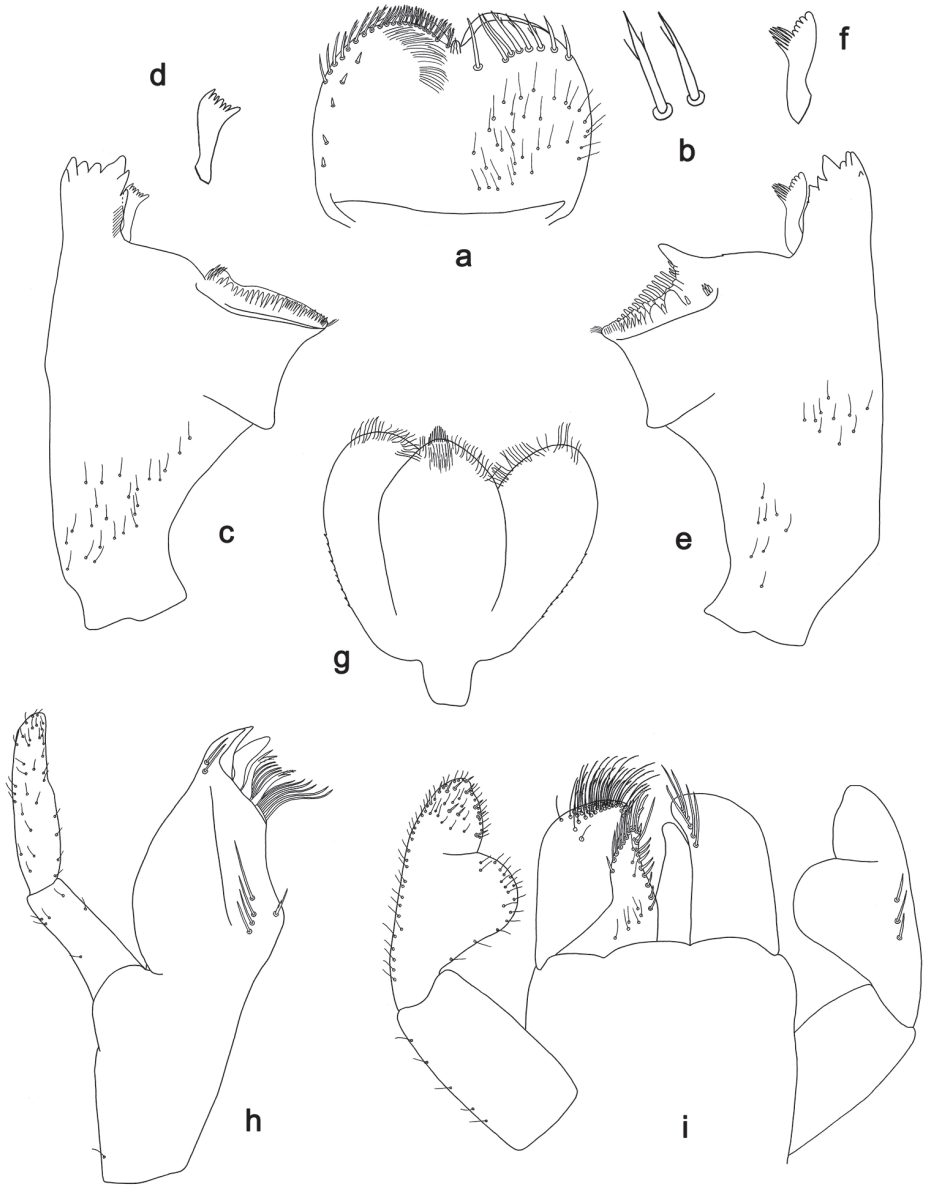

Figure 17. *Labiobaetis gamay* sp. nov., larva morphology **a** labrum **b** setae of arc on dorsal surface of labrum **c** right mandible **d** right prostheca **e** left mandible **f** left prostheca **g** hypopharynx and superlinguae **h** maxilla **i** labium.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 17g). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal

half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 17h). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and four long, simple setae. Maxillary palp slightly longer than length of galea-lacinia; 2-segmented; palp segment II 1.4 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

Labium (Fig. 17i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. nine spine-like setae, distalmost seta much longer than other setae; apex with two long and one medium, robust, pectinate setae and one short, robust seta; outer margin with seven spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and one or two medium, simple setae in anteromedial area; dorsally with a row of five long, spine-like, simple setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with broad thumb-like distomedial protuberance; distomedial protuberance 0.7 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of three long, spine-like setae near outer margin. Segment III conical; apex slightly truncate; length 1.1 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 18g) well developed.

Foreleg (Fig. 18a, b). Ratio of foreleg segments 1.4:1.0:0.8:0.3. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with 10–14 curved, spine-like setae, mostly one or two setae additionally near margin in basal area; length of setae 0.19 × maximum width of femur. Apex rounded, with a pair of spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like setae and fine simple setae, on apex one longer, spine-like seta. Ventral margin with a row of short, curved, spine-like setae, on apex some longer, partly bipectinate setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 2/3. ***Tarsus.*** Dorsal margin with a row of short, stout setae and fine, simple setae. Ventral margin with a row of curved, spine-like setae and in distal area fine simple setae. Claw with one row of 12 or 13 denticles; distally pointed; with ca. four stripes; subapical setae absent.

Terga (Fig. 18c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 18d). Present on segments I–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill I ca. 2/3 length of segment II. Gill IV as long as length of segments V and ½ VI combined. Gill VII as long as length of segment VIII.

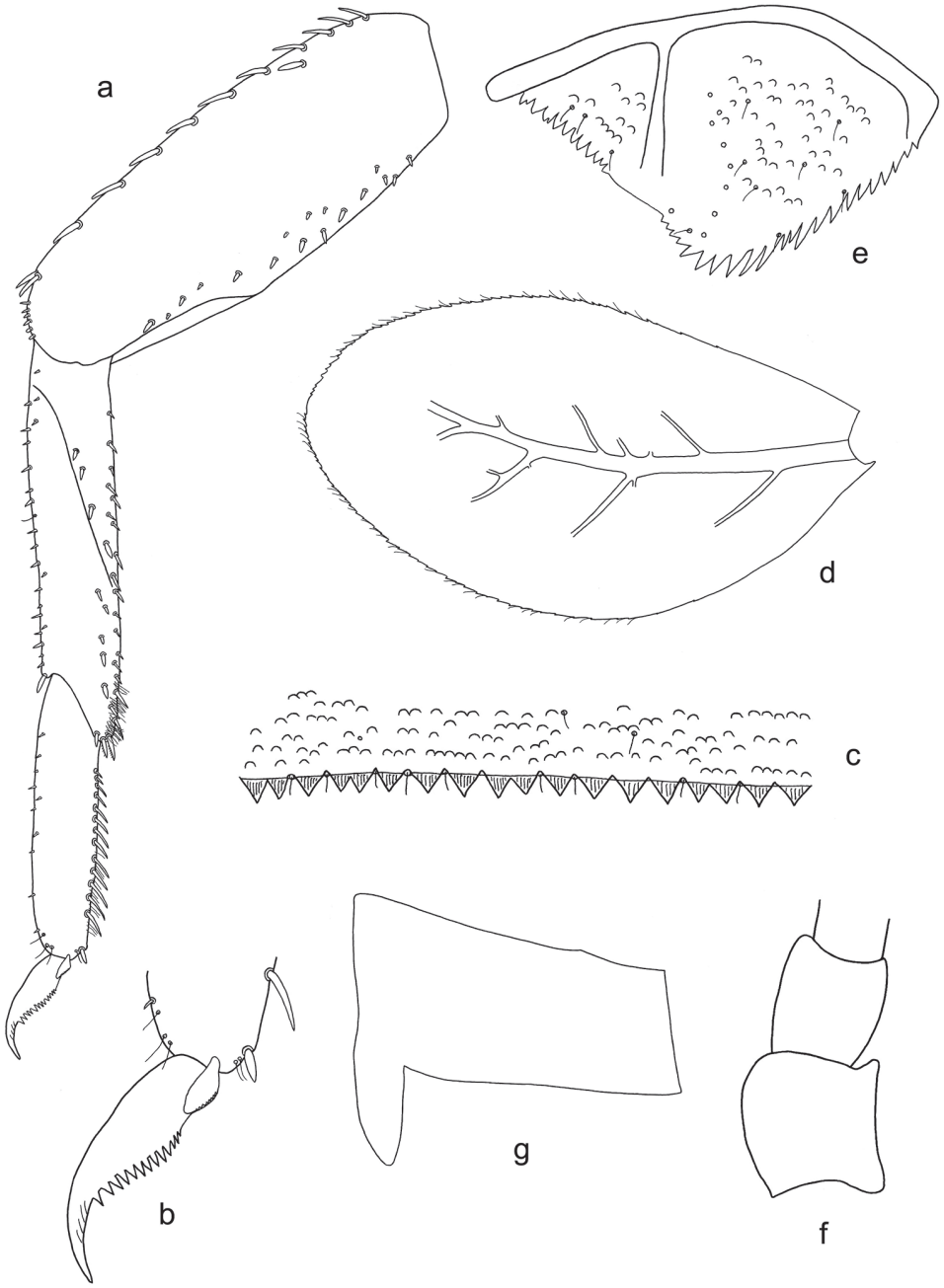

Figure 18. *Labiobaetis gamay* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

Paraproct (Fig. 18e). Distally not expanded, with 19–22 stout, marginal spines. Surface scattered with U-shaped scale bases and fine, simple setae. Cercotractor with numerous small, marginal spines.

Etymology. Named after the Cebuano word meaning reduced, referring to the strongly reduced feathers of the submarginal setae on the dorsal labrum surface.

Distribution. Philippines: Luzon and Mindoro (Fig. 49a).

Biological aspects. The specimens were collected at altitudes from sea level to 140 m, partly on hygropetric rocks or rock surface in riffles or runs.

Type material. ***Holotype.*** Philippines • larva; Oriental Mindoro, Roxas, Brgy. San Vicente, lower reach of Taugad River; 12°37.30'N, 121°22.97'E; 140 m; 2016–2019; leg. Freitag and Garces; on slide; GBIFCH 00592274; PNM. ***Paratypes.*** Philippines • 27 larvae; same data as holotype; 2 on slide; GenBank. MT830953, MT830954; GBIFCH 00 654922, GBIFCH 00763637; ZSM; 25 in alcohol; GBIFCH 00515433, GBIFCH 00515434, GBIFCH 00515458, GBIFCH 00515460; ZSM • 10 larvae; Oriental Mindoro, Roxas, Brgy. San Vicente; 12°37'06"N, 121°23'49"E; 140 m; 2016–2019; leg. Freitag, Garces and Pangantihon; 2 on slides; GenBank: MT830955; GBIFCH 00763639, GBIFCH 00763338; AdMU; 8 in alcohol; GBIFCH 00515435, GBIFCH 00515459; AdMU • 15 larvae; Luzon, La Union, Sudipen Municipality, Amburayan River; 16°54'38"N, 120°28'40"E; 20 m; 14.IV.2019; leg. Freitag, Garces and Pangantihon; 1 on slide; GenBank: MT830956; GBIFCH 00763655; ZSM; 14 in alcohol; GBIFCH 00515436, GBIFCH 00515461; ZSM • 31 larvae; Luzon, Ilocos Sur, Suyo Municipality, big river downstream Sangbay n. Ragsak; 16°59'32"N, 120°32'21"E; 100 m; 15.IV.2019; leg. Freitag, Garces and Pangantihon; 1 on slide; GenBank: MT830957; GBIFCH 00763657; ZSM; 30 in alcohol; GBIFCH 00515437; ZSM • 14 larvae; Luzon, La Union, San Juan Municipality, Baroro River; 16°39'27"N, 120°25'55"E; 90 m; 19.IV.1996; leg. Mendoza; 1 on slide; GenBank: MT830958; GBIFCH 00763658; ZSM; 13 in alcohol; GBIFCH 00515438, GBIFCH 515439; ZSM.

***Labiobaetis pangantihoni* sp. nov.**

http://zoobank.org/AAA2FE3C-DA89-41AA-A20A-4AF457BB0848

Figures 19, 20, 43b, 49a

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus nine or ten long, feathered setae; B) labial palp segment II with a rather slender, thumb-like distomedial protuberance, segment III slightly pentagonal; C) fore femur rather broad, length 3.4 × maximum width, dorsal margin with eleven or 12 curved, spine-like setae; D) claw with 10–13 denticles; E) paraproct distally not expanded, with ca. 16 stout marginal spines.

Description. Larva (Figs 19, 20, 43b). Body length 3.5–4 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. 2.5 × as long as head length.

Colouration. Head, thorax, and abdomen dorsally brown, with bright pattern as in Fig. 43b, fore protoptera brown with bright striation. Head, thorax, and abdomen ventrally light brown, genae brown, abdominal segments VIII and IX darker brown. Legs light brown, femur with distomedial brown spot, apex brown, tibia distally brown. Caudalii light brown with a brown band at ca. 1/3 of cerci length.

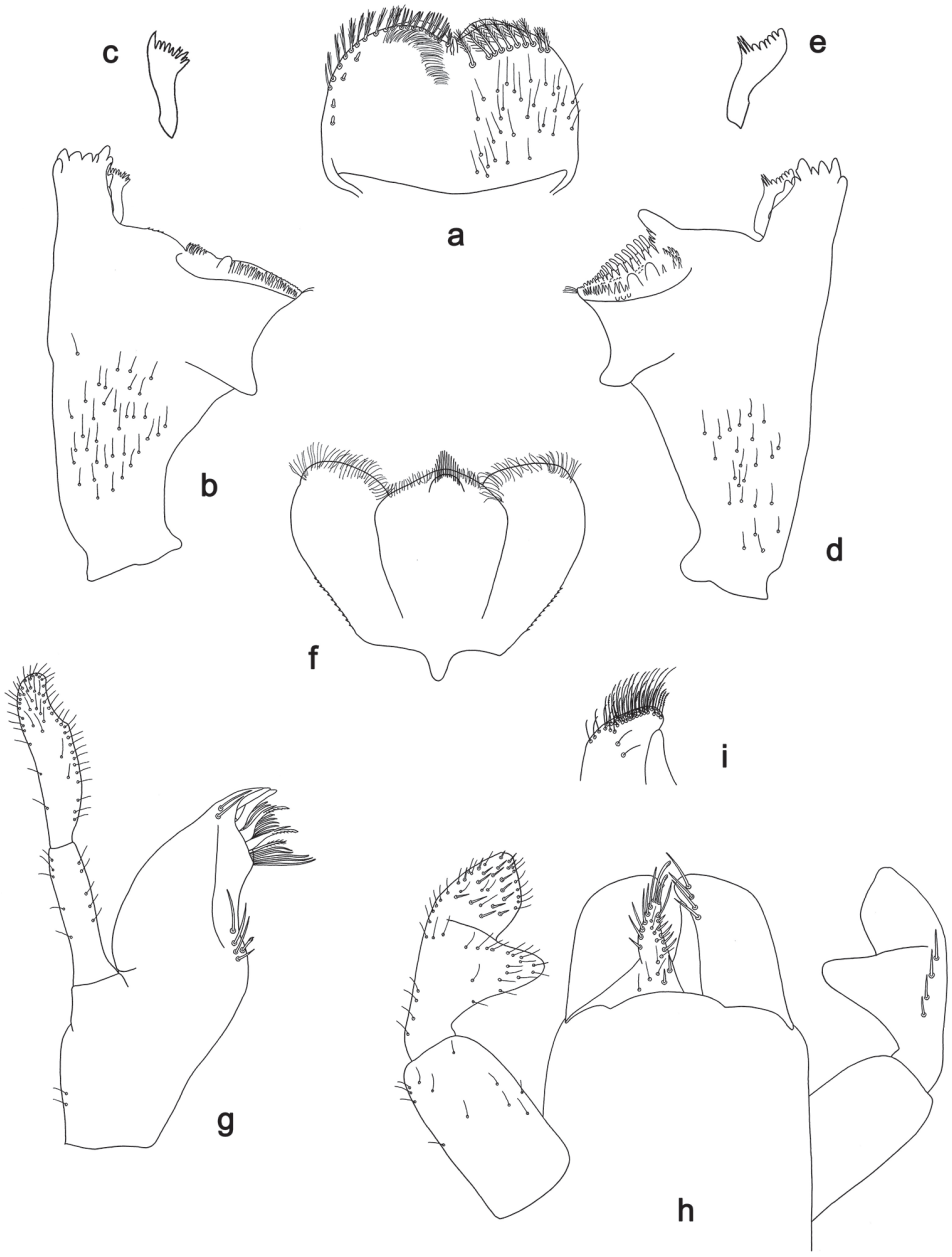

Figure 19. *Labiobaetis pangantihoni* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium **i** apex of paraglossa.

Antenna (Fig. 20f) with scape and pedicel subcylindrical, with well-developed distolateral process at scape.

Labrum (Fig. 19a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple

setae scattered over surface; submarginal arc of setae composed of one plus nine or ten long, feathered setae. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. four short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 19b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle without a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex, with minute denticles. Tuft of setae at apex of mola present.

Left mandible (Fig. 19d, e). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 19f). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 19g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and four or five long, simple setae. Maxillary palp 1.3 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.3 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with excavation at inner distolateral margin.

Labium (Fig. 19h, i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. eight spine-like setae, distalmost seta much longer than other setae; apex with two long and one medium, robust, pectinate setae; outer margin with six medium to long, spine-like setae; ventral surface with short, fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and two medium, simple setae in anteromedial area; dorsally with a row of four long, spine-like, simple setae near inner margin. Labial palp with segment I 0.9 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with rather slender, thumb-like distomedial protuberance; distomedial protuberance 0.8 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of four spine-like, simple setae near outer margin. Segment III slightly pentagonal; apex slightly truncate; length 1.1 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 20g) well developed.

Foreleg (Fig. 20a, b). Ratio of foreleg segments 1.2:1.0:0.6:0.2. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with eleven or twelve curved, spine-like setae;

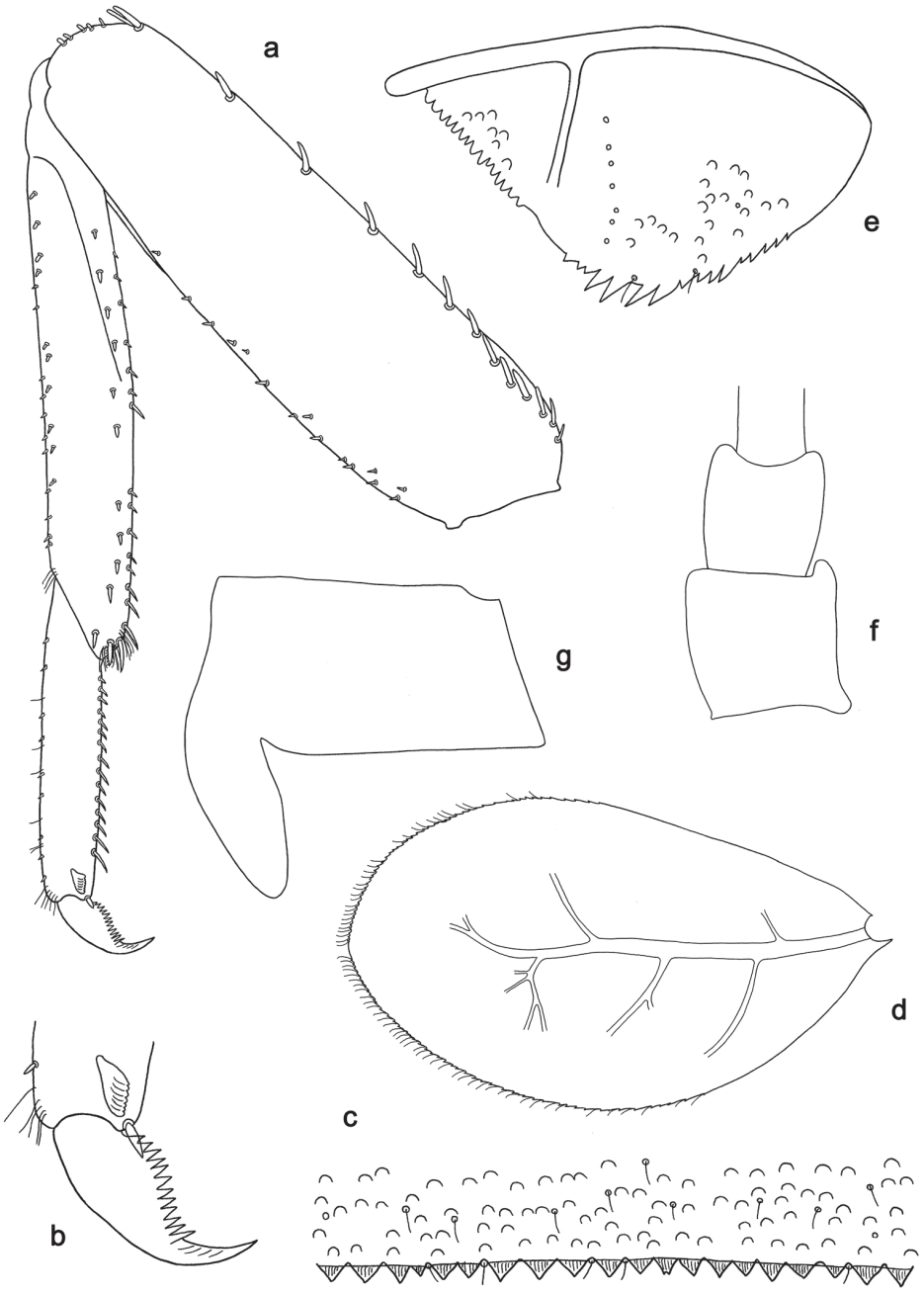

Figure 20. *Labiobaetis pangantihoni* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

length of setae 0.16 × maximum width of femur. Apex rounded, with a pair of spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like

setae, near margin another row of short, spine-like setae. Ventral margin with row of short to medium, curved, spine-like setae, on apex some longer and partly bipectinate setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus.*** Dorsal margin with a row of short stout setae and fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 10–13 denticles; distally pointed; with ca. four stripes; subapical setae absent.

Terga (Fig. 20c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 20d). Present on segments I–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill I ca. 1/2 length of segment II. Gill IV as long as length of segments V and 1/2 VI combined. Gill VII as long as length of segments VIII and 1/4 IX combined.

Paraproct (Fig. 20e). Distally not expanded, with ca. 16 stout, marginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Mr. Clister V. Pangantihon, outstanding collector, entomologist and project assistant of the AdMU Biodiversity Laboratory.

Distribution. Philippines: Palawan (Fig. 49a).

Biological aspects. The specimens were collected at altitudes from sea level to 180 m, partly on submerged wood in runs or riffles.

Type material. ***Holotype.*** Philippines • larva; Palawan, Balabac, Danglis River near the road; 07°57'39"N, 117°02'59"E; 170 m; 2019; leg. Pelingen and Pangantihon; on slide; GBIFCH 00592336; PNM. ***Paratypes.*** Philippines • 9 larvae; same data as holotype; 3 on slides; GenBank: MT830959; GBIFCH 00592321, GBIFCH 00763684, GBIFCH 00592335; ZSM, temporarily stored in AdMU; 5 in alcohol; GBIFCH 00515426; PCSD; 1 in alcohol; GBIFCH 00515400; AdMU • 1 larva; Palawan, Balabac, Danglis Falls/Busay; 07°57'39"N, 117°02'59"E; 180 m; 2019; leg. Pelingen and Pangantihon; in alcohol; GBIFCH 00515427; AdMU • 5 larvae; Palawan, Quezon, Isugod, Aramaywan River; 09°21'07"N, 118°08'26"E; 14 m; 2019; leg. Pangantihon and Pelingen; 1 on slide; GBIFCH 00592331; AdMU; 2 in alcohol; GBIFCH 00515429; PNM; 2 in alcohol; GBIFCH 00515401, GBIFCH 00515402; AdMU • 2 larvae; Palawan, Quezon, Aramaywan River; 09°18'25"N, 118°07'42"E; 20 m; 2019; leg. Pangantihon and Pelingen; in alcohol; GBIFCH 00515428; AdMU.

Labiobaetis tagbanwa **sp. nov.**
http://zoobank.org/F6926F19-3CEB-4C21-8E62-A14C0D7F4839
Figures 21, 22, 43c, 49a

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus 8–10 long, feathered setae with reduced feathers; B) labial palp segment II with a broad thumb-like distomedial protuberance, segment III conical; C) fore femur rather broad, length ca. 3 × maximum width, dorsal margin

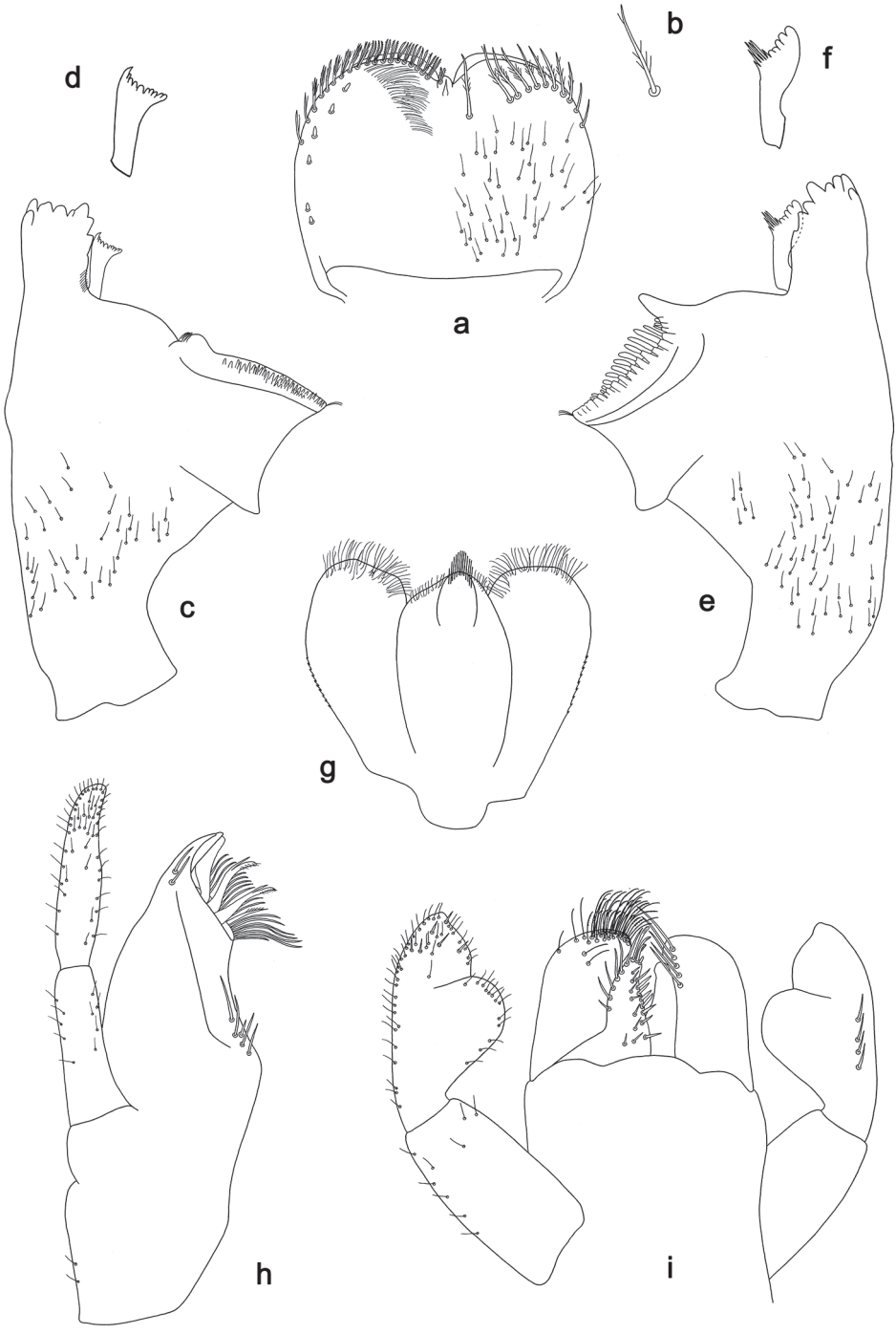

Figure 21. *Labiobaetis tagbanwa* sp. nov., larva morphology **a** labrum **b** seta of arc on dorsal surface of labrum **c** right mandible **d** right prostheca **e** left mandible **f** left prostheca **g** hypopharynx and superlinguae **h** maxilla **i** labium.

with ca. 13 curved, spine-like setae; D) hind protoptera medium developed; E) paraproct distally not expanded, with ca. 18 stout, marginal spines.

Description. Larva (Figs 21, 22, 43c). Body length 4.1–5.3 mm. Cerci ca. 3/4 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

Colouration. Head, thorax, and abdomen dorsally brown, with bright markings as in Fig. 43c, abdominal segments I, VII and X light brown, fore protoptera basally brown, distally light brown with bright striation. Head, thorax, and abdomen ventrally light brown, genae brown, abdominal segments laterally somewhat darker, abdominal segments VIII and IX brown, abdominal segment V, VI and VII medially with darker areas. Legs ecru, femur with distomedial brown spot, apex brown, tibia and tarsus distally light brown. Caudalii light brown, with a brown band at ca. 1/3 of cerci length, cerci distally brown.

Antenna (Fig. 22f) with scape and pedicel subcylindrical, with well-developed distolateral process at scape.

Labrum (Fig. 21a, b). Rectangular, length 0.8 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 8–10 long, feathered setae with reduced feathers. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. six short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 21c, d). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex. Tuft of setae at apex of mola present.

Left mandible (Fig. 21e, f). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola slightly convex. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 21g). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half not expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 21h). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and four long, simple setae. Maxillary palp 1.2 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.2 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

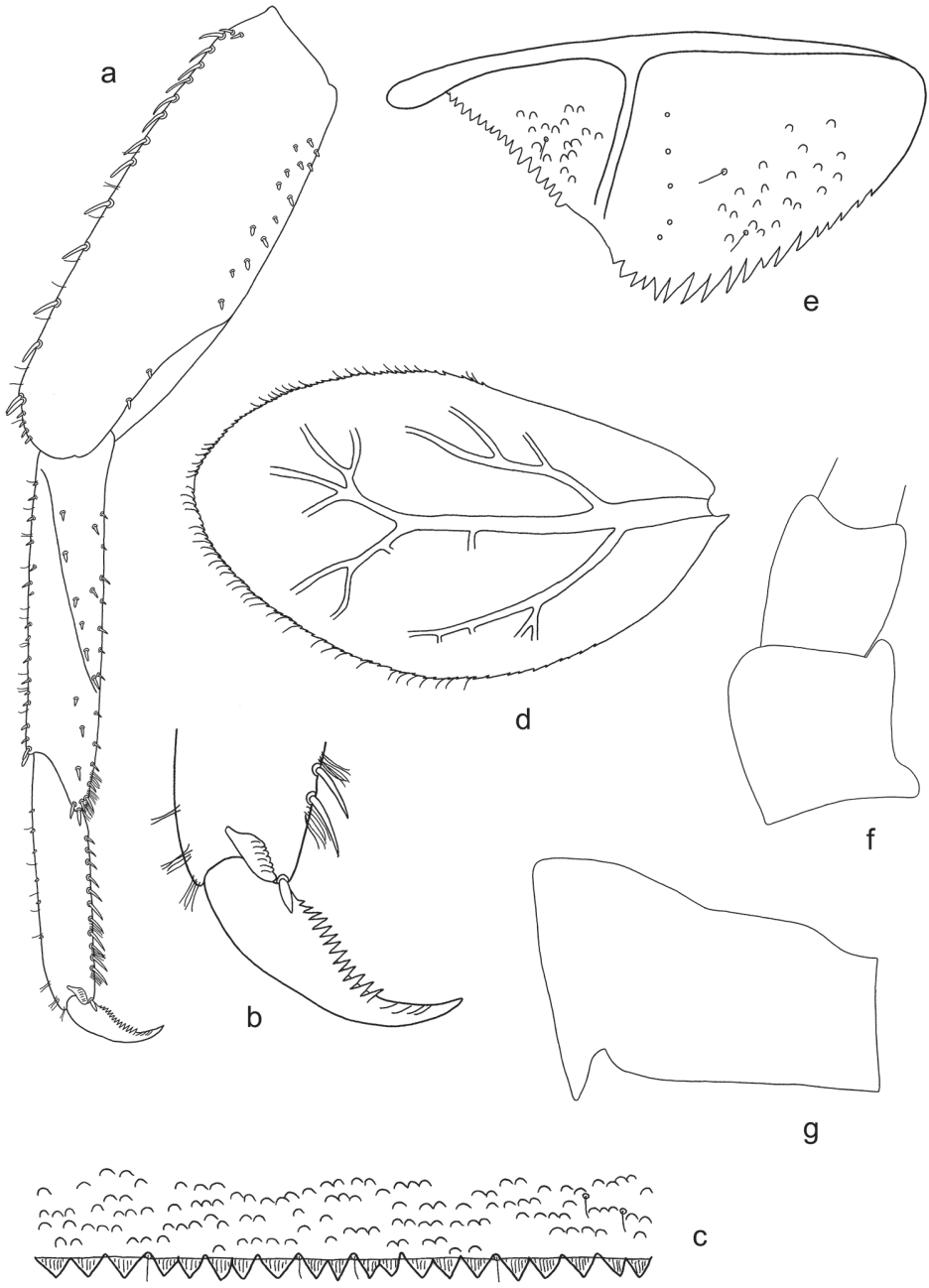

Figure 22. *Labiobaetis tagbanwa* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

Labium (Fig. 21i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. eight spine-like setae; apex with two long and one medium, robust, pectinate setae and one short, robust seta; outer margin with six

medium to long spine-like setae; ventral surface with short, simple setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and two medium, simple setae in anteromedial area; dorsally with a row of five long, spine-like, simple setae near inner margin. Labial palp with segment I 0.9 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with broad thumb-like distomedial protuberance; distomedial protuberance 0.5 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of three or four spine-like, simple setae near outer margin. Segment III conical; apex slightly pointed; length 0.9 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 22g) medium developed.

Foreleg (Fig. 22a, b). Ratio of foreleg segments 1.5:1.0:0.7:0.3. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with ca. 13 curved, spine-like setae; length of setae 0.18 × maximum width of femur. Apex rounded, with a pair of spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like setae and fine, simple setae, on apex a pair of longer, spine-like setae. Ventral margin with a row of short, curved, spine-like setae, on apex some longer setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 2/3. ***Tarsus.*** Dorsal margin with a row of short, stout setae and fine, simple setae. Ventral margin with a row of curved, spine-like setae and in distal area fine simple setae. Claw with one row of 11–14 denticles; distally pointed; with ca. four stripes; subapical setae absent.

Terga (Fig. 22c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 22d). Present on segments I–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill I ca. 1/2 length of segment II. Gill IV as long as length of segments V and 1/2 VI combined. Gill VII as long as length of segment VIII.

Paraproct (Fig. 22e). Distally not expanded, with ca. 18 stout, marginal spines. Surface scattered with U-shaped scale bases and fine, simple setae. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to the indigenous Tagbanwa people of Palawan.

Distribution. Philippines: Palawan (Fig. 49a).

Biological aspects. The specimens were collected from sea level to 100 m on rock surface or submerged wood in riffles or runs.

Type material. ***Holotype.*** Philippines • larva; Palawan, Quezon, Aramaywan River, cogon grass; 09°22'33"N, 118°08'41"E; 15 m; 2019; leg. Pangantihon and Pelingen; on slide; GBIFCH 00592324; PNM. ***Paratypes.*** Philippines • 16 larvae; same data as holotype; 1 on slide; GenBank: MT830962; GBIFCH 00763680; ZSM, temporarily stored in AdMU; 1 on slide; GBIFCH 00592350; AdMU; 3 in alcohol; GBIFCH 00515432, GBIFCH 00515457; PNM; 2 in alcohol; GenBank: MT830961; GBIFCH 00763681, GBIFCH 00515430; ZSM, temporarily stored in AdMU; 6 in

alcohol; GBIFCH 00515431; PCSD; 3 in alcohol; GBIFCH 00515410; AdMU • 1 larva; Palawan, Puerto Princesa, Luzviminda, Iwahig River; 09°41'20"N 118°37'29"E; 13.VI.2009; leg. Freitag; on slide; GenBank: MT830960; GBIFCH 00654885; AdMU • 1 larva; Palawan, Aborlan, Cabigaan, Talakaigan, mount. Riv. upstr. dam; 09°26'55"N, 118°26'44"E; 100 m; 14.VI.1995; leg. Freitag; in alcohol; GBIFCH 00515456; AdMU.

***Labiobaetis valdezorum* sp. nov.**
http://zoobank.org/DCC0D1B4-B4C0-4FF4-A224-173008DCAF39
Figures 23, 24, 44a, 49a

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus 9–12 feathered setae; B) labial palp segment II with broad, thumb-like distomedial protuberance; C) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with 12–15 curved, spine-like setae, fore tarsus broad with dorsal and ventral margins slightly convex; D) claw with eleven or twelve denticles; E) paraproct distally not expanded, with 23–32 stout marginal spines and some additional submarginal spines.

Description. Larva (Figs 23, 24, 44a). Body length 5.5–5.9 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. 2.5 × as long as head length.

Colouration. Head, thorax, and abdomen dorsally light brown, with darker pattern as in Fig. 44a, abdominal segments VIII and IX dark brown. Fore protoptera light brown, basally darker, with bright striation. Head, thorax, and abdomen ventrally light brown, frons and genae darker brown, abdominal segments VIII and IX dark brown. Legs light brown, femur with distomedial dark brown spot, apically brown, tarsus dorsodistally dark brown. Caudalii light brown with a dark brown band at ca. 1/3 of cerci length.

Antenna (Fig. 24f) with scape and pedicel subcylindrical, with well-developed distolateral process at scape.

Labrum (Fig. 23a). Rectangular, length 0.8 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 9–12 long, feathered setae. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. eight short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 23b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex. Tuft of setae at apex of mola present.

Left mandible (Fig. 23d, e). Incisor and kinetodontium fused. Incisor with four denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola slightly

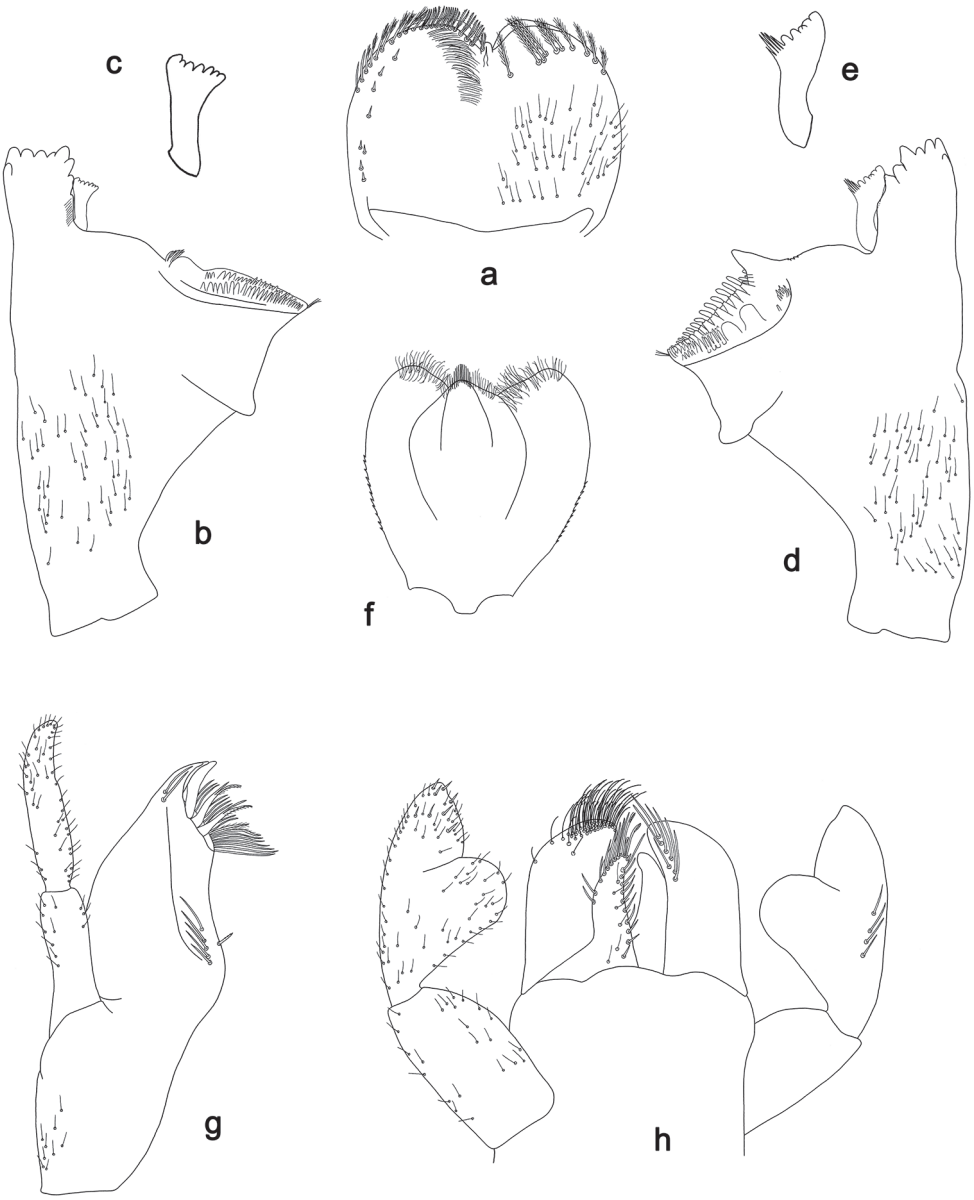

Figure 23. *Labiobaetis valdezorum* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium.

convex, with minute denticles toward subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 23f). Lingua shorter than superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 23g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and five medium to long, simple setae. Maxillary palp slightly longer than length of galea-lacinia; 2-segmented; palp segment II 1.4 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

Labium (Fig. 23h). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. ten spine-like setae increasing in length distally; apex with two long and one medium, robust, pectinate setae and one short, robust seta; outer margin with eight long, spine-like setae; ventral surface with short, fine, simple and short, spine-like setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and one medium, simple seta in anteromedial area; dorsally with a row of six or seven long, spine-like, simple setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with broad thumb-like distomedial protuberance; distomedial protuberance 0.6 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of three or four spine-like, simple setae near outer margin. Segment III conical; apex slightly pointed; length subequal to width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 24g) well developed.

Foreleg (Fig. 24a, b). Ratio of foreleg segments 1.2:1.0:0.6:0.2. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with a row of 12–15 curved, spine-like setae, sometimes a few additional setae near margin in basal area; length of setae 0.14 × maximum width of femur. Apex rounded, with a pair of spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like setae, on apex one longer, spine-like seta. Ventral margin with a row of mainly short, spine-like setae, on apex some longer and partly bipectinate setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus.*** Dorsal margin with a row of short, stout setae. Ventral margin with a row of curved, spine-like setae and in distal area fine simple setae. Claw with one row of eleven or twelve denticles; with ca. six stripes; subapical setae absent.

Terga (Fig. 24c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 24d). Present on segments I–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer

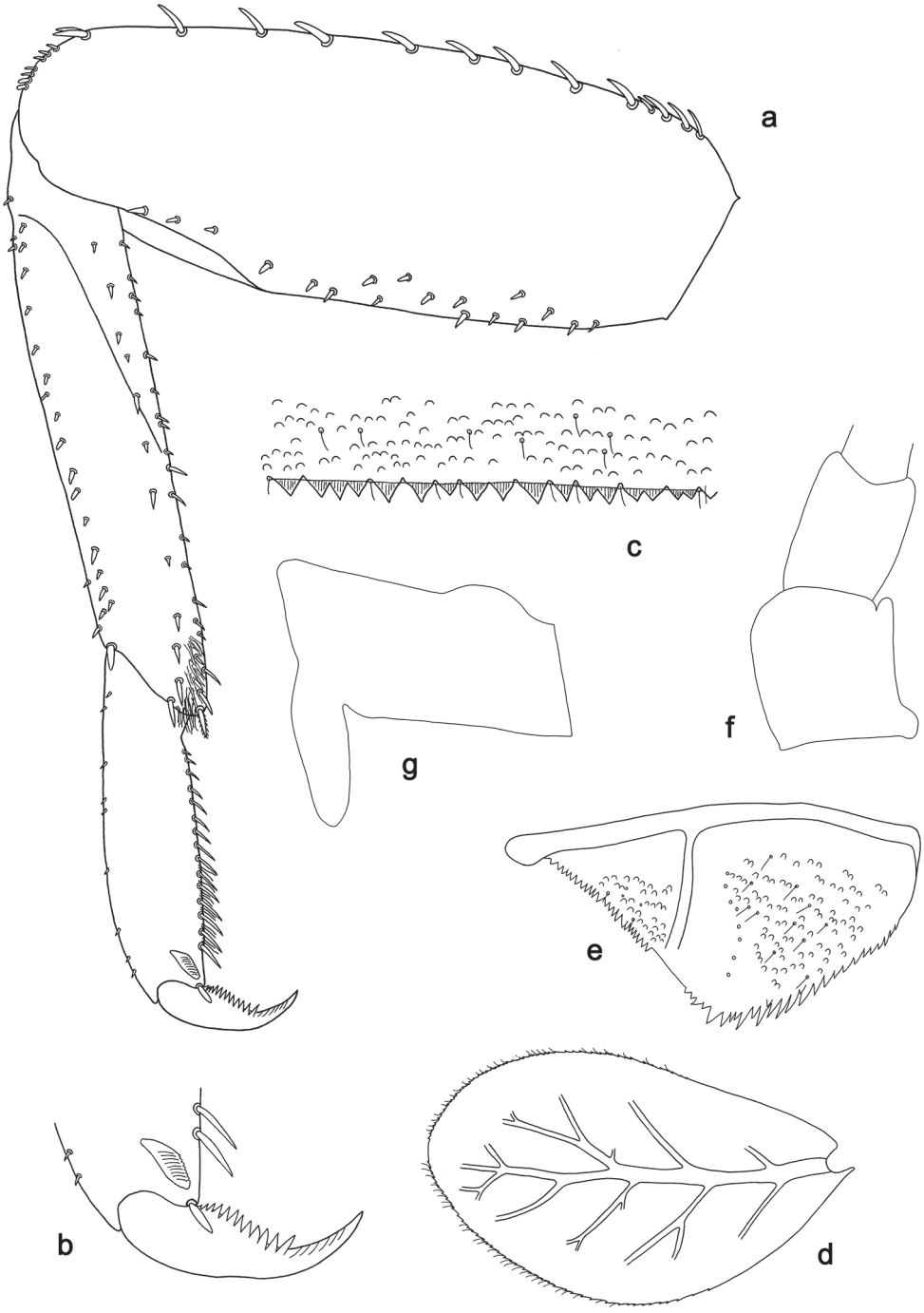

Figure 24. *Labiobaetis valdezorum* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum.

margins. Gill I as long as length of segment II. Gill IV as long as length of segments V and half of VI combined. Gill VII as long as length of segment VIII.

Paraproct (Fig. 24e). Distally not expanded, with 23–32 stout, marginal spines and some submarginal spines. Surface scattered with U-shaped scale bases and fine, simple setae. Cercotractor with numerous small, marginal spines, apically pointed.

Etymology. Dedicated to Dr. Emma Aguada Valdez, Mr. Rolando Valdez and Mr. Francis Paolo Valdez for their generous help and support in the scientific projects of the AdMU Biodiversity Laboratory.

Distribution. Philippines: Negros and Cebu (Fig. 49a).

Biological aspects. The specimens were collected at altitudes from 150 m to 480 m, on bottom gravel or submerged wood in runs or riffles.

Type material. ***Holotype*****.** Philippines • larva; Negros Oriental, Valencia, Casaroro River downstream; 09°18'N, 123°14'E; 150 m; 01.IX.2019; leg. Garces and Pelingen; on slide; GenBank. MT830963; GBIFCH 00654888; PNM. ***Paratypes*****.** Philippines • 24 larvae; same data as holotype; 3 on slides; GenBank. MT830965, MT830966; GBIFCH 00654879, GBIFCH 00592277, GBIFCH 00654880; ZSM; 1 on slide; GenBank: MT830964; GBIFCH 00654882; AdMU; 7 in alcohol; GBIFCH 00515419; ZSM; 13 in alcohol; GBIFCH 00515418, GBIFCH 00515420; AdMU • 1 larva; Negros Oriental, Valencia, Apolong, Casaroro River upstream; 09°17'N, 123°13'E; 470 m; 01.IX.2019; leg. Garces and Pelingen; in alcohol; GBIFCH 00515421; ZSM • 15 larvae; Cebu, Cebu City, Lusaran; 10°28'13"N, 123°52'26"E; 200 m; 16.IX.1996; leg. Mendoza; 1 on slide; GenBank: MT830967; GBIFCH 00763671; ZSM; 10 in alcohol; GBIFCH 00515422, GBIFCH 00515423, GBIFCH 00515424; AdMU; 4 in alcohol; GBIFCH 00515425; ZSM.

Labiobaetis wantzeni sp. nov.

http://zoobank.org/1651E9BC-B331-4AB0-85C3-8BFB5746B3EC
Figures 25, 26, 44b, 49a

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus 7–10 long, feathered setae; B) labial palp segment II with a broad, thumb-like distomedial protuberance, segment III conical; C) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with a row of ca. 18 curved, spine-like setae; D) claw with 10–13 denticles; E) hind protoptera medium developed; F) paraproct distally not expanded, with ca. 30 stout marginal spines.

Description. Larva (Figs 25, 26, 44b). Body length 5.2–7.1 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. 2.5 × as long as head length.

Colouration**.** Head dorsally light brown, thorax and abdomen dorsally mainly dark brown with pattern as in Fig. 44b, abdominal segments I, VI, and X light brown; fore protoptera basally dark brown, distally light brown with bright striation. Head, thorax, and abdomen ventrally mainly light brown, genae dark brown, abdominal seg-

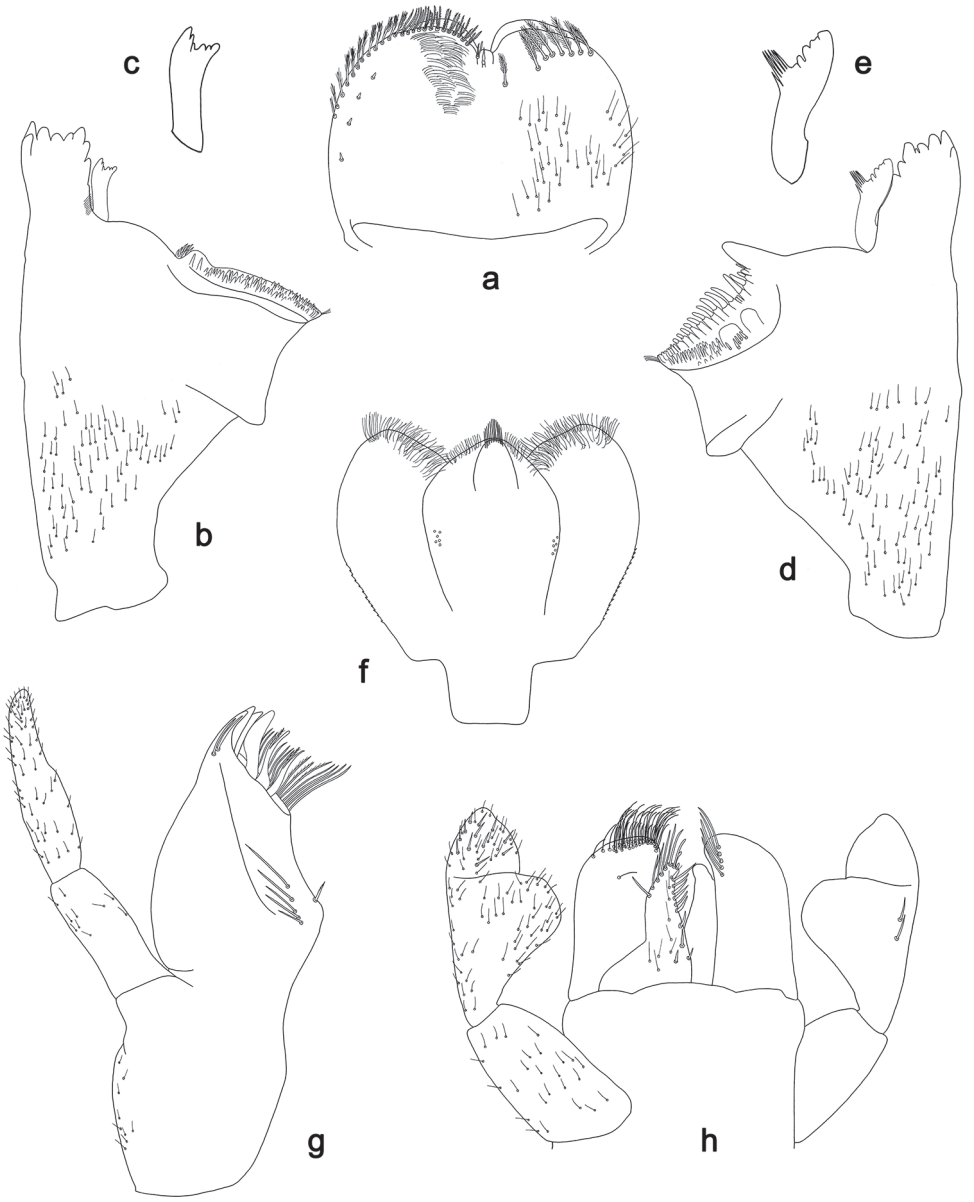

Figure 25. *Labiobaetis wantzeni* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium.

ments laterally with darker areas and abdominal segments VII–IX dark brown. Legs light brown, femur with distomedial and apical dark brown spots, tibia distally with dark brown area. Caudalii light brown with a brown band at ca. 1/3 of cerci length, cerci distally brown.

Antenna (Fig. 26f) with scape and pedicel subcylindrical, with well-developed distolateral process at scape.

Labrum (Fig. 25a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 7–10 long, feathered setae. Ventrally with marginal row of setae composed of lateral and anterolateral long, feathered setae and medial long, bifid, pectinate setae; ventral surface with ca. four short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 25b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex. Tuft of setae at apex of mola present.

Left mandible (Fig. 25d, e). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola slightly convex. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 25f). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, short; distal half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 25g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and five medium to long, simple setae. Maxillary palp 1.2 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.5 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with excavation at inner distolateral margin.

Labium (Fig. 25h). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. 8 spine-like setae increasing in length distally; apex with two long, one medium and one short, robust setae; outer margin with five long, spine-like setae; ventral surface with short, fine, simple and short, spine-like setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and one or two medium, simple setae in anteromedial area; dorsally with a row of five long, spine-like, simple setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with broad thumb-like distomedial protuberance; distomedial protuberance 0.5 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with two or three spine-like, simple setae near outer margin. Segment III conical; apex rounded; length 0.9 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera (Fig. 26g, h) medium to well developed.

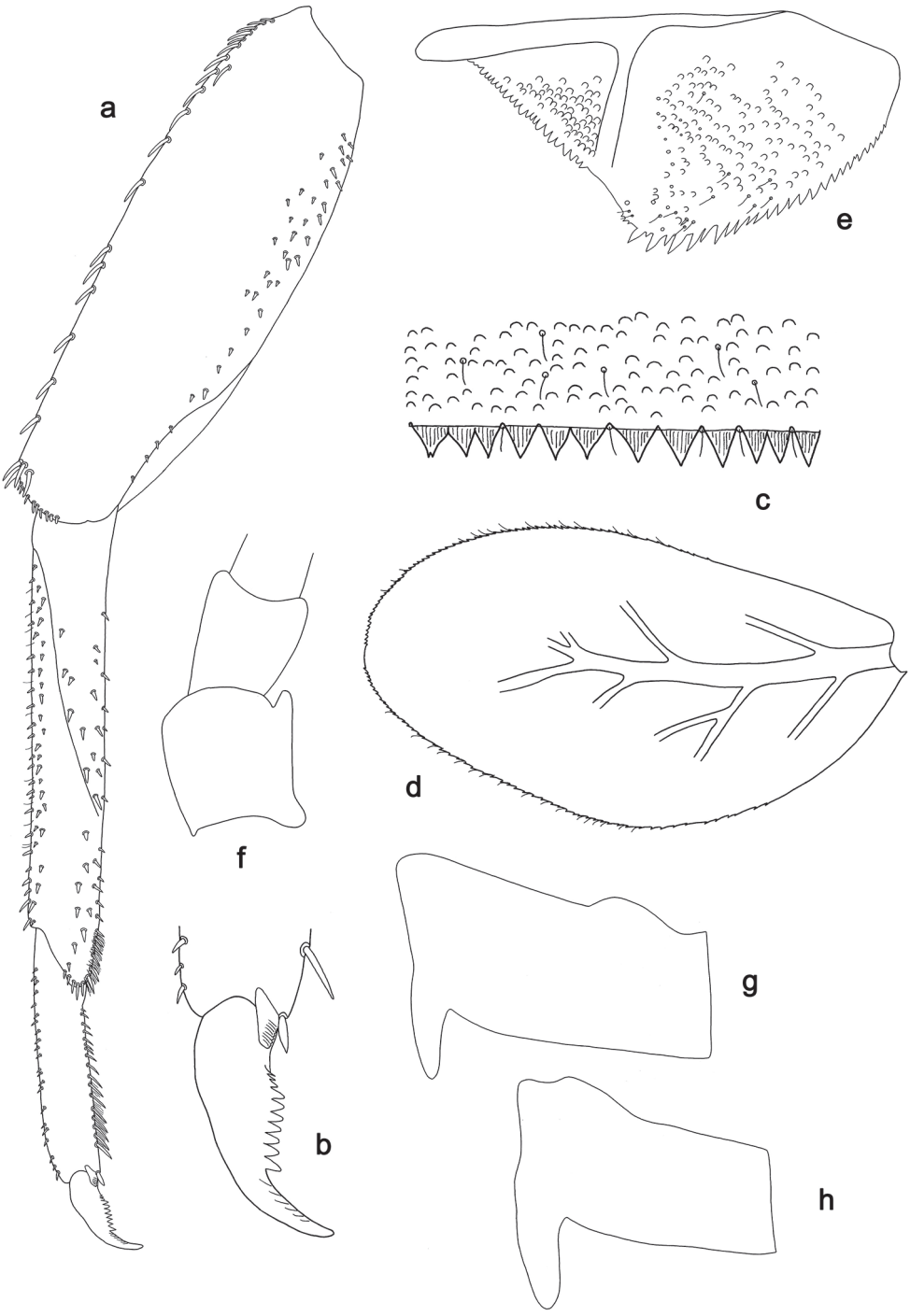

Figure 26. *Labiobaetis wantzeni* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape **g** metanotum **h** metanotum.

Foreleg (Fig. 26a, b). Ratio of foreleg segments 1.3:1.0:0.5:0.2. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with a row of 15–18 curved, spine-like setae, sometimes a few extra setae basally near margin; length of setae 0.14 × maximum width of femur. Apex rounded, with one or two pairs of spine-like setae and some short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like setae and fine, simple setae, near margin another row of short, spine-like setae. Ventral margin with a row of short, spine-like setae, on apex some longer spine-like setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 2/3. ***Tarsus.*** Dorsal margin with a row of short, stout setae. Ventral margin with a row of curved, spine-like setae and in distal area fine simple setae. Claw with one row of 10–13 denticles; distally pointed; with ca. six stripes; subapical setae absent.

Terga (Fig. 26c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular spines, mainly longer than wide.

Gills (Fig. 26d). Present on segments I–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill I ca. 2/3 length of segment II. Gill IV as long as length of segments V and half VI combined. Gill VII as long as length of segments VIII and 1/4 IX combined.

Paraproct (Fig. 26e). Distally not expanded, with ca. 30 stout, marginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Prof. Karl Matthias Wantzen (France), collector of some material, for his outstanding contribution to freshwater ecological research and conservation.

Distribution. Philippines: Camiguin and Mindanao (Fig. 49a).

Biological aspects. The specimens were collected at altitudes from sea level to 900 m, on bottom gravel, submerged wood, leaf packs or grass bunches in runs or riffles.

Type material. ***Holotype.*** Philippines • larva; Camiguin, Sagay, Bonbon, lower Binangawan River; 09°06'39"N 124°43'45"E; 30 m; 09.XII.2018; leg. Freitag and Wantzen; on slide; GenBank: MT830968; GBIFCH 00654898; PNM. ***Paratypes.*** Philippines • 8 larvae; same data as holotype; 3 on slides; GenBank: MT830973, MT830969, MT830972; GBIFCH 00654900, GBIFCH 00654897, GBIFCH 00654896; ZSM; 1 on slide; GBIFCH 00592276; AdMU; 2 in alcohol; GBIFCH 00515412, GBIFCH 00515413; AdMU; 2 in alcohol; GBIFCH 00515416, GBIFCH 00515417; ZSM • 2 larvae; Camiguin, Looc /Tuasan R, ca. 9.5 km SE Mambajao; 09°12'N, 124°41'E; 240 m; 08.XII.2018; leg. Freitag; 1 on slide; GBIFCH 00515522; AdMU; 1 on slide; GenBank: MT830970; GBIFCH 00763641; ZSM • 1 larva; Camiguin, Mt. Mabajao Sagay, upstream Binangawan Falls; 09°09'25"N, 124°43'57"E; 900 m; 09.XII.2018; leg. Freitag; in alcohol; GBIFCH 00515414; AdMU • 7 larvae; Mindanao, Ozamis, Tangub, Labo River; 08°09'42"N, 124°42'28"E; 470 m; 13.IV.1994; leg. Mendoza; 1 on slide; GenBank: MT830971; GBIFCH 00763642; ZSM; 6 in alcohol; GBIFCH 00515415; AdMU.

Labiobaetis sumigarensis group of species (Kaltenbach and Gattolliat 2019)

Following combination of characters: A) dorsal surface of labrum with submarginal arc of clavate, apically smooth setae; B) labial palp segment II with large, lobed or thumb-like distomedial protuberance, outer margin of protuberance predominantly concave (sometimes with hook-like modification of the protuberance); C) left mandible without setae at apex of mola, with minute denticles between prostheca and mola; D) six pairs of gills; E) hind protoptera absent; F) distolateral process at scape poorly developed or absent; G) patellotibial suture short, on basal 1/3 area of tibia; H) colour of larvae dorsally uniform brown.

***Labiobaetis molawinensis* (Müller-Liebenau, 1982)**

Figures 27, 49b

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of ca. 15 clavate setae; B) labial palp segment II with a large, lobed distomedial protuberance, segment III slightly pentagonal, apically slightly truncate; C) left mandible without setae at apex of mola; D) fore femur rather slender, length 3.6 × maximum width, dorsal margin with a row of ca. ten curved, spine-like

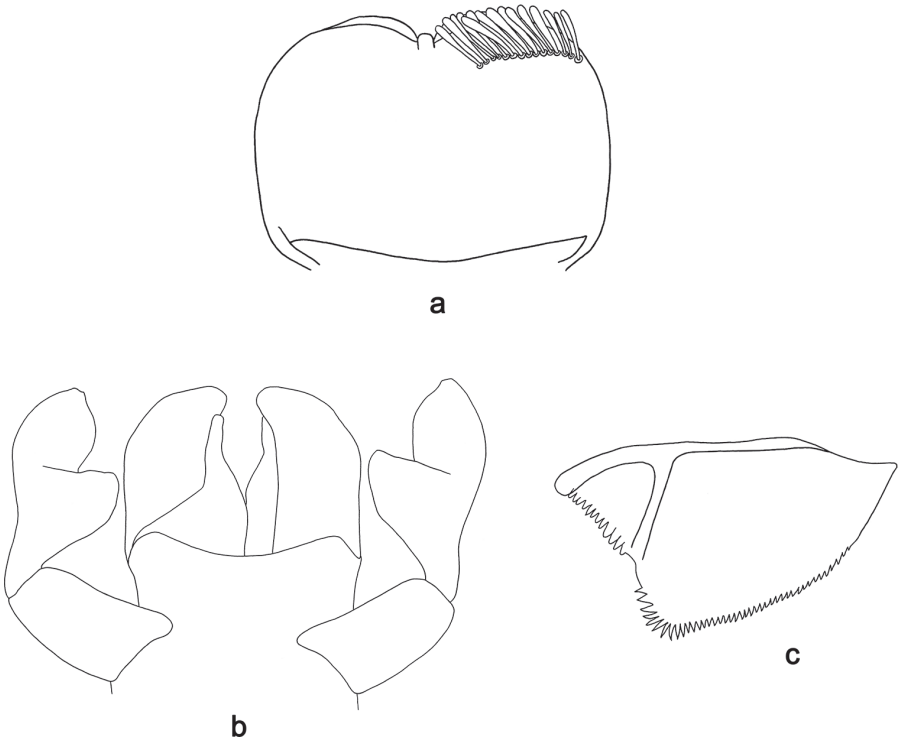

Figure 27. *Labiobaetis molawinensis*, larva morphology **a** labrum **b** labium **c** paraproct.

setae; E) tarsal claw with ca. eleven denticles; F) paraproct distally not expanded, with > 40 stout marginal spines.

Examined material. ***Paratype*.** Philippines • 1 larva; rapids, Molawin Creek, college, Laguna; 28.VII.1977; leg. C.R. Realon; Coll. Pescador; on slide; ZSM.

Other material. Philippines • 1 larva; Luzon, Laguna, Los Banos, UP Campus, Molawin River; 14°10'05"N, 121°11'44"E; 29.IX.1998; leg. Mendoza; on slide; GBIFCH 00654910; AdMU • 1 larva; Luzon, Laguna, Samil River; 14°08'N, 121°31'E; 27.VI.2018; 370 m; leg. Freitag et al.; on slide; GBIFCH 00654912; ZSM • 1 larva; Luzon, Aurora, Baler, Cemento, rocky coast; 15°45'21"N, 121°34'46"E; 0 m; 04.II.1998; leg. Mendoza; on slide; GBIFCH 00654892; AdMU.

Labiobaetis sumigarensis (Müller-Liebenau, 1982)

Figures 28, 49b

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of ca. 26 clavate setae; B) labial palp segment II with a hook-like

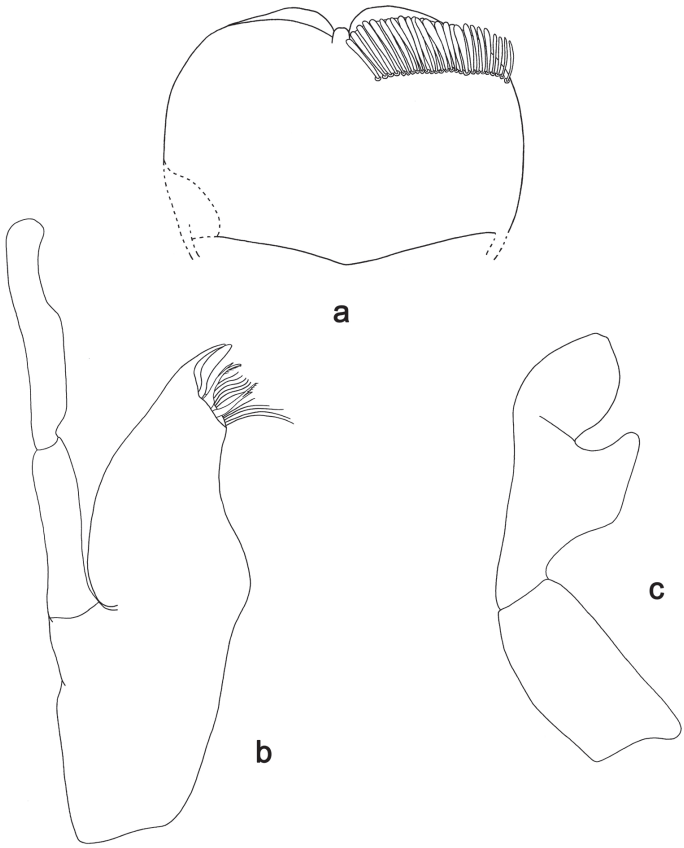

Figure 28. *Labiobaetis sumigarensis*, larva morphology **a** labrum **b** maxilla **c** labial palp.

distomedial protuberance, segment III slightly pentagonal, apically slightly pointed; C) left mandible without setae at apex of mola; D) fore femur rather broad, length 3.4 × maximum width, dorsal margin with ca. 15 curved, spine-like setae; E) tarsal claw with ca. ten denticles; F) paraproct slightly expanded, with 35–39 stout marginal spines, some with split tips.

Examined material. ***Holotype.*** Philippines • 1 larva; Mountain Prov., Sumigar Stream, Sumigar, Banaue; 03.X.1967; leg. Pescador; on slide; ZSM.

Other material. Philippines • 1 larva; Luzon, Ifugao, Banaue, Sumigar Bridge; 16°59'37"N, 121°02'51"E; 1700 m; IX.1997; leg. Mey; on slide; GBIFCH 00592357; AdMU.

Labiobaetis baganii **sp. nov.**
http://zoobank.org/69A8B24A-CED0-4E1A-AC2D-59D31B156558
Figures 29, 30, 44c, 49b

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of 17–21 long, clavate setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III slightly pentagonal; C) left mandible without setae at apex of mola; D) fore femur rather slender, length ca. 4 × maximum width, dorsal margin with 8–11 curved, spine-like setae; E) paraproct distally expanded, with 39–43 stout, marginal spines.

Description. Larva (Figs 29, 30, 44c). Body length 3.1–5 mm. Cerci ca. 1/2 of body length. Paracercus: ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

Colouration. Head, thorax, and abdomen dorsally brown, thorax with pattern as in Fig. 44c, fore protoptera brown. Head, thorax, and abdomen ventrally light brown. Legs light brown, femur with a brown distomedial spot connected to a brown streak along ventral margin, apex brown. Caudalii light brown.

Antenna (Fig. 30f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 29a, b). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium to long, fine, simple setae scattered over surface; submarginal arc of setae composed of 17–21 long, clavate setae. Ventrally with marginal row of setae composed of anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. five short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 29c, d). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex, with minute denticles. Tuft of setae at apex of mola present.

Left mandible (Fig. 29e, f). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight,

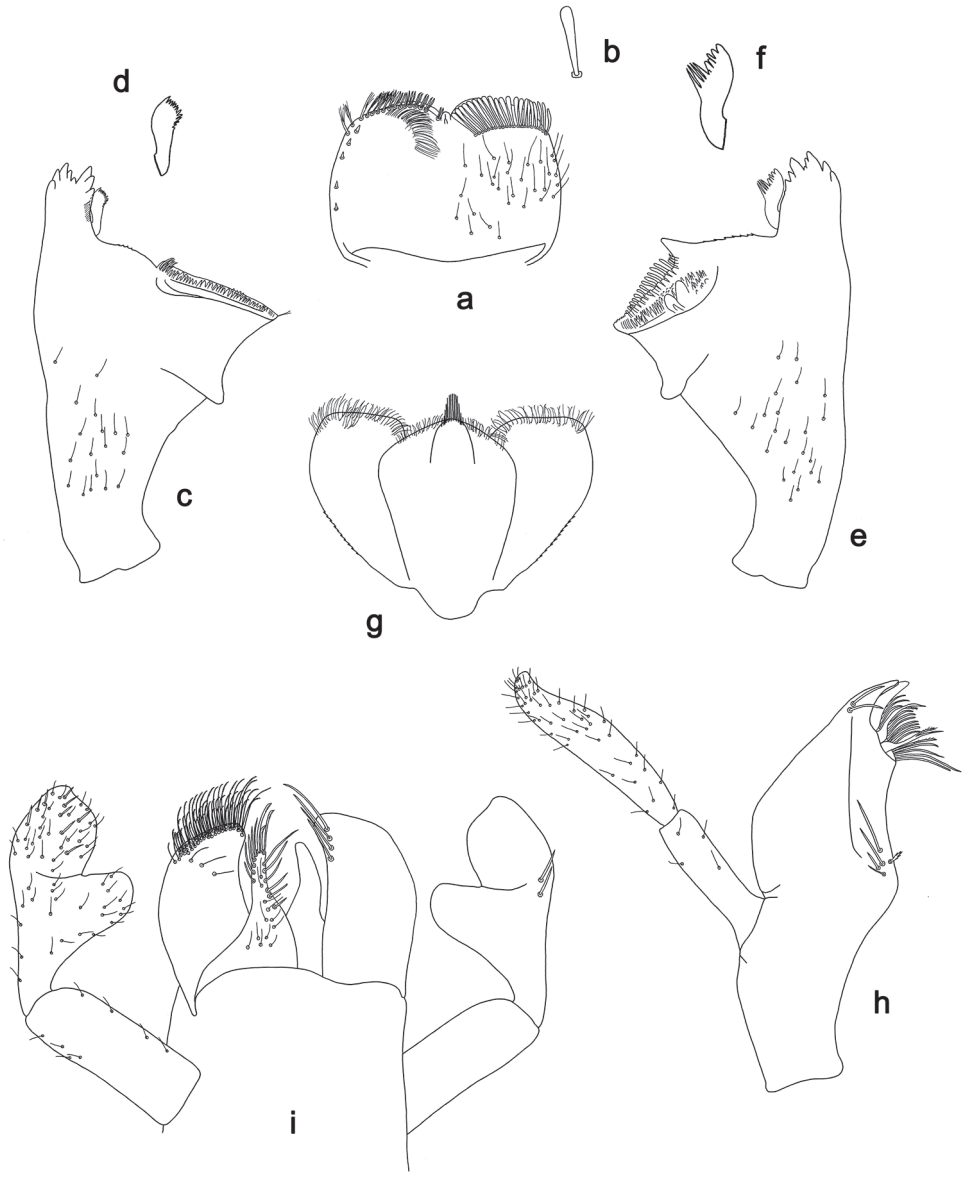

Figure 29. *Labiobaetis baganii* sp. nov., larva morphology **a** labrum **b** seta of arc on dorsal surface of labrum **c** right mandible **d** right prostheca **e** left mandible **f** left prostheca **g** hypopharynx and superlinguae **h** maxilla **i** labium.

with minute denticles towards subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola absent.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 29g). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed; distal half laterally expanded. Superlinguae distally straight; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 29h). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and three or four medium to long, simple setae. Maxillary palp 1.4 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.5 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with excavation at inner distolateral margin.

Labium (Fig. 29i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with six spine-like setae increasing in length distally; apex with two long and one medium, robust, pectinate setae; outer margin with five spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and a row of three or four medium, simple setae in anteromedial area; dorsally with a row of four long, spine-like, simple setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.7 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with two long, spine-like, simple setae near outer margin. Segment III slightly pentagonal; apex rounded; length 1.3 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera absent.

Foreleg (Fig. 30a, b). Ratio of foreleg segments 1.1:1.0:0.4:0.1. ***Femur.*** Length ca. 4 × maximum width. Dorsal margin with 8–11 long, curved, spine-like setae; length of setae 0.24 × maximum width of femur. Apex rounded, with a pair of long, curved, spine-like setae and one or two short, stout setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of short, spine-like setae, on apex one longer, spine-like seta. Ventral margin with a row of short, curved, spine-like setae, on apex some longer, partly bipectinate setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 1/3. ***Tarsus.*** Dorsal margin with some fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of ten or eleven denticles; distally pointed; with ca. three stripes; subapical setae absent.

Terga (Fig. 30c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 30d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and half VI combined. Gill VII little longer than length of segment VIII.

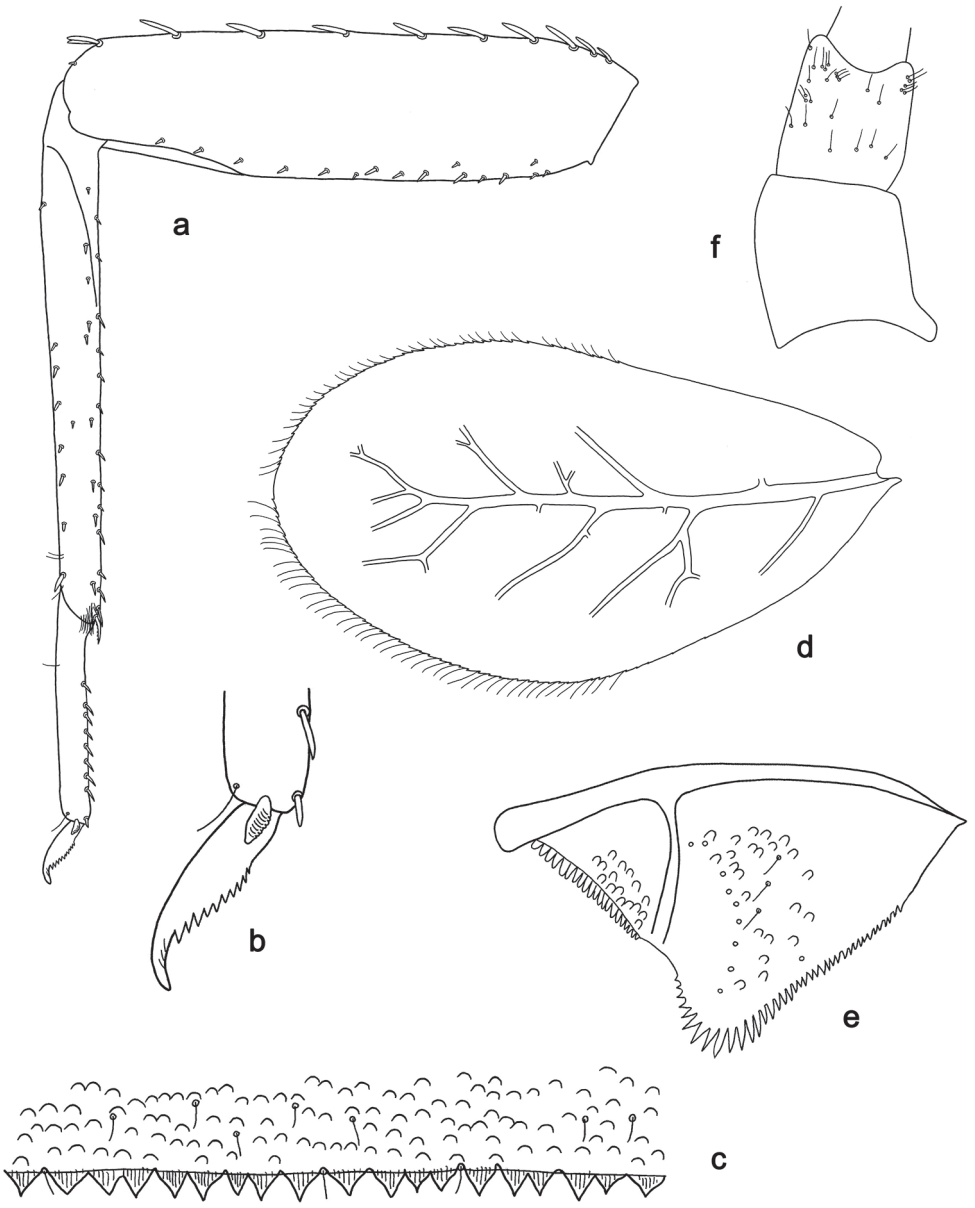

Figure 30. *Labiobaetis baganii* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape.

Paraproct (Fig. 30e). Distally expanded, with 39–43 stout, marginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Mr. Bagani Sularte (Philippines), outstanding illustrator and friend of one of the authors (JG), for support in her dissertation work.

Distribution. Philippines: Mindanao and Camiguin (Fig. 49b).

Biological aspects. The specimens were collected at altitudes from sea level to 660 m, mainly in submerged wood or leaf packs in the runs.

Type material. ***Holotype*.** Philippines • larva; Mindanao, Agusan N, Cabadbaran River; 09°10'15"N, 125°40'55"E; 240 m.; 03.VI.2018; leg. Freitag and Pangantihon; on slide; GenBank: MT830974; GBIFCH 00654895; PNM. ***Paratypes*.** Philippines • 2 larvae; same data as holotype; 1 on slide; GBIFCH 00592303; ZSM; 1 in alcohol; GBIFCH 00515483; AdMU • 1 larva; Mindanao, Agusan del Sur, San Francisco, Bayogan, Tagkunayan Creek; 08°28'N, 125°59'E; 120 m; 05.II.1998; leg. Mendoza; on slide; GBIFCH 00592317; AdMU • 1 larva; Mindanao, Agusan del Norte, Jabonga, Creek upstream of village near Mainit; 09°20'40"N, 125°30'50"E; 50 m; 02.IV.2019, leg. Freitag; in alcohol; GBIFCH 00515484; ZSM • 1 larva; Mindanao, Agusan N, Cabadbaran, Del Pilar, Payas River; 09°11'34"N, 125°36'34"E; 660 m; 23.VI.2018; leg. Pangantihon; in alcohol; GBIFCH 00515485; ZSM • 15 larvae; Camiguin, Sagay, Bonbon, lower Binangawan River; 09°06'39"N 124°43'45"E; 30 m; 09.XII.2018; leg. Freitag and Wantzen; 2 on slides; GenBank: MT830975; GBIFCH 00654899, GBIFCH 592326; ZSM; 2 in alcohol; GBIFCH 00515486, GBIFCH 00515488; AdMU; 11 in alcohol; GBIFCH 515487; AdMU.

***Labiobaetis delocadoi* sp. nov.**

http://zoobank.org/61631C84-8BAE-4C88-8CDE-AC051839D419

Figures 31, 32, 44d, 49b

Diagnosis. Larva. Following combinations of characters: A) dorsal surface of labrum with submarginal arc of 16–19 long, clavate setae; B) labial palp segment II with a hook-like distomedial protuberance, segment III slightly pentagonal; C) left mandible without setae at apex of mola; D) fore femur rather slender, length ca. 4 × maximum width, dorsal margin with ca. eleven curved, spine-like setae; E) paraproct distally expanded, with 36–39 stout, marginal spines.

Description. Larva (Figs 31, 32, 44d). Body length 3.2–4.6 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

***Colouration*.** Head, thorax, and abdomen dorsally light brown, fore protoptera light brown with bright striation. Head, thorax, and abdomen ventrally light brown. Legs light brown, femur with a distomedial brown spot and a brown streak at dorsal margin, apex brown, tibia darker in distomedial area. Caudalii light brown, with a brown band at ca. 1/2 of cerci length.

Antenna (Fig. 32f) with scape and pedicel subcylindrical, with very poorly developed distolateral process at scape.

Labrum (Fig. 31a, b). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of 16–19 long, clavate

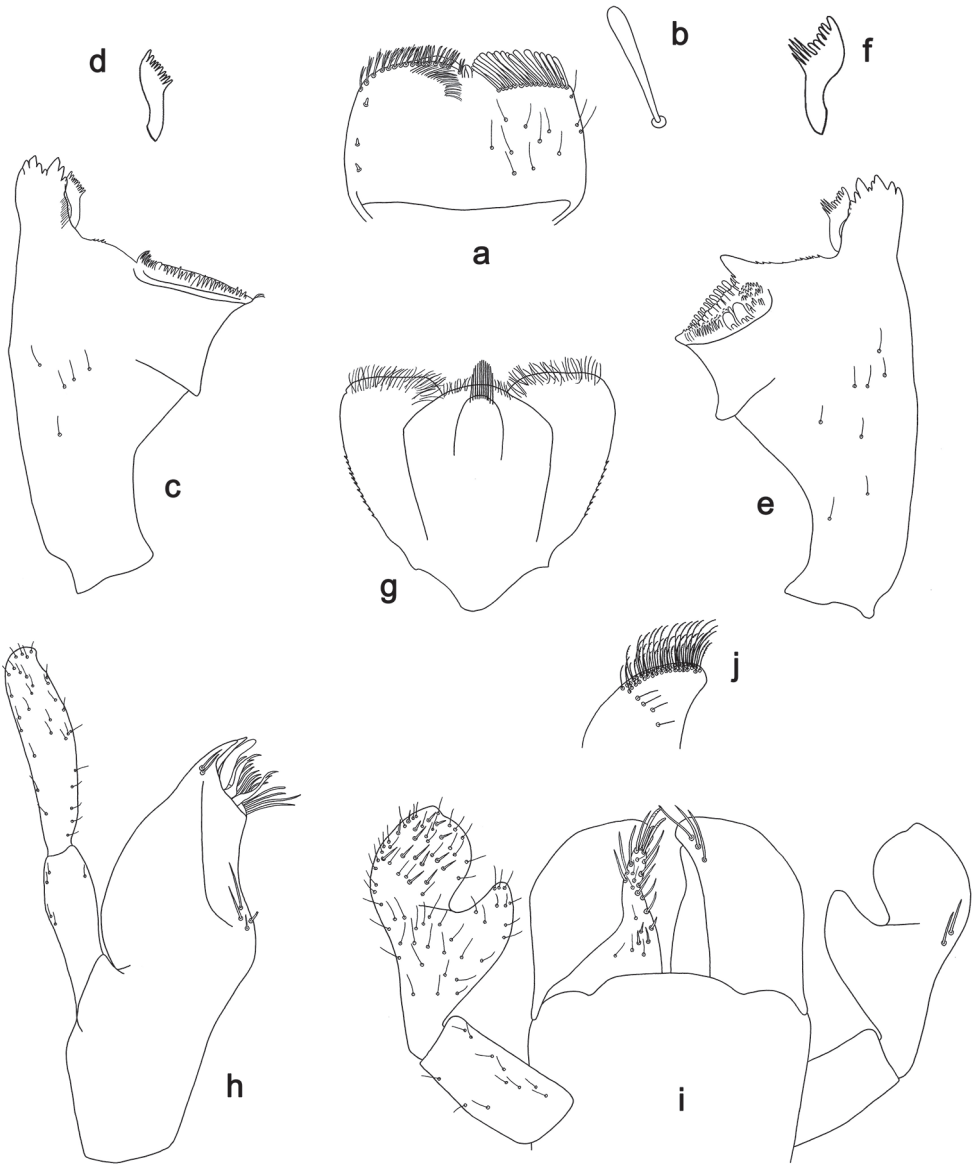

Figure 31. *Labiobaetis delocadoi* sp. nov., larva morphology **a** labrum **b** seta of arc on dorsal surface of labrum **c** right mandible **d** right prostheca **e** left mandible **f** left prostheca **g** hypopharynx and superlinguae **h** maxilla **i** labium **j** apex of paraglossa.

setae. Ventrally with marginal row of setae composed of anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. three short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 31c, d). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with

a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex, with minute denticles. Tuft of setae at apex of mola present.

Left mandible (Fig. 31e, f). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight, with minute denticles towards subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola absent.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 31g). Lingua shorter than superlinguae. Lingua longer than broad; medial tuft of stout setae well developed; distal half laterally expanded. Superlinguae distally straight; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 31h). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and three or four medium to long, simple setae. Maxillary palp 1.3 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.6 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

Labium (Fig. 31i, j). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. seven spine-like setae increasing in length distally; apex with two long and one medium, robust, pectinate setae; outer margin with four or five long, spine-like setae; ventral surface with short, fine, simple and short, spine-like setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and a row of four medium, simple setae in anteromedial area; dorsally with a row of three long, spine-like setae near inner margin. Labial palp with segment I 0.6 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with hook-like distomedial protuberance; distomedial protuberance 0.8 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with one or two long, spine-like setae near outer margin. Segment III slightly pentagonal; apex slightly pointed; length 1.3 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera absent.

Foreleg (Fig. 32a, b). Ratio of foreleg segments 1.1:1.0:0.4:0.2. ***Femur.*** Length ca. 4 × maximum width. Dorsal margin with ten or eleven long, curved, spine-like setae; length of setae 0.28 × maximum width of femur. Apex rounded, with a pair of long, curved, spine-like setae and one or two short, stout setae and some fine, simple setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a partial row of short, spine-like setae and a row of fine, simple setae, on apex one longer, spine-like seta. Ventral margin with a row of short,

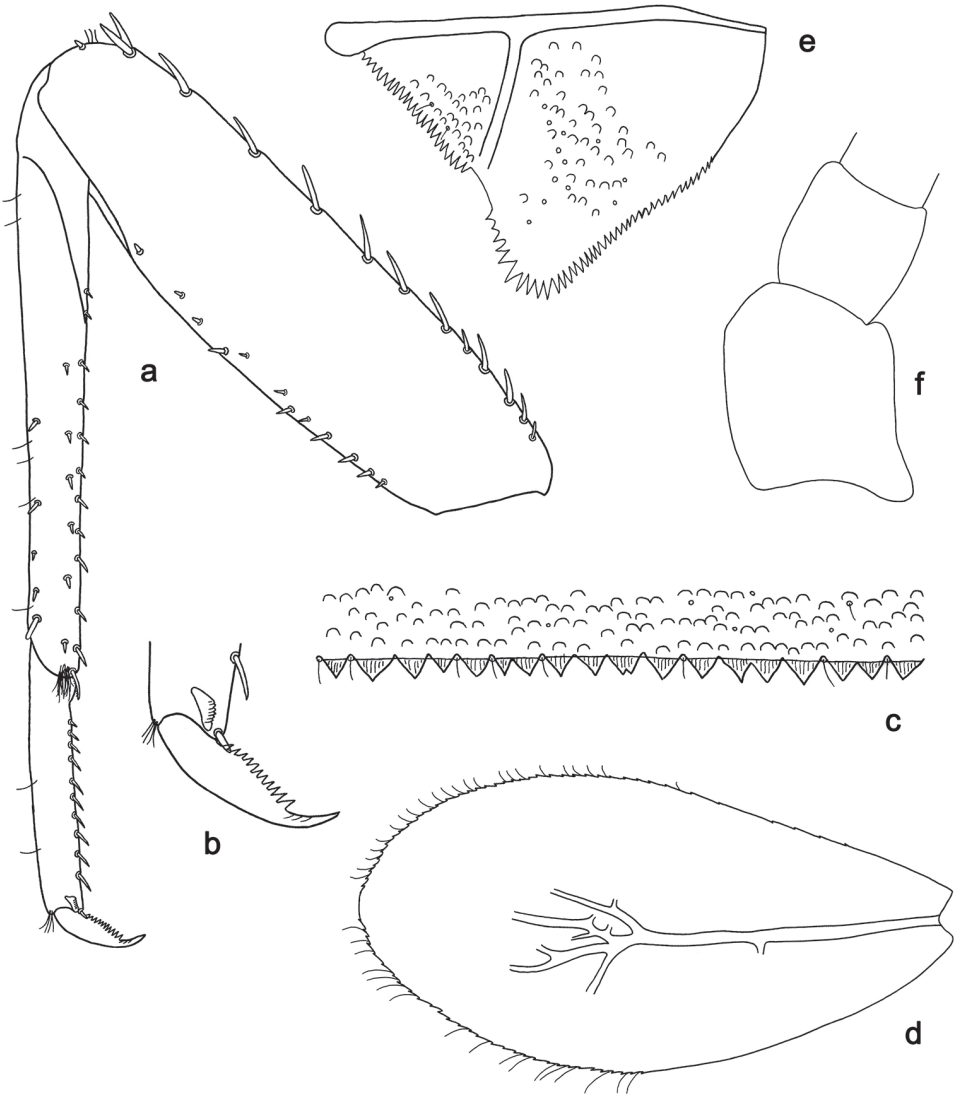

Figure 32. *Labiobaetis delocadoi* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape.

curved, spine-like setae, on apex one longer, bipectinate, spine-like seta and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 1/3. ***Tarsus.*** Dorsal margin with some fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 11–13 denticles; distally pointed; with ca. three stripes; subapical setae absent.

Terga (Fig. 32c). Surface with irregular rows of U-shaped scale bases and scattered fine, simple setae and micropores. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 32d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae partly extending from main trunk towards outer and inner margins. Gill IV as long as length of segments V and 1/3 VI combined. Gill VII little longer than length of segment VIII.

Paraproct (Fig. 32e). Distally expanded, with 36–39 stout, marginal spines. Surface scattered with U-shaped scale bases and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Mr. Emmanuel Delocado (Philippines), entomologist and member of the AdMU Biodiversity Laboratory.

Distribution. Philippines: Cebu and Leyte (Fig. 49b).

Biological aspects. The specimens were collected at altitudes of 50 m and 700 m, partly on rock surface in riffles or runs.

Type material. ***Holotype*.** Philippines • larva; Cebu, Cantipla; 10°24'55"N, 123°49'05"E; 750 m; 30.X.1995; leg. Mendoza; on slide; GenBank: MT830976; GBIFCH 00654886; PNM. ***Paratypes*.** Philippines • 2 larvae; same data as holotype; 1 on slide; GBIFCH 00592307; ZSM; 1 in alcohol; GBIFCH 00515451; AdMU • 86 larvae; Leyte, Southern Leyte, Brgy. Malico, San Francisco, Taglibas River; 10°01'07"N, 125°12'35'E; 50 m; 19–20.X.2019; leg. Garces and Pelingen; 1 on slide; MT830977; GBIFCH 00763668; AdMU; 6 in alcohol; GBIFCH 00515467; ZSM; 79 in alcohol; GBIFCH 00515494; AdMU.

***Labiobaetis freitagi* sp. nov.**

http://zoobank.org/2BC2CBB7-4E28-423E-B02D-6CB35711BDCC

Figures 33, 34, 45a, 49b

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of ca. 17 long, clavate setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III sub-rectangular; C) left mandible without setae at apex of mola; D) fore femur rather slender, length 3.6 × maximum width, dorsal margin with ca. ten curved, spine-like setae; E) paraproct distally expanded, with 39–46 stout, marginal spines.

Description. Larva (Figs 33, 34, 45a). Body length 3.1–4.8 mm. Cerci ca. 2/3 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

***Colouration*.** Head, thorax, and abdomen dorsally light brown, fore protoptera light brown with bright striation. Head, thorax, and abdomen ventrally light brown, genae brown. Legs light brown, femur with a distomedial brown spot, dorsal and ventral margin and apex brown. Caudalii light brown.

Antenna (Fig. 34g) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 33a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium to long, fine,

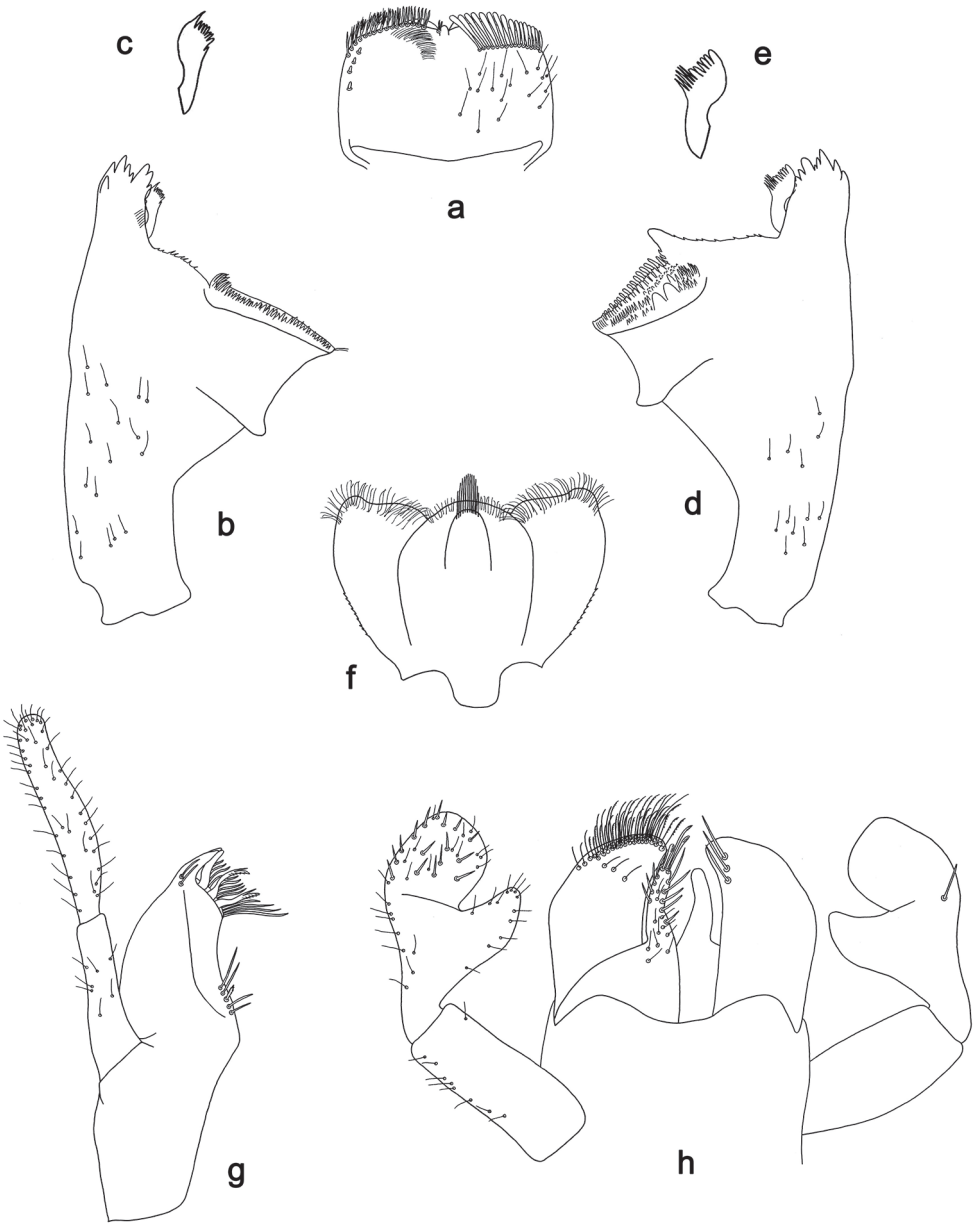

Figure 33. *Labiobaetis freitagi* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium.

simple setae scattered over surface; submarginal arc of setae composed of 16 or17 long, clavate setae. Ventrally with marginal row of setae composed of anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. four short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 33b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex, with minute denticles. Tuft of setae at apex of mola present.

Left mandible (Fig. 33d, e). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight, with minute denticles towards subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola absent.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 33f). Lingua shorter than superlinguae. Lingua longer than broad; medial tuft of stout setae well developed; distal half laterally expanded. Superlinguae distally slightly concave; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 33g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and four medium to long, simple setae. Maxillary palp 1.7 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.5 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

Labium (Fig. 33h). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. five spine-like setae increasing in length distally; apex with two long and one medium, robust, pectinate setae; outer margin with four spine-like setae; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and a row of three or four medium, simple setae in anteromedial area; dorsally with a row of three long, spine-like setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.8 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with one long, spine-like seta near outer margin. Segment III subrectangular; apex rounded; length 1.0 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera absent.

Foreleg (Fig. 34a–c). Ratio of foreleg segments 1.2:1.0:0.6:0.2. ***Femur.*** Length ca. 4 × maximum width. Dorsal margin with ten or eleven long, curved, spine-like setae; length of setae 0.25 × maximum width of femur. Apex rounded, with a pair of long, curved, spine-like setae and some short stout and fine, simple setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin sometimes with a row of spine-like setae and always with a row of fine, simple

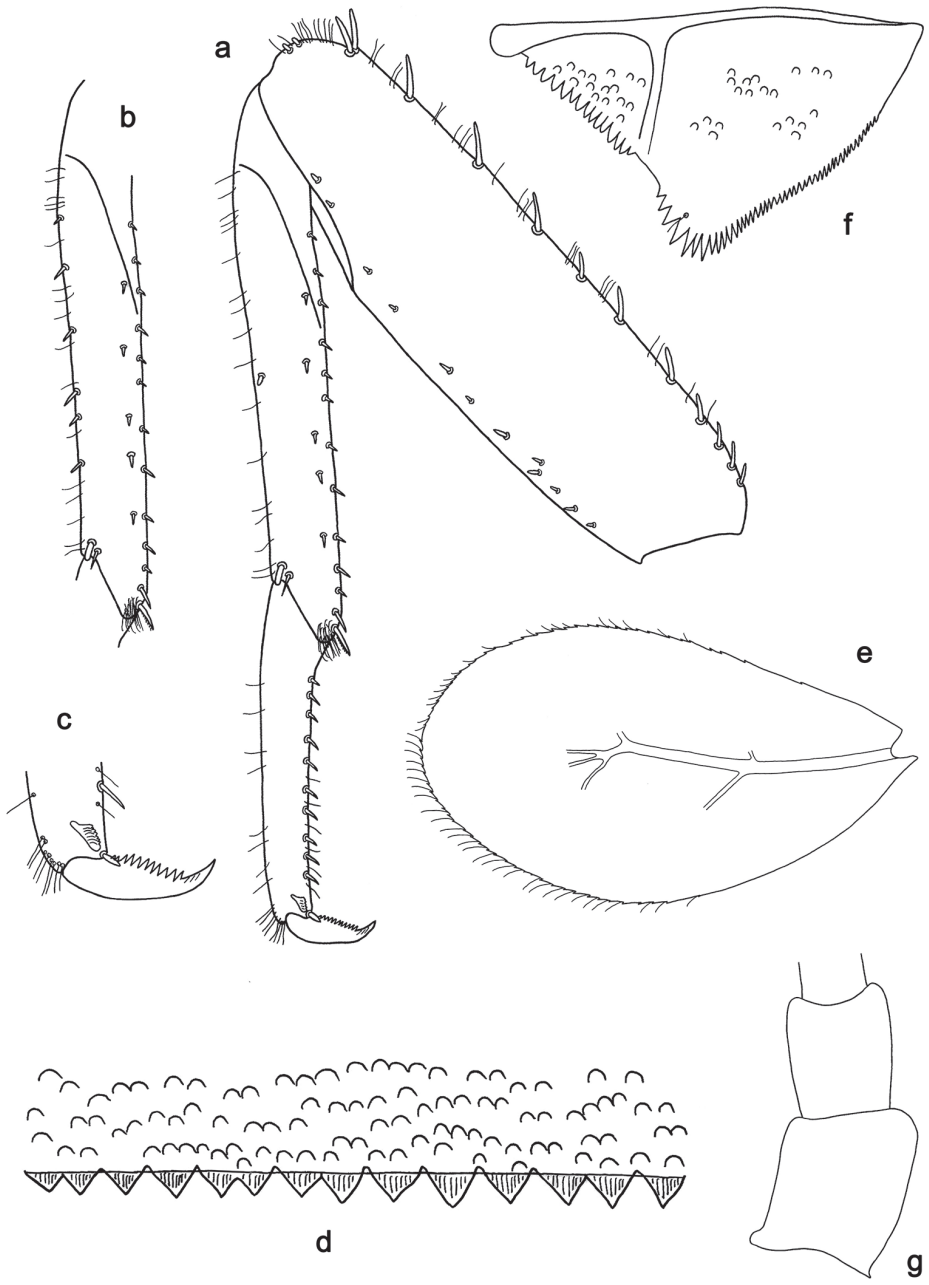

Figure 34. *Labiobaetis freitagi* sp. nov., larva morphology **a** foreleg **b** fore tibia **c** fore claw **d** tergum IV **e** gill IV **f** paraproct **g** antennal scape.

setae, on apex two longer, spine-like setae. Ventral margin with a row of short, curved, spine-like setae, on apex some longer, partly bipectinate setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present

on basal 1/3. ***Tarsus*.** Dorsal margin with a row of fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of ten or eleven denticles; distally pointed; with ca. three stripes; subapical setae absent.

Terga (Fig. 34d). Surface with irregular rows of U-shaped scale bases. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 34e). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae partly extending from main trunk to inner and outer margins, pigmentation mainly limited to main trunk. Gill IV as long as length of segments V and 1/3 VI combined. Gill VII as long as length of segment VIII.

Paraproct (Fig. 34f). Distally expanded with 39–46 stout, marginal spines. Surface scattered with U-shaped scale bases. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Prof. Hendrik Freitag (Philippines/Germany), collector of some material, for his outstanding contribution to freshwater biodiversity research in Southeast Asia.

Distribution. Philippines: Palawan (Fig. 49b).

Biological aspects. The specimens were collected at altitudes from sea level to 150 m, in leaf packs or submerged wood in runs or riffles.

Type material. *Holotype*. Philippines • larva; Palawan, Brooke's Point, Mainit 7 Falls; 08°51'48"N, 117°47'45"E; 150 m; 2019; leg. Pelingen and Pangantihon; on slide; GBIFCH 00592322; PNM. ***Paratypes*.** Philippines • 22 larvae; same data as holotype; in alcohol; GenBank: MT830978; GBIFCH 00515497, GBIFCH 00763677; AdMU • 7 larvae; Palawan, P.Princesa Cabayugan District, Cabayugan River, near Nagsatayan Creek, S of Martarpi; 10°09'47"N, 118°50'37"E; 37 m; 05.VIII.2000; leg. Freitag; 1 on slide; GenBank: MT830978; GBIFCH 00763678; ZSM, temporarily stored in AdMU; 6 in alcohol; GBIFCH 00515498; PNM • 11 larvae; Palawan, Quezon, Isugod, Aramaywan River; 09°21'07"N, 118°08'26"E; 14 m; 2019; leg. Pangantihon and Pelingen; 1 on slide; GBIFCH 00592332; AdMU; 1 on slide; GBIFCH 00592333; ZSM, temporarily stored in AdMU; 6 in alcohol; GBIFCH 00515496; AdMU; 3 in alcohol; GenBank: MT830980; GBIFCH 00763682, GBIFCH 00515456; ZSM, temporarily stored in AdMU • 10 larvae; Palawan, Balabac, Suray River, Indalawan, near the road; 07°57'01"N, 117°04'29"E; 16 m; 2019; leg. Pangantihon and Pelingen; in alcohol; GenBank: MT830981; GBIFCH 00763683, GBIFCH 00515499; PCSD.

Labiobaetis pelingeni sp. nov.

http://zoobank.org/613FE6FB-4601-4A01-A07E-7FDF97AF55B1
Figures 35, 36, 45b, 49b

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of 15–17 long, clavate setae; B) labial palp segment II with a thumb-like distomedial protuberance, segment III slightly pentagonal; C) left mandible without setae at apex of mola; D) fore femur rather broad, length ca. 3 × maximum width, dorsal margin with 11–14 curved, spine-like setae; E) paraproct distally expanded, with ca. 35 stout, marginal spines.

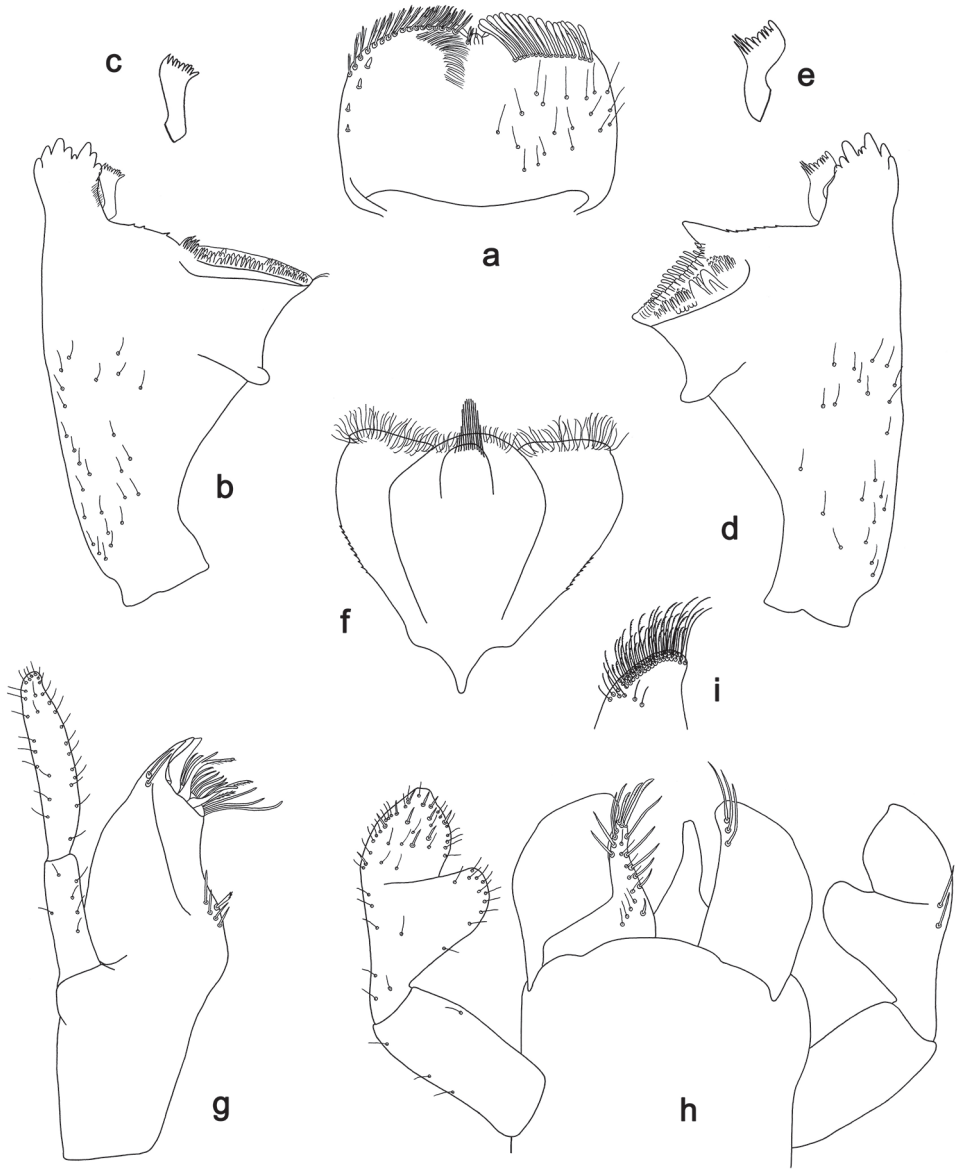

Figure 35. *Labiobaetis pelingeni* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** maxilla **h** labium **i** apex of paraglossa.

Description. Larva (Figs 35, 36, 45b). Body length 3.5–4.2 mm. Cerci ca. 1/2 of body length. Paracercus ca. 2/3 of cerci length. Antenna approx. twice as long as head length.

Colouration. Head, thorax, and abdomen dorsally light brown, fore protoptera light brown. Head, thorax, and abdomen ventrally light brown. Legs light brown, femur with distomedial brown spot and brown apex. Caudalii light brown.

Antenna (Fig. 36f) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 35a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium to long, fine, simple setae scattered over surface; submarginal arc of setae composed of 15–17 long, clavate setae. Ventrally with marginal row of setae composed of anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. four short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 35b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex, with minute denticles. Tuft of setae at apex of mola present.

Left mandible (Fig. 35d, e). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight, with minute denticles towards subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola absent.

Both mandibles with lateral margins almost straight. Basal half with fine, simple setae scattered over dorsal surface.

Hypopharynx and superlinguae (Fig. 35f). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed; distal half laterally expanded. Superlinguae distally straight; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 35g). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and three or four medium to long, simple setae. Maxillary palp 1.3 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.6 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

Labium (Fig. 35h, i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with six spine-like setae increasing in length distally; apex with two long and one medium, robust, pectinate setae; outer margin with four spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and two medium, simple setae in anteromedial area; dorsally with a row of three long, spine-like setae near inner margin. Labial palp with segment I 0.8 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with thumb-like distomedial protuberance; distomedial protuberance 0.6 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with two long, spine-like, simple setae near outer

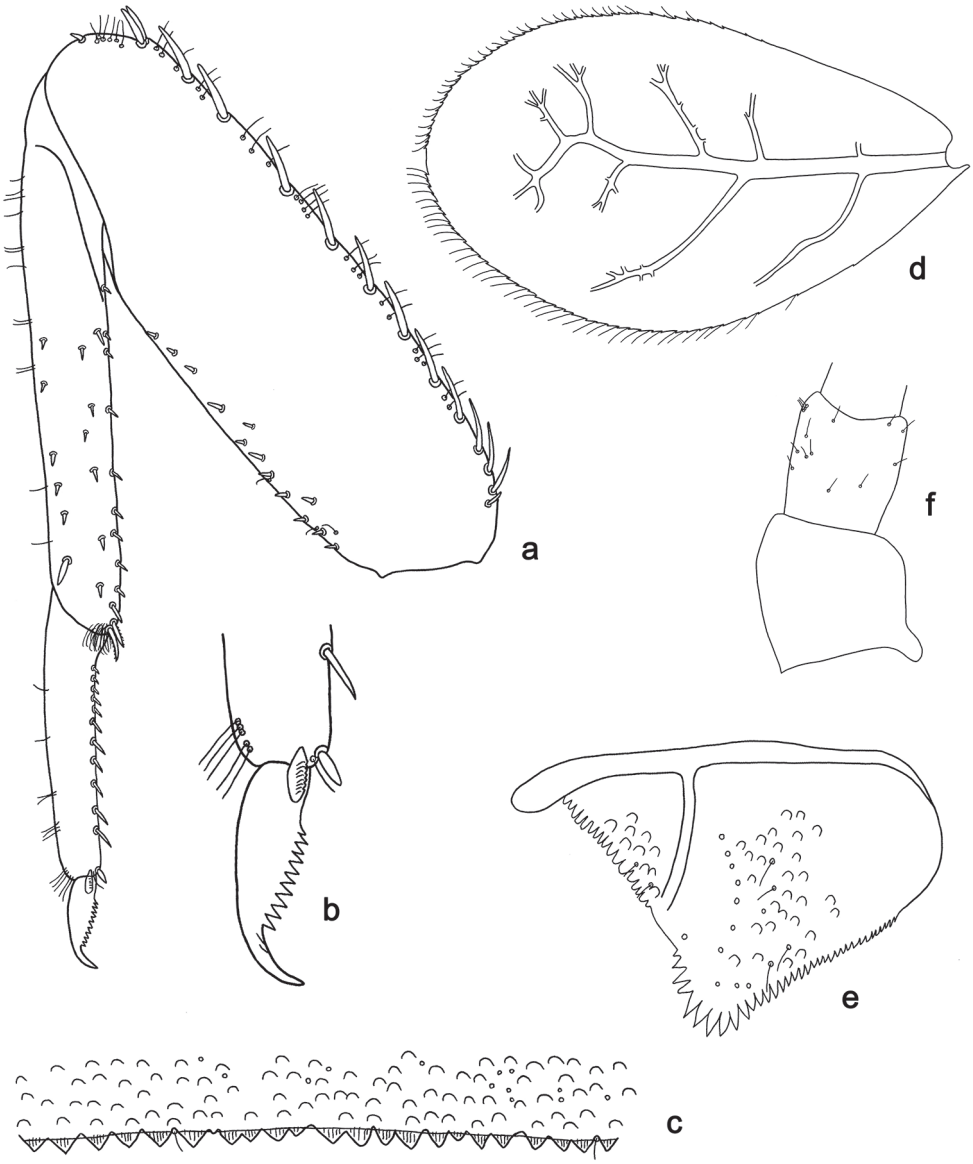

Figure 36. *Labiobaetis pelingeni* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** antennal scape.

margin. Segment III slightly pentagonal; apex slightly truncate; length 1.2 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera absent.

Foreleg (Fig. 36a, b). Ratio of foreleg segments 1.2:1.0:0.5:0.2. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with 11–14 long, curved, spine-like setae; length

of setae 0.27 × maximum width of femur. Apex rounded; with a pair of long, curved, spine-like setae and one or two short, stout setae and some fine, simple setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia*.** Dorsal margin with a row of short, spine-like setae and fine simple setae, on apex one longer, spine-like seta. Ventral margin with a row of short, curved, spine-like setae, on apex some longer, partly bipectinate setae and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 1/3. ***Tarsus*.** Dorsal margin with a row of fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of nine or ten denticles; distally pointed; with ca. two stripes; subapical setae absent.

Terga (Fig. 36c). Surface with irregular rows of U-shaped scale bases and scattered micropores. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 36d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and 1/3 VI combined. Gill VII as long as length of segment VIII.

Paraproct (Fig. 36e). Distally expanded, with ca. 35 stout, marginal spines. Surface scattered with U-shaped scale bases, fine, simple setae and micropores. Cercotractor with numerous small, marginal spines.

Etymology. Dedicated to Mr. Arthien Lovell Pelingen (Philippines), entomologist and former project assistant of the AdMU Biodiversity Laboratory.

Distribution. Philippines: Negros and Cebu (Fig. 49b).

Biological aspects. The specimens were collected at altitudes of 50 m and 480 m, on submerged wood or in riverside pools.

Type material. ***Holotype*.** Philippines • larva; Negros Oriental, Valencia, Malaunay, small tributary; 09°18'17"N, 123°10'07"E; 480 m; 01.IX.2019; leg. Garces and Pelingen; on slide; GBIFCH 00592315; PNM. ***Paratypes*.** Philippines • 11 larvae; same data as holotype; 2 on slides; GenBank: MT830982; GBIFCH 00654901, GBIFCH 00592305; ZSM; 7 in alcohol; GBIFCH 00515490, GBIFCH 515491; AdMU; 2 in alcohol; GBIFCH 00515463; ZSM • 9 larvae; Cebu, Sogod, Bagatayam; 10°45'32"N, 123°59'49"E; 50 m.; 08.IX.1996; leg. Mendoza; 1 on slide; GenBank: MT830983; GBIFCH 00763672; AdMU; 5 in alcohol; GBIFCH 00515492; AdMU; 3 in alcohol; GBIFCH 515493, GBIFCH 00515462; ZSM.

Labiobaetis vallus group of species (new group of species)

Following combination of characters: A) dorsal surface of labrum with submarginal arc of lanceolate setae; B) labial palp segment II with rather small, slender, thumb-like protuberance, distally bent upwards; C) hypopharynx with medial tuft of stout setae consisting of setae with minute apical serration; D) six pairs of gills; E) hind protoptera absent; F) no distolateral process at scape; G) paracercus short, ca. ¼ of cerci length.

***Labiobaetis giselae* sp. nov.**
http://zoobank.org/9F0DC137-4C52-4B1C-A2DD-E2C40A8588DE
Figures 37, 38, 45c, 49c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of three long, lanceolate setae; B) labial palp segment II with a hook-like distomedial protuberance, segment III conical; C) hypopharynx with well-developed medial tuft of long, stout setae, setae apically with minute serration; D) fore femur rather broad, length 2.6 × maximum width, dorsal margin with ca. 12 long, curved, spine-like setae and a second row of spine-like setae near margin; E) paraproct distally expanded with ca. six stout, marginal spines; F) paracercus short, ca. ¼ of cerci length.

Description. Larva (Figs 37, 38, 45c). Body length 3.4–4.5 mm. Cerci ca. 2/3 of body length. Paracercus ca. 1/4 of cerci length. Antenna approx. twice as long as head length.

Colouration. Head and pronotum dorsally brown, meso- and metanotum light brown, fore protoptera light brown with brown apex. Abdominal segments II–VI dorsally dark brown, segments I and VII–X light brown, segments VII and X with brown markings as in Fig. 45c. Head and thorax ventrally light brown, abdominal segments II–VI ventrally dark brown, segments I and VII–X light brown, segment IX with brown anterior margin and segment X laterally darker. Femur ecru with a distomedial brown spot connected to brown streaks at dorsal and ventral margin and a basal brown area; tibia and tarsus light brown. Caudalii light brown.

Antenna (Fig. 38g) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 37a). Rectangular, length 0.6 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium, fine, simple setae scattered over surface; submarginal arc of setae composed of three long, lanceolate setae. Ventrally with marginal row of setae composed of anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. four short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 37b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with four denticles, inner margin of innermost denticle without a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola straight. Tuft of setae at apex of mola present.

Left mandible (Fig. 37d, e). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with four denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight, with minute denticles towards subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins slightly convex. Basal half with fine, simple setae scattered over dorsal surface.

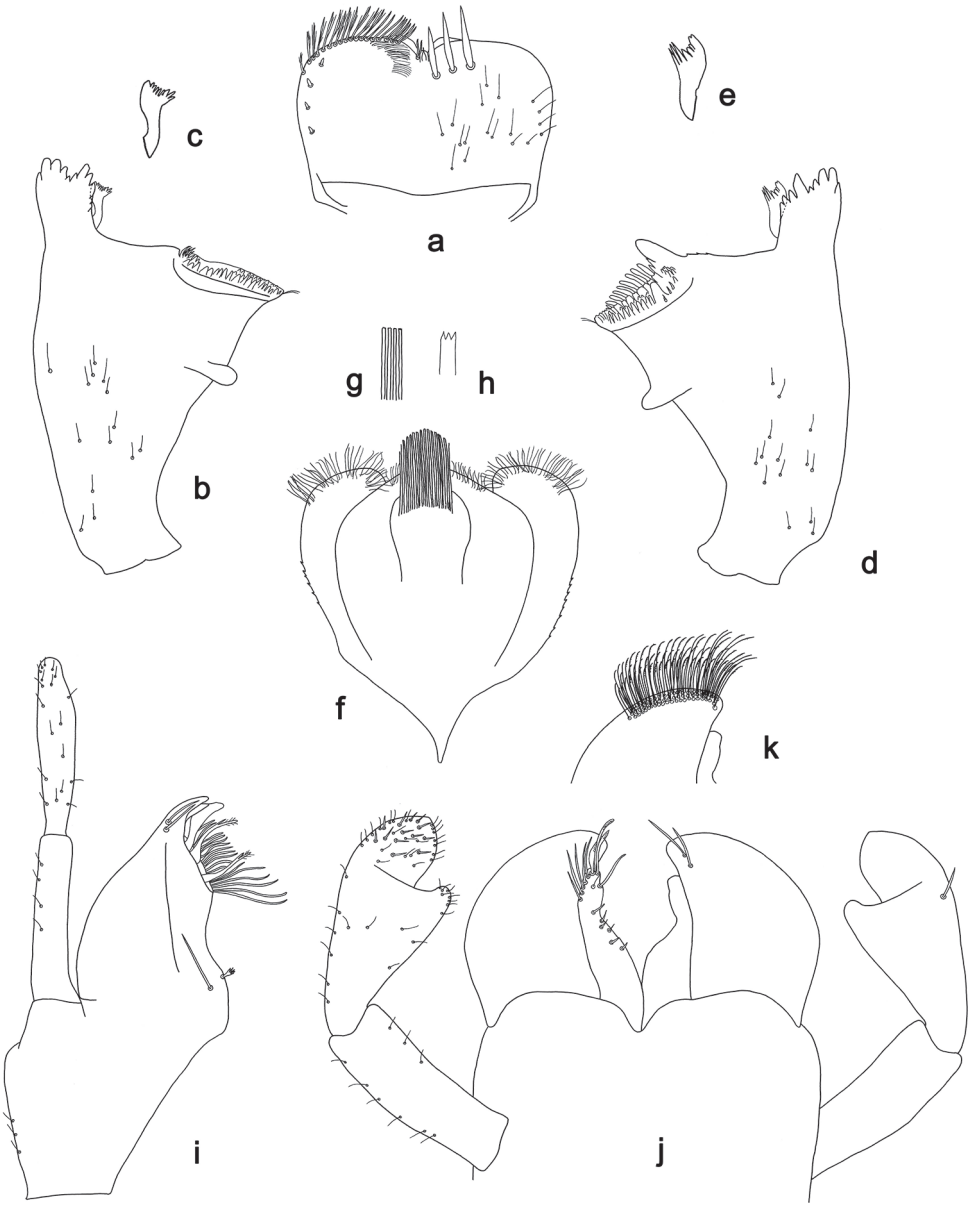

Figure 37. *Labiobaetis giselae* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** hypopharynx, detail of tuft of stout setae **h** hypopharynx, seta of tuft of stout setae **i** maxilla **j** labium **k** apex of paraglossa.

Hypopharynx and superlinguae (Fig. 37f–h). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, long, setae apically with minute serration; distal half laterally expanded. Superlinguae distally rounded; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 37i). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like, middle and proximal denti-setae slender, bifid and pectinate. Medially with one spine-like, pectinate seta and one long, simple seta. Maxillary palp 1.6 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.1 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

Labium (Fig. 37j, k). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. four spine-like setae, distalmost seta much longer than other setae; apex with two long and one medium, robust, pectinate setae; outer margin with five long, spine-like setae; ventral surface with short, fine, simple and short, spine-like setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area; dorsally with two or three long, spine-like setae near inner margin. Labial palp with segment I 0.9 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with hook-like distomedial protuberance; distomedial protuberance 0.5 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with one long, spine-like seta near outer margin. Segment III conical; apex slightly pointed; length 1.0 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera absent.

Foreleg (Fig. 38a, b). Ratio of foreleg segments 1.2:1.0:0.6:0.2. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with ca. 12 long, curved, spine-like setae and a second row of long, spine-like setae near margin; length of setae 0.29 × maximum width of femur. Apex rounded, with a pair of curved, spine-like setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of fine, simple setae. Ventral margin with a row of short, curved, spine-like setae, on apex one longer, spine-like seta and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal half. ***Tarsus.*** Dorsal margin with a row of fine, simple setae. Ventral margin with a row of curved, spine-like setae. Claw with one row of 12 or 13 denticles; distally pointed; with ca. four stripes; subapical setae absent.

Terga (Fig. 38c). Surface with scattered micropores. Posterior margin of tergum IV with triangular spines, approx. as long as wide.

Gills (Fig. 38d). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and 1/3 VI combined. Gill VII as long as length of segments VIII and 1/3 IX combined.

Paraproct (Fig. 38e, f). Distally expanded, with ca. six stout, marginal spines. Surface scattered with short, broad, lanceolate setae and micropores. Cercotractor with numerous broad, marginal spines, apically denticulate.

Etymology. Dedicated to the late Mrs. Gisela Horzel (Germany), mother of one of the authors (TK).

Distribution. Philippines: Luzon (Fig. 49c).

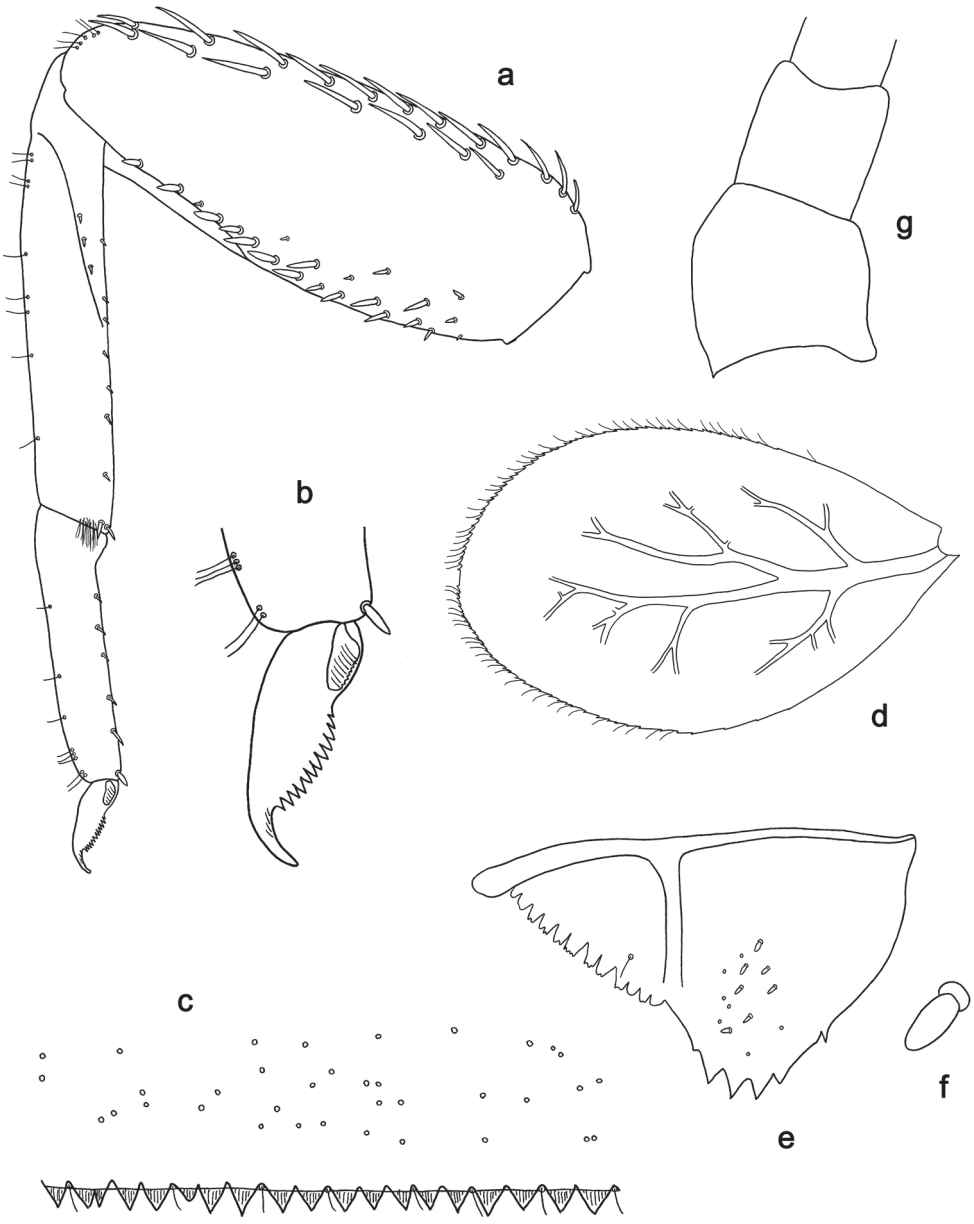

Figure 38. *Labiobaetis giselae* sp. nov., larva morphology **a** foreleg **b** fore claw **c** tergum IV **d** gill IV **e** paraproct **f** seta of paraproct **g** antennal scape.

Biological aspects. The specimens were collected at an altitude of 240 m on bottom gravel in runs or riffles.

Type material. ***Holotype*.** Philippines • larva; Luzon, Nueva Ecija, Pantabangan, Candaclan River; 15°46'48"N, 121°13'17"E; 240 m; 05.II.1998, leg. Mendoza; on slide; GBIFCH 00592280; PNM. ***Paratypes*.** Philippines • 4 larvae; same data as hol-

otype; 2 on slides; GenBank: MT830984; GBIFCH 00654911, GBIFCH 00515469; ZSM; 2 in alcohol; GBIFCH 00515482; AdMU.

***Labiobaetis mendozai* sp. nov.**
http://zoobank.org/58715368-B200-4AF6-87ED-38FB7CA90E58
Figures 39, 40, 45d, 49c

Diagnosis. Larva. Following combination of characters: A) dorsal surface of labrum with submarginal arc of one plus 5–8 long, lanceolate setae; B) labial palp segment II with a slender, thumb-like protuberance, segment III slightly pentagonal with small apical projection; C) hypopharynx with well-developed medial tuft of long, stout setae, setae apically with minute serration; D) fore femur length 3.4 × maximum width, dorsal margin with 8–11 curved, spine-like setae and at least a partial row of spine-like setae near margin; E) paraproct distally expanded, with ca. nine stout, marginal spines; F) paracercus short, ca. 1/4 of cerci length.

Description. Larva (Figs 39, 40, 45d). Body length 3.2–4.6 mm. Cerci ca. 2/3 of body length. Paracercus ca. 1/4 of cerci length. Antenna approx. twice as long as head length.

***Colouration*.** Head, thorax, and abdomen dorsally brown with bright pattern as in Fig. 45d. Head, thorax, and abdomen light brown. Femur ecru with a distomedial brown spot connected to a brown streak at ventral margin and a light brown basal area. Tibia and tarsus light brown. Caudalii light brown.

Antenna (Fig. 40g) with scape and pedicel subcylindrical, without distolateral process at scape.

Labrum (Fig. 39a). Rectangular, length 0.7 × maximum width. Distal margin with medial emargination and a small process. Dorsally with medium to long, fine, simple setae scattered over surface; submarginal arc of setae composed of one plus 5–8 long, lanceolate setae, submedian seta and last seta of arc narrower. Ventrally with marginal row of setae composed of anterolateral long, feathered setae and medial long, bifid setae; ventral surface with ca. three short, spine-like setae near lateral and anterolateral margin.

Right mandible (Fig. 39b, c). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles, inner margin of innermost denticle with a row of thin setae. Prostheca robust, apically denticulate. Margin between prostheca and mola slightly convex. Tuft of setae at apex of mola present.

Left mandible (Fig. 39d, e). Incisor and kinetodontium fused. Incisor with five denticles; kinetodontium with three denticles. Prostheca robust, apically with small denticles and comb-shaped structure. Margin between prostheca and mola straight, with minute denticles towards subtriangular process. Subtriangular process long and slender, above level of area between prostheca and mola. Denticles of mola apically constricted. Tuft of setae at apex of mola present.

Both mandibles with lateral margins slightly convex. Basal half with fine, simple setae scattered over dorsal surface.

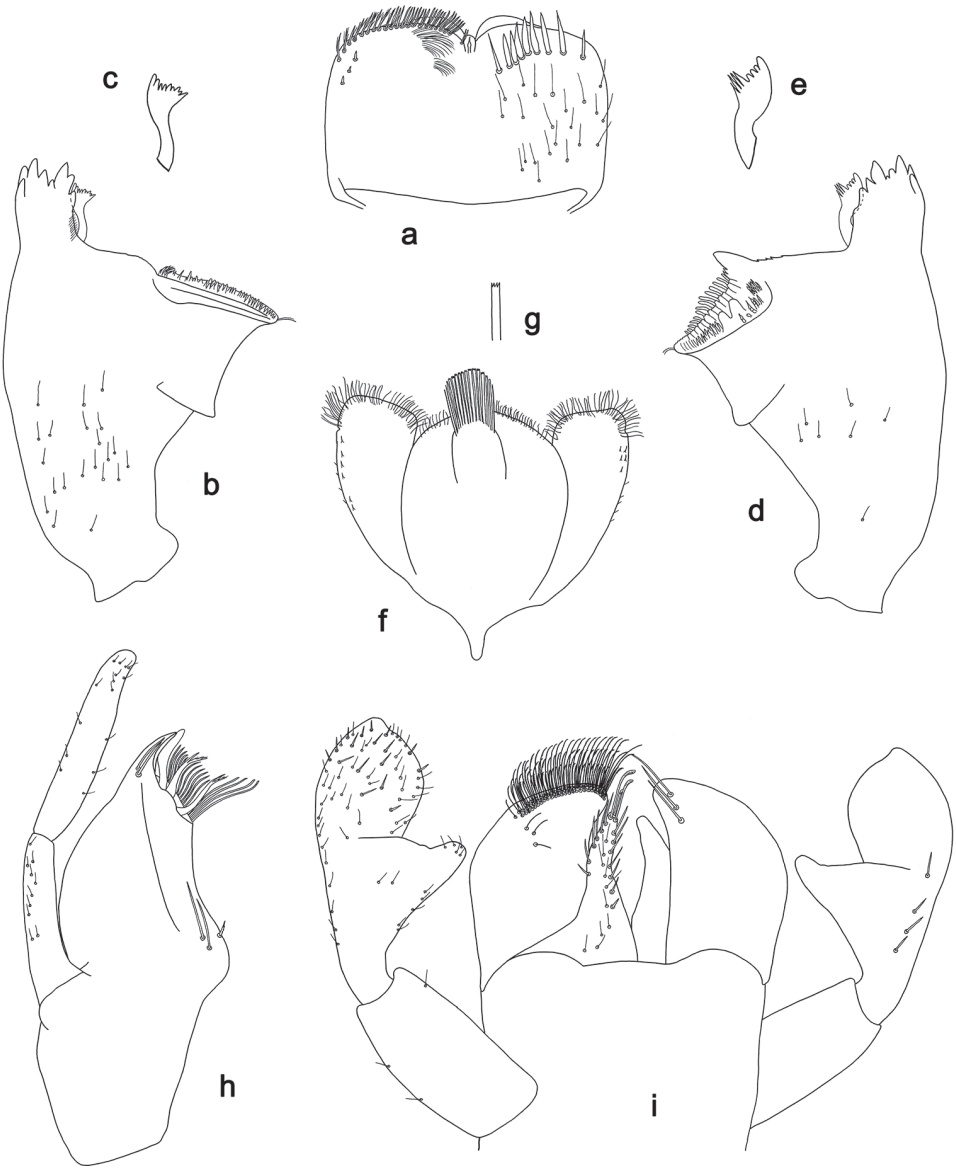

Figure 39. *Labiobaetis mendozai* sp. nov., larva morphology **a** labrum **b** right mandible **c** right prostheca **d** left mandible **e** left prostheca **f** hypopharynx and superlinguae **g** hypopharynx, seta of tuft of stout setae **h** maxilla **i** labium.

Hypopharynx and superlinguae (Fig. 39f, g). Lingua approx. as long as superlinguae. Lingua longer than broad; medial tuft of stout setae well developed, long, setae apically with minute serration; distal half laterally expanded. Superlinguae distally straight; lateral margin rounded; fine, long, simple setae along distal margin.

Maxilla (Fig. 39h). Galea-lacinia ventrally with two simple, apical setae under canines. Inner dorsal row of setae with three denti-setae, distal denti-seta tooth-like,

middle and proximal denti-setae slender, bifid and pectinate. Medially with one bipectinate, spine-like seta and two or three long, simple setae. Maxillary palp 1.4 × as long as length of galea-lacinia; 2-segmented; palp segment II 1.3 × length of segment I; setae on maxillary palp fine, simple, scattered over surface of segments I and II; apex of last segment rounded, with slight excavation at inner distolateral margin.

Labium (Fig. 39i). Glossa basally broad, narrowing toward apex; shorter than paraglossa; inner margin with ca. seven spine-like setae increasing in length distally; apex with two long and one medium, robust, pectinate setae; outer margin with five or six spine-like setae increasing in length distally; ventral surface with fine, simple, scattered setae. Paraglossa sub-rectangular, curved inward; apex rounded; with three rows of long, robust, distally pectinate setae in apical area and three medium, simple setae in anteromedial area; dorsally with a row of three long, spine-like setae near inner margin. Labial palp with segment I 0.6 × length of segments II and III combined. Segment I ventrally with short, fine, simple setae. Segment II with slender, thumb-like, distomedial protuberance, distally bent upward; distomedial protuberance 0.8 × width of base of segment III; ventral surface with short, fine, simple setae; dorsally with a row of 2–4 medium, spine-like setae near outer margin. Segment III slightly pentagonal; apex with small projection; length 1.2 × width; ventrally covered with short, spine-like, simple setae and short, fine, simple setae.

Hind protoptera absent.

Foreleg (Fig. 40a–c). Ratio of foreleg segments 1.2:1.0:0.4:0.1. ***Femur.*** Length ca. 3 × maximum width. Dorsal margin with 8–11 curved, spine-like setae and at least a partial row of spine-like setae near margin; length of setae 0.27 × maximum width of femur. Apex rounded; with a pair of curved, spine-like setae. Many stout, lanceolate setae scattered along ventral margin; femoral patch absent. ***Tibia.*** Dorsal margin with a row of fine, simple setae. Ventral margin with a row of short, curved, spine-like setae, on apex one longer, spine-like seta and a tuft of fine, simple setae. Anterior surface scattered with stout, lanceolate setae. Patellotibial suture present on basal 1/3. ***Tarsus.*** Dorsal margin with a row of fine, simple setae. Ventral margin with a row of curved, spine-like setae with minute marginal pectination (pectination difficult to see). Claw with one row of ten denticles; distally pointed; with ca. three stripes; subapical setae absent.

Terga (Fig. 40d). Surface with irregular rows of W-shaped scale bases and scattered micropores. Posterior margin of tergum IV with triangular spines, wider than long.

Gills (Fig. 40e). Present on segments II–VII. Margin with small denticles intercalating fine simple setae. Tracheae extending from main trunk to inner and outer margins. Gill IV as long as length of segments V and half VI combined. Gill VII as long as length of segments VIII and 1/3 IX combined.

Paraproct (Fig. 40f). Distally expanded, with ca. nine stout, marginal spines. Surface scattered with U-shaped scale bases and fine, simple setae. Cercotractor with numerous broad, marginal spines.

Etymology. Dedicated to the late Mr. Joseph Mendoza (Philippines), outstanding insect collector.

Distribution. Philippines: Mindanao (Fig. 49c).

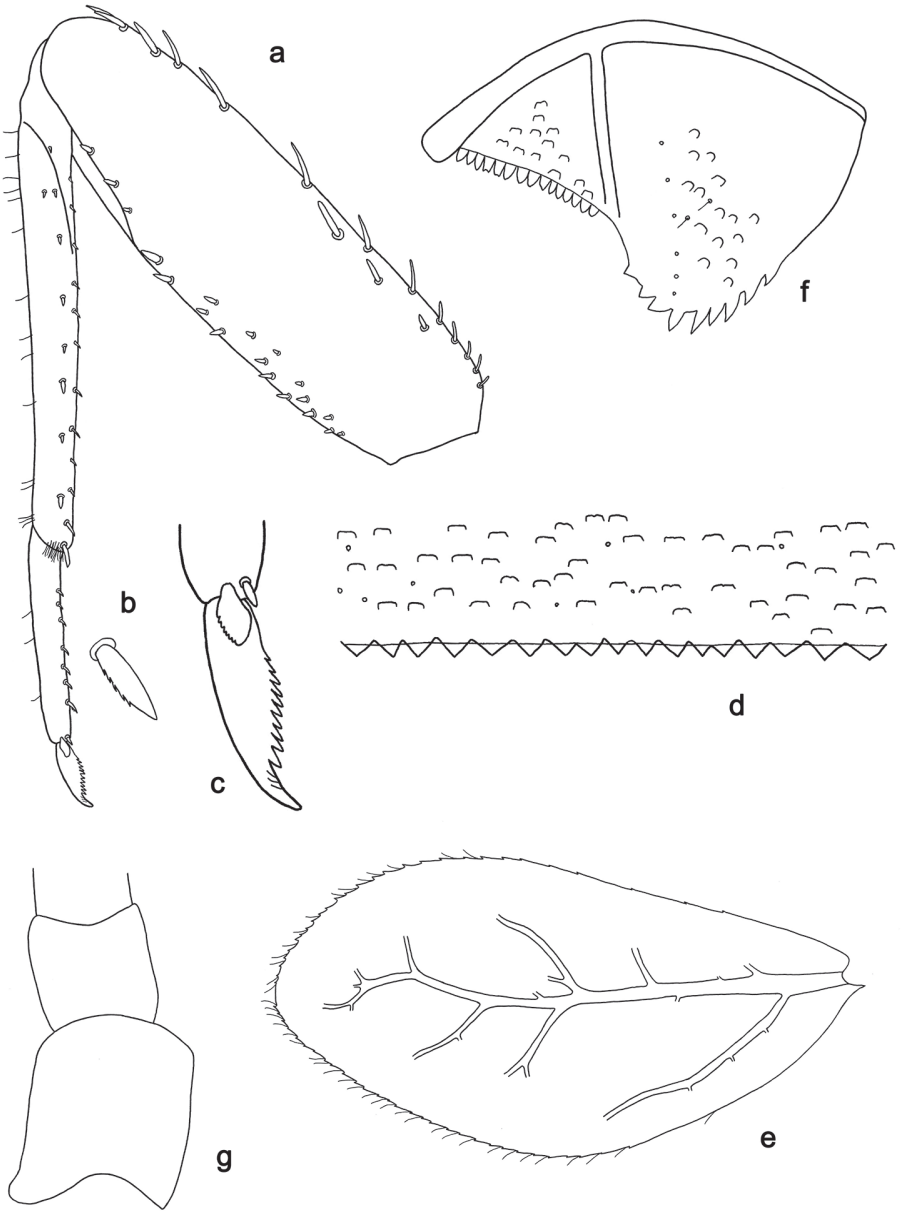

Figure 40. *Labiobaetis mendozai* sp. nov., larva morphology **a** foreleg **b** seta of ventral margin of tarsus **c** fore claw **d** tergum IV **e** gill IV **f** paraproct **g** antennal scape.

Biological aspects. The specimens were collected at altitudes from sea level to 120 m, on bottom gravel or submerged wood, or in leaf litter in side pools.

Type material. ***Holotype*.** Philippines • larva; Mindanao, Surigao del Sur, Tandag, Pangi, Pangi River; 09°06'18"N, 126°08'53"E; 10 m; 30.XI.2018, leg. Pangantihon;

on slide; GBIFCH 00592272; PNM. ***Paratypes.*** Philippines • 5 larvae; same data as holotype; 1 in alcohol; GBIFCH 00515480; ZSM; 4 in alcohol; GBIFCH 00515481; AdMU • 2 larvae; Mindanao, Agusan del Sur, San Francisco, Bayogan, Tagkunayan Creek; 08°28'N, 125°59'E; 120 m; 05.II.1998; leg. Mendoza; 1 on slide; GBIFCH 00515476; AdMU; 1 on slide; GenBank: MT830985; GBIFCH 654894; ZSM • 1 larva; Mindanao, Surigao del Sur, Tandag, Buenavista River; 09°08'18"N, 126°08'45"E; 80 m; 03.XII.2018; leg. Panganthion; in alcohol; GBIFCH 00515478; ZSM.

Key to the *Labiobaetis* species of the Philippines (larvae)*

1 Dorsal surface of labrum with submarginal arc of simple setae (Fig. 2a) ..... **(numeratus group) 2**

– Dorsal surface of labrum with submarginal arc of other types of setae **7**

2 Setae at apex of mola of left mandible absent (Fig. 11d) .... ***L. lachicae* sp. nov.**

– Setae at apex of mola of left mandible present **3**

3 Hypopharynx with medial tuft of stout setae poorly developed (Fig. 2t); mola of right mandible proximally beginning with a double hump (Fig. 13b) **4**

– Hypopharynx with medial tuft of stout setae well developed, short (Fig. 2s); mola of right mandible proximally not beginning with a double hump **5**

4 Posterior margin of tergum IV with triangular spines (Fig. 16c) ..... ***L. sabordoi* sp. nov.**

– Posterior margin of tergum IV with rounded spines (Fig. 14c) ..... ***L. palawano* sp. nov.**

5 Left mandible with comb-shaped structure at base of mola (Fig. 5f, g) **6**

– Left mandible without comb-shaped structure at base of mola (Fig. 9d) ..... ***L. camiguinensis* sp. nov.**

6 Paraproct with 18–21 marginal spines ..... ***L. aldabae* sp. nov.**

– Paraproct with 29–34 marginal spines plus a few submarginal spines ..... ***L. acei* sp. nov.**

7 Dorsal surface of labrum with submarginal arc of clavate setae (Fig. 2c) ..... **(*sumigarensis* group) 8**

– Dorsal surface of labrum with submarginal arc of other types of setae **13**

8 Labial palp segment II enlargement pronounced hook-like with inner margin straight, segment III oblong and apically slightly truncate (Fig. 28c) ..... ***L. sumigarensis***

– Labial palp different **9**

9 Labial palp segment II elongate thumb-like with distal margin strongly concave and inner margin concave (Figs 31i, 33h) **10**

– Labial palp segment II broad thumb-like with distal margin not or only slightly concave (Fig. 29i) **11**

* Some of the species may be difficult to identify below the species group level, more than one good slide is recommended

10 Labial palp segment III apically slightly pointed (Fig. 31i); maxillary palp longer than galea-lacinia (ca. 1.3×) (Fig. 31h) ..... ***L. delocadoi* sp. nov.**

– Labial palp segment III apically rounded (Fig. 33h); maxillary palp much longer than galea-lacinia (ca. 1.7×) (Fig. 33g) ..... ***L. freitagi* sp. nov.**

11 Paraproct distally not expanded (Fig. 27c); distolateral process at scape poorly developed (Fig. 2g) ..... ***L. molawinensis***

– Paraproct distally expanded (Fig. 30e); distolateral process at scape absent (Fig. 2f) **12**

12 Maxillary palp with distolateral excavation (Fig. 29h); dorsal surface of labrum with submarginal arc of 17–21 clavate setae (Fig. 29a) ..... ***L. baganii* sp. nov.**

– Maxillary palp with slight distolateral excavation (Fig. 35g); dorsal surface of labrum with submarginal arc of 15–17 clavate setae (Fig. 35a)..... ***L. pelingeni* sp. nov.**

13 Dorsal surface of labrum with submarginal arc of lanceolate setae (Fig. 2e)... **(*vallus* group) 14**

– Dorsal surface of labrum with submarginal arc of other types of setae..... **15**

14 Dorsal surface of labrum with submarginal arc of ca. three lanceolate setae; row of fine setae at innermost denticle of kinetodontium of right mandible absent (Fig. 37b) ..... ***L. giselae* sp. nov.**

– Dorsal surface of labrum with submarginal arc of one plus ca. eight lanceolate setae; row of fine setae at innermost denticle of kinetodontium of right mandible present (Fig. 39b) ..... ***L. mendozai* sp. nov.**

15 Dorsal surface of labrum with submarginal arc of feathered setae (Fig. 2b), feathers may be reduced or strongly reduced; labial palp segment II enlargement thumb-like, segment III conical (Fig. 2j); femoral patch absent ..... **(*operosus* group) 16**

– Dorsal surface of labrum with submarginal arc of dendritic setae (Fig. 2d); labial palp segment II enlargement narrow, elongate thumb-like, segment III apically rounded (Fig. 3j); femoral patch present (Fig. 4a) ..... **(*dendrisetis* group) *L. dalisay* sp. nov.**

16 Dorsal surface of labrum with submarginal arc of setae with reduced or strongly reduced feathers (Figs 17b, 21b) **17**

– Dorsal surface of labrum with submarginal arc of feathered setae, feathers not reduced (Fig. 19a) **18**

17 Feathered setae of submarginal arc on dorsal surface of labrum strongly reduced, with few lateral branches only (Fig. 17b); hind protoptera well developed (Fig. 18g) ..... ***L. gamay* sp. nov.**

– Feathered setae of submarginal arc on dorsal surface of labrum moderately reduced (Fig. 21b); hind protoptera of medium size (Fig. 22g) ..... ***L. tagbanwa* sp. nov.**

18 Labial palp segment II enlargement narrow thumb-like (Fig. 19h); row of fine setae at innermost denticle of kinetodontium of right mandible absent (Fig. 19b)..... ***L. pangantihoni* sp. nov.**

– Labial palp segment II enlargement broad thumb-like (Fig. 23h); row of fine setae at innermost denticle of kinetodontium of right mandible present (Fig. 23b).....**19**

19 Fore tarsus dorsoventrally concave (broadened) (Fig. 24a); spines at posterior margin of tergum IV shorter than wide (Fig. 24c).... ***L. valdezorum* sp. nov.**

– Fore tarsus dorsoventrally parallel sided (Fig. 26a); spines at posterior margin of tergum IV mainly longer than wide (Fig. 26c)..... ***L. wantzeni* sp. nov.**

Distribution

The material treated in this study was collected in many different locations across the Philippine archipelago, including most of the big islands as well as some smaller islands (Figs 48, 49). There are still many regions in the Philippines as well as in Southeast Asia where no sampling of mayflies has yet been done and many species known to date are from a single population only. This implies that the current diversity and distribution must be still considered very preliminary. In terms of altitude, the *Labiobaetis* species of the Philippines were found from sea level to mountain areas up to 1,820 m. The GPS coordinates of the locations of examined material are given in Table 2.

Genetics

COI sequences were obtained from all 18 new species (Table 1). The genetic distances (K2P) of the species in the Philippines are between 15% and 27%, and therefore much higher than 3.5%, which is generally considered as a likely maximal value for intraspecific divergence (Hebert et al. 2003, Ball et al. 2005, Zhou et al. 2010) (Table 3). Very

Table 2. GPS coordinates of locations of examined specimens.

Species	Species group	Locality	GPS coordinates
L. dalisay sp. nov.	*dendrisetis* gr.	Philippines: Luzon	15°45'48''N, 121°25'21''E
			15°46'48''N, 121°13'17''E
			16°21'33"N, 120°30'31"E
L. acei sp. nov.	*numeratus* gr.	Philippines: Luzon	17°03'53"N, 121°05'10"E
			16°59'37"N, 121°02'51"E
L. aldabae sp. nov.	*numeratus* gr.	Philippines: Luzon	14°08'N, 121°31'E
			15°46'48''N, 121°13'17''E
			14°32'47''N, 121°13'42''E
			16°57'17''N, 120°38'52' E
			16°34'11"N, 120°50'12"E
			16°21'33"N, 120°30'31"E
			16°40'58"N, 120°56'59"E
		Philippines: Negros	09°18'17''N, 123°10'07''E
L. camiguinensis sp. nov.	*numeratus* gr.	Philippines: Camiguin	09°06'39''N, 124°43'45''E
			09°09'25''N, 124°43'57''E

Species	Species group	Locality	GPS coordinates
L. lachicae sp. nov.	*numeratus* gr.	Philippines: Mindanao	08°28'N, 125°59'E
			09°03'33''N, 126°05'57''E
			09°06'18''N, 126°08'53''E
L. palawano sp. nov.	*numeratus* gr.	Philippines: Busuanga	12°03'46''N, 120°13'25''E
			12°01'45''N, 120°12'19''E
		Philippines: Palawan	10°09'47''N, 118°50'37''E
			10°01'26''N, 119°04'37''E
L. sabordoi sp. nov.	*numeratus* gr.	Philippines: Negros	09°18'N, 123°14'E
		Philippines: Romblon	12°33'38''N, 122°07'19''E
			12°20'40''N, 122°40'37''E
L. gamay sp. nov.	*operosus* gr.	Philippines: Mindoro	12°37'06''N, 121°23'49''E
			12°37'18"N, 121°22'58"E
		Philippines: Luzon	16°54'38"N, 120°28'40"E
			16°59'32"N, 120°32'21"E
			16°39'27"N, 120°25'55"E
L. pangantihoni sp. nov.	*operosus* gr.	Philippines: Palawan	07°57'39''N, 117°02'59''E
			07°57'39''N, 117°02'59''E
			09°21'07''N, 118°08'26''E
			09°18'25''N, 118°07'42''E
L. tagbanwa sp. nov.	*operosus* gr.	Philippines: Palawan	09°41'20''N, 118°37'29''E
			09°26'55''N, 118°26'44''E
			09°22'33''N, 118°08'41''E
L. valdezorum sp. nov.	*operosus* gr.	Philippines: Negros	09°18'N, 123°14'E
			09°17'N, 123°13'E
		Philippines: Cebu	10°28'13"N, 123°52'26"E
L. wantzeni sp. nov.	*operosus* gr.	Philippines: Camiguin	09°06'39''N, 124°43'45''E
			09°12'N, 124°41'E
			09°09'25''N, 124°43'57''E
		Philippines: Mindanao	08°09'42''N, 124°42'28''E
L. molawinensis	*sumigarensis* gr.	Philippines: Luzon	14°09'53''N, 121°14'48''E
			14°10'05''N, 121°11'44''E
			14°08'N, 121°31'E
			15°45'21''N, 121°34'46''E
L. sumigarensis	*sumigarensis* gr.	Philippines: Luzon	16°59'37''N, 121°02'51''E
L. baganii sp. nov.	*sumigarensis* gr.	Philippines: Mindanao	09°10'15''N, 125°40'55''E
			09°20'40''N, 125°30'50''E
			08°28'N, 125°59'E
			09°11'34''N, 125°36'34''E
		Philippines: Camiguin	09°06'39''N, 124°43'45''E
L. delocadoi sp. nov.	*sumigarensis* gr.	Philippines: Cebu	10°24'55''N, 123°49'05''E
		Philippines: Leyte	10°01'07''N, 125°12'35'E
L. freitagi sp. nov.	*sumigarensis* gr.	Philippines: Palawan	08°51'48''N, 117°47'45''E
			10°09'47''N, 118°50'37''E
			09°21'07''N, 118°08'26''E
			07°57'01''N, 117°04'29''E
L. pelingeni sp. nov.	*sumigarensis* gr.	Philippines: Negros	09°18'17''N, 123°10'07''E
		Philippines: Cebu	10°45'32"N, 123°59'49"E
L. giselae sp. nov.	*vallus* gr.	Philippines: Luzon	15°46'48''N, 121°13'17''E
L. mendozai sp. nov.	*vallus* gr.	Philippines: Mindanao	09°08'18''N, 126°08'45''E
			08°28'N, 125°59'E
			09°06'18''N, 126°08'53''E

limited genetic distances (between 0% and 3%) were found between specimens of the same species, as in *L. acei* sp. nov., *L. palawano* sp. nov., *L. sabordoi* sp. nov., *L. gamay* sp. nov., *L. tagbanwa* sp. nov., *L. valdezorum* sp. nov., *L. wantzeni* sp. nov., *L. baganii*

Table 3. Intraspecific (bold) and interspecific genetic distances of the new species (COI; Kimura 2-parameter; %; mean; minimum-maximum).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	*L. dalisay* sp. nov.	**0**																	
2	*L. acei* sp. nov.	18	**0**																
3	*L. aldabae* sp. nov.	20 20–22	16 15–16	**3** **0–6**															
4	*L. camiguinensis* sp. nov.	23	19	16	**0**														
5	*L. lachicae* sp. nov.	22	18	18	6	**0**													
6	*L. palawano* sp. nov.	22 21–22	17 16–17	18 17–18	15 14–15	16 15–16	**2**												
7	*L. sabordoi* sp. nov.	22 21–22	17	19 18–19	20	18 17–18	16 15–16	**1**											
8	*L. gamay* sp. nov.	25 24–25	21 21–22	20 19–21	20	21	20 19–20	22 22–23	**0** **0–1**										
9	*L. pangantihoni* sp. nov.	22	15	17 16–17	17	18	17 16–18	17	20 20–21	**0**									
10	*L. tagbanwa* sp. nov.	22	20	17 17–18	19	19	20 19–20	19 18–19	13	20	**1** **0–1**								
11	*L. valdezorum* sp. nov.	22	22	20 19–21	21	22	22 21–22	23 22–23	18 18–19	23	17 17–18	**0**							
12	*L. wantzeni* sp. nov.	24	19	18 17–19	21	23	20 19–21	21 20–21	21	19	21	20	**1** **0–2**						
13	*L. baganii* sp. nov.	22	18	18 17–19	20 19–20	21 20–21	18	19	21 20–21	20 19–20	19 18–20	24	21	**2**					
14	*L. delocadoi* sp. nov.	24 23–24	24 23–24	23 21–25	23 22–23	23 22–23	21 20–21	23 22–24	23 22–24	22 21–22	23 22–23	24	23	24 23–24	**2**				
15	*L. freitagi* sp. nov.	26	25	22 21–22	23 22–23	23 23–24	23 23–24	23 22–23	26 26–27	23 22–23	26 25–26	27 26–27	26	22	23 22–24	**0** **0–1**			
16	*L. pelingeni* sp. nov.	24 23–24	19 18–19	19 18–21	22 21–22	19	20 19–20	22 21–22	24 23–24	21	22 21–22	23 23–24	24 22–24	21 20–21	23 22–23	23 22–24	**3**		
17	*L. giselae* sp. nov.	21	18	18 17–19	21	20	23 22–23	20	22	19	20 19–20	20 20–21	17 17–18	21 20–21	21 20–21	23 22–23	22 21–22	**0**	
18	*L. mendozai* sp. nov.	23	21	19	20	20	19 18–19	22	22	23	19 18–19	20 20–21	24 23–25	22	24 23–24	27 26–27	21	21	**0**

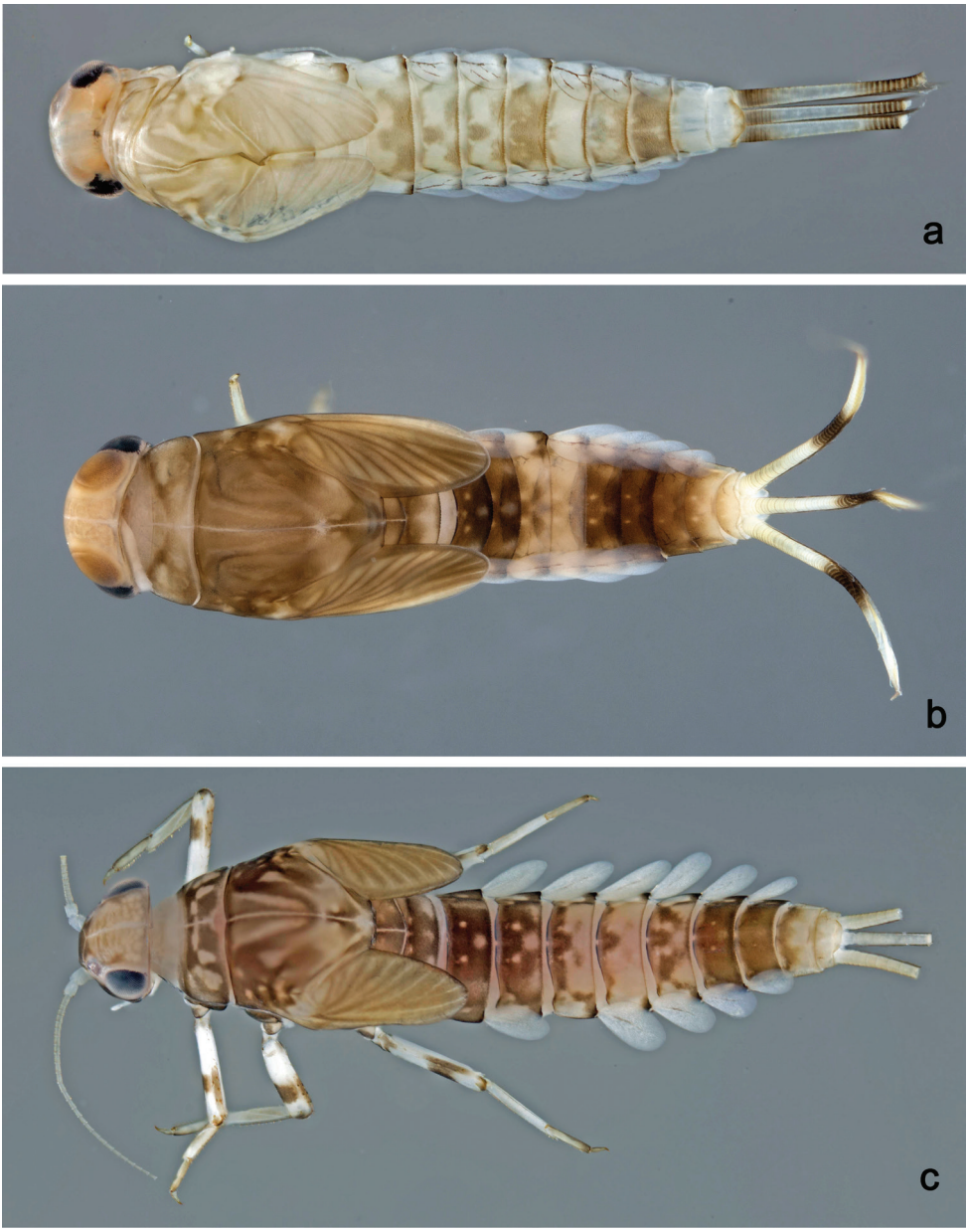

Figure 41. Habitus, larvae, dorsal view **a** *Labiobaetis dalisay* sp. nov. **b** *Labiobaetis acei* sp. nov. **c** *Labiobaetis aldabae* sp. nov.

sp. nov., *L. delocadoi* sp. nov., *L. freitagi* sp. nov. and *L. pelingeni* sp. nov. An exception is *L. aldabae* sp. nov., where we found a genetic distance up to 5% between different locations on the same island (Luzon) and 6% between locations on different islands (Luzon and Negros).

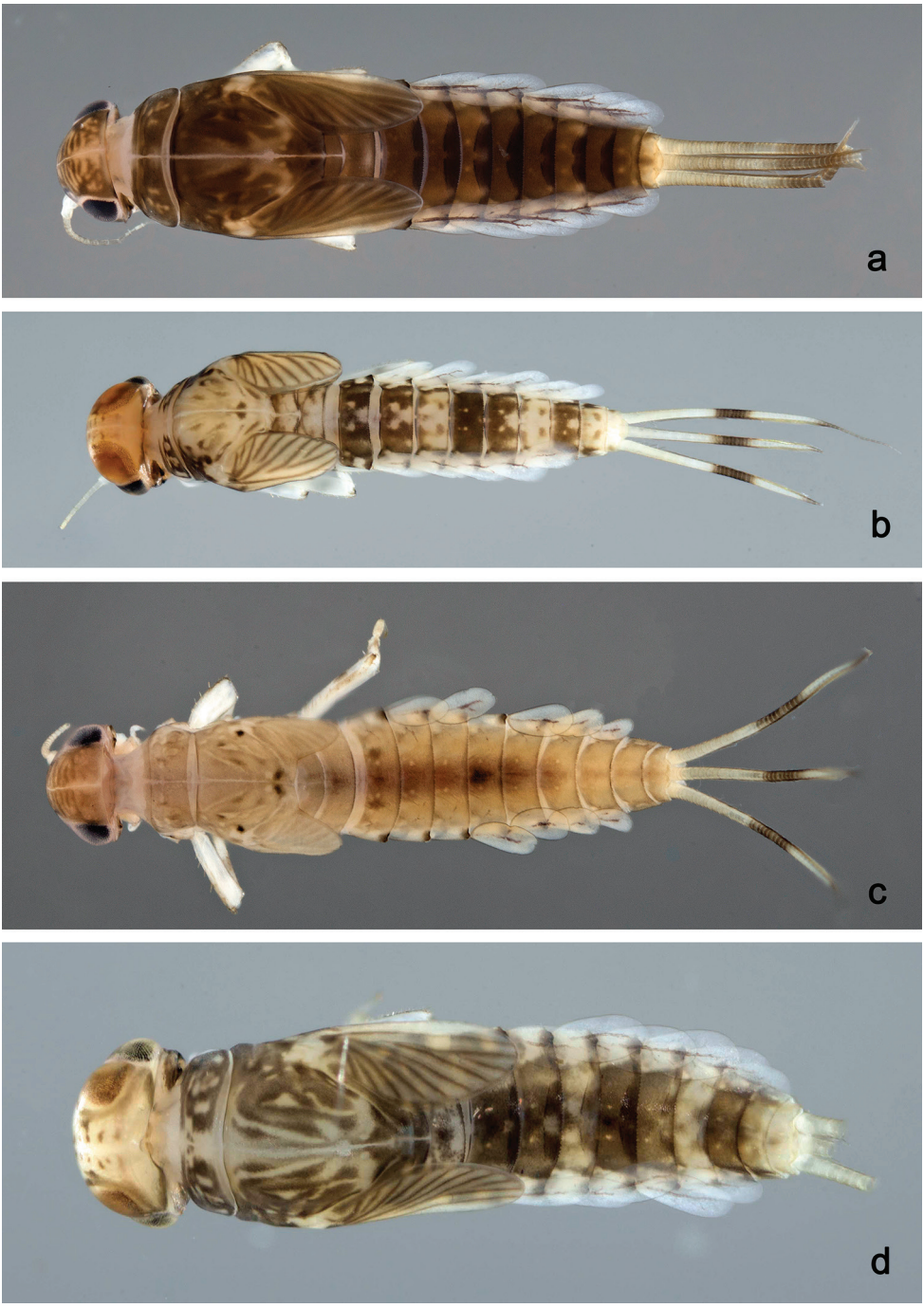

Figure 42. Habitus, larvae, dorsal view **a** *Labiobaetis camiguinensis* sp. nov. **b** *Labiobaetis lachicae* sp. nov. **c** *Labiobaetis palawano* sp. nov. **d** *Labiobaetis sabordoi* sp. nov.

Figure 43. Habitus, larvae, dorsal view **a** *Labiobaetis gamay* sp. nov. **b** *Labiobaetis pangantihoni* sp. nov. **c** *Labiobaetis tagbanwa* sp. nov.

Discussion

Assignment to *Labiobaetis*

For the assignment of the new species to *Labiobaetis* we refer to Kluge and Novikova (2014), Müller-Liebenau (1984) and McCafferty and Waltz (1995). *Labiobaetis* is

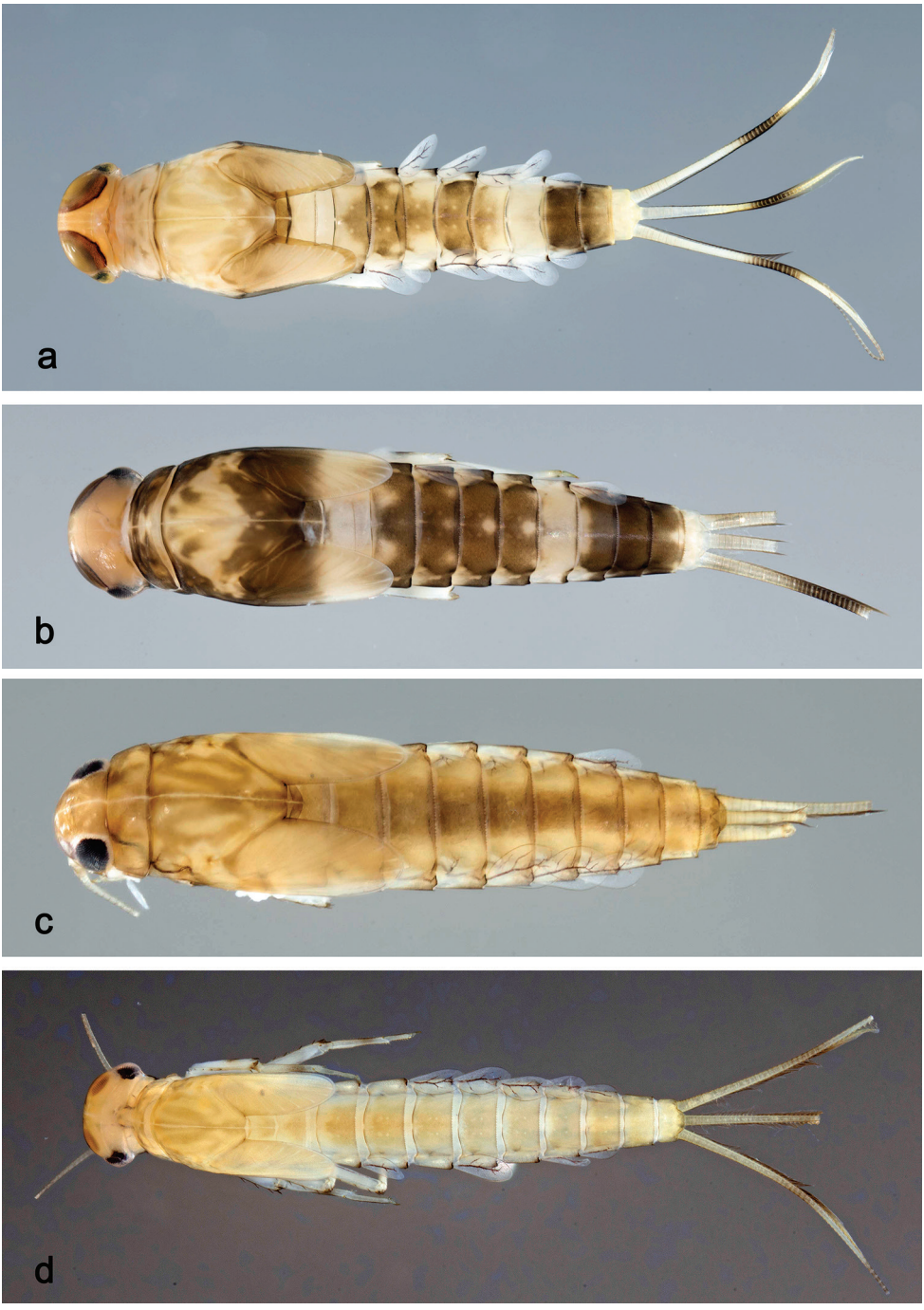

Figure 44. Habitus, larvae, dorsal view **a** *Labiobaetis valdezorum* sp. nov. **b** *Labiobaetis wantzeni* sp. nov. **c** *Labiobaetis baganii* sp. nov. **d** *Labiobaetis delocadoi* sp. nov.

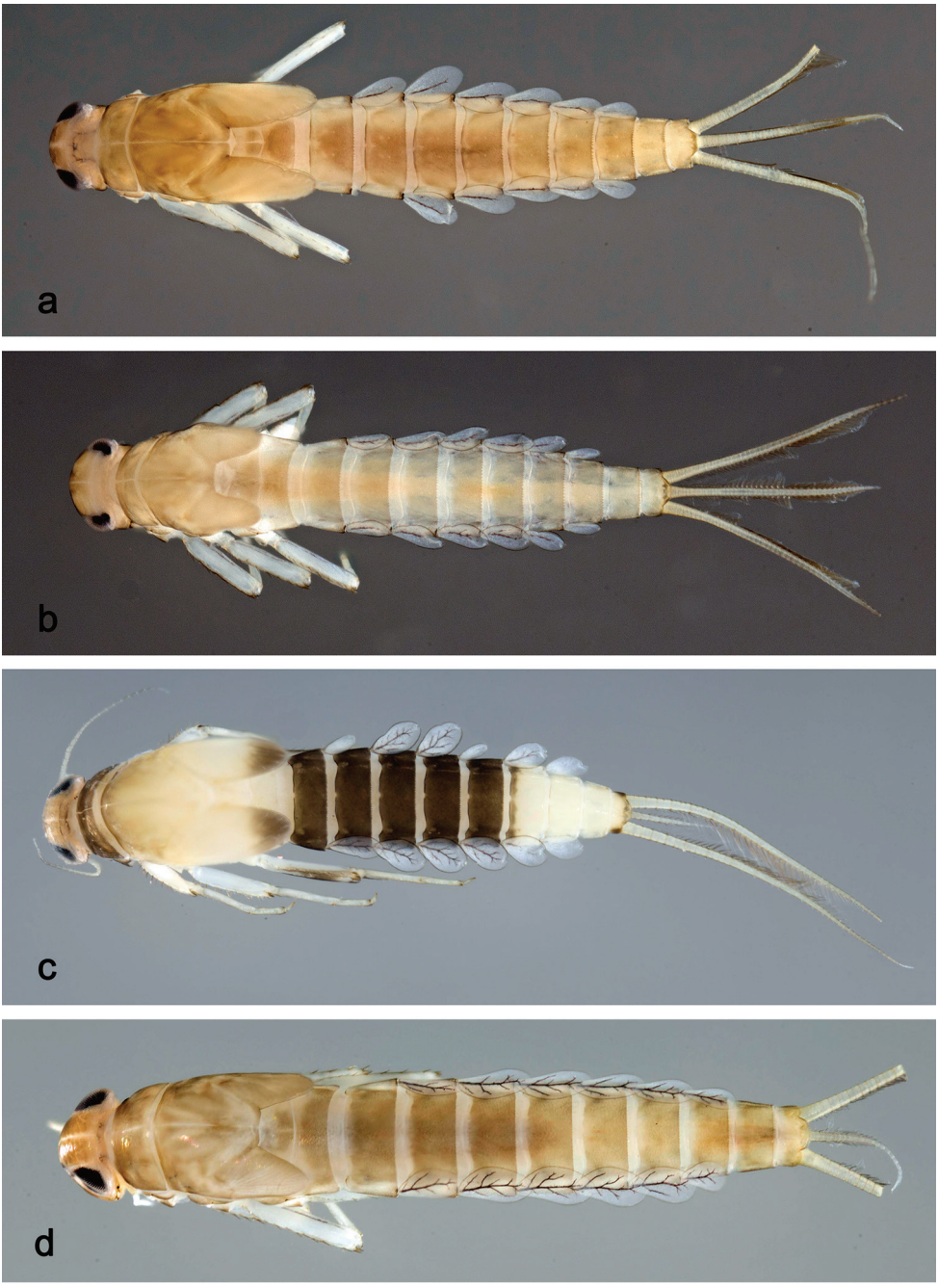

Figure 45. Habitus, larvae, dorsal view **a** *Labiobaetis freitagi* sp. nov. **b** *Labiobaetis pelingeni* sp. nov. **c** *Labiobaetis giselae* sp. nov. **d** *Labiobaetis mendozai* sp. nov.

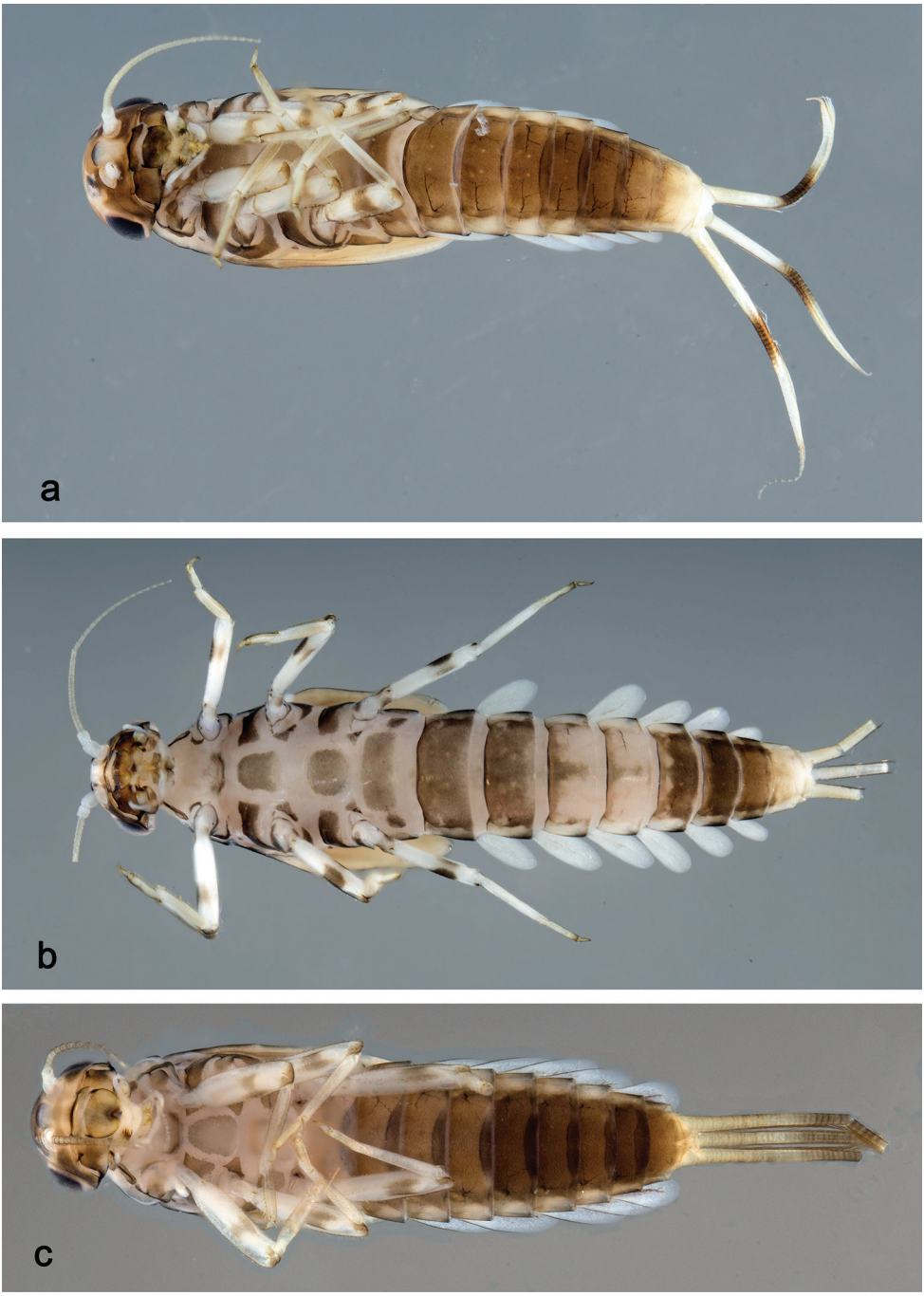

Figure 46. Habitus, larvae, ventral view **a** *Labiobaetis acei* sp. nov. **b** *Labiobaetis aldabae* sp. nov. **c** *Labiobaetis camiguinensis* sp. nov.

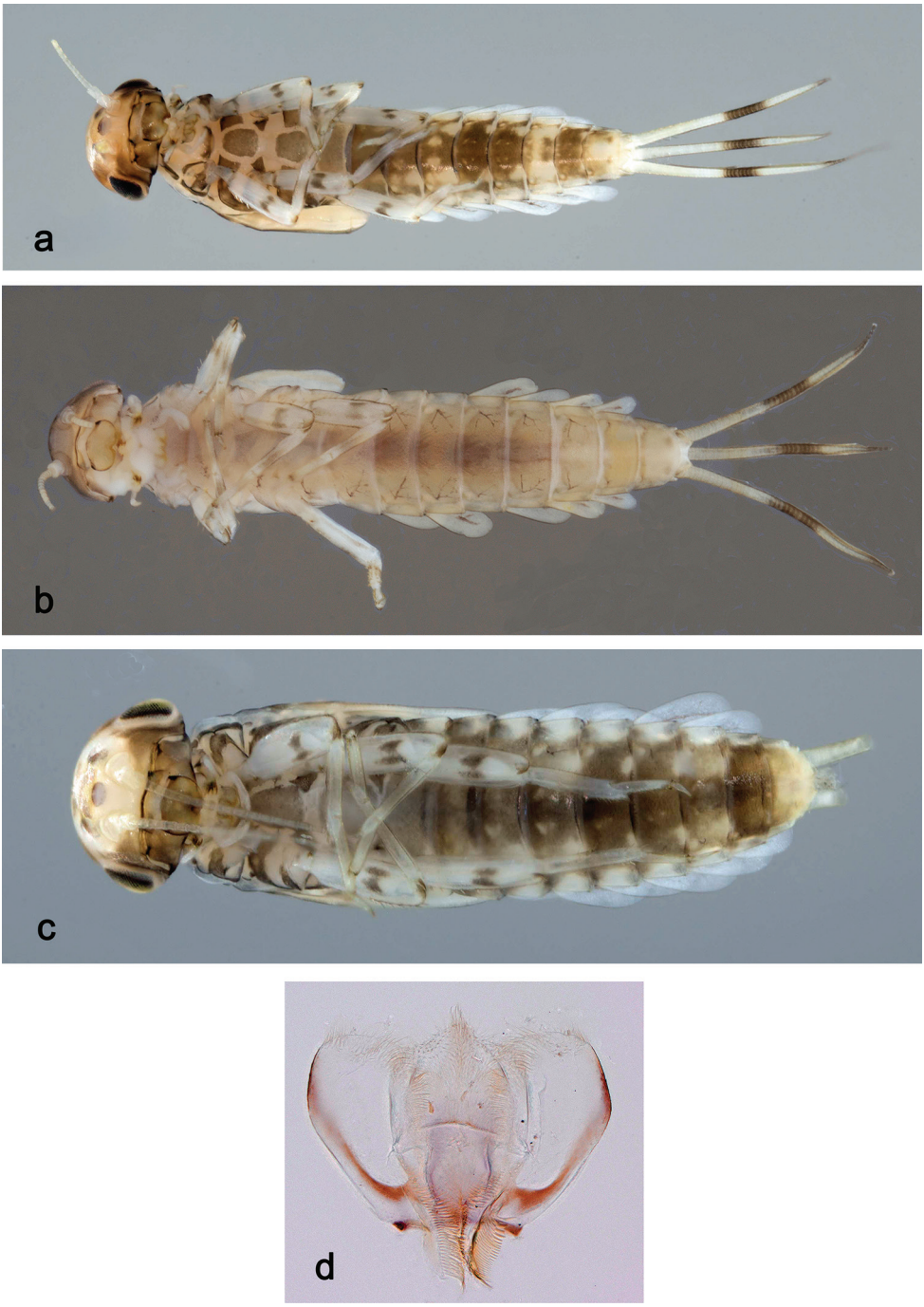

Figure 47. Habitus, larvae, ventral view **a** *Labiobaetis lachicae* sp. nov. **b** *Labiobaetis palawano* sp. nov. **c** *Labiobaetis sabordoi* sp. nov. **d** Hypopharynx and superlinguae of *Labiobaetis camiguinensis* sp. nov.

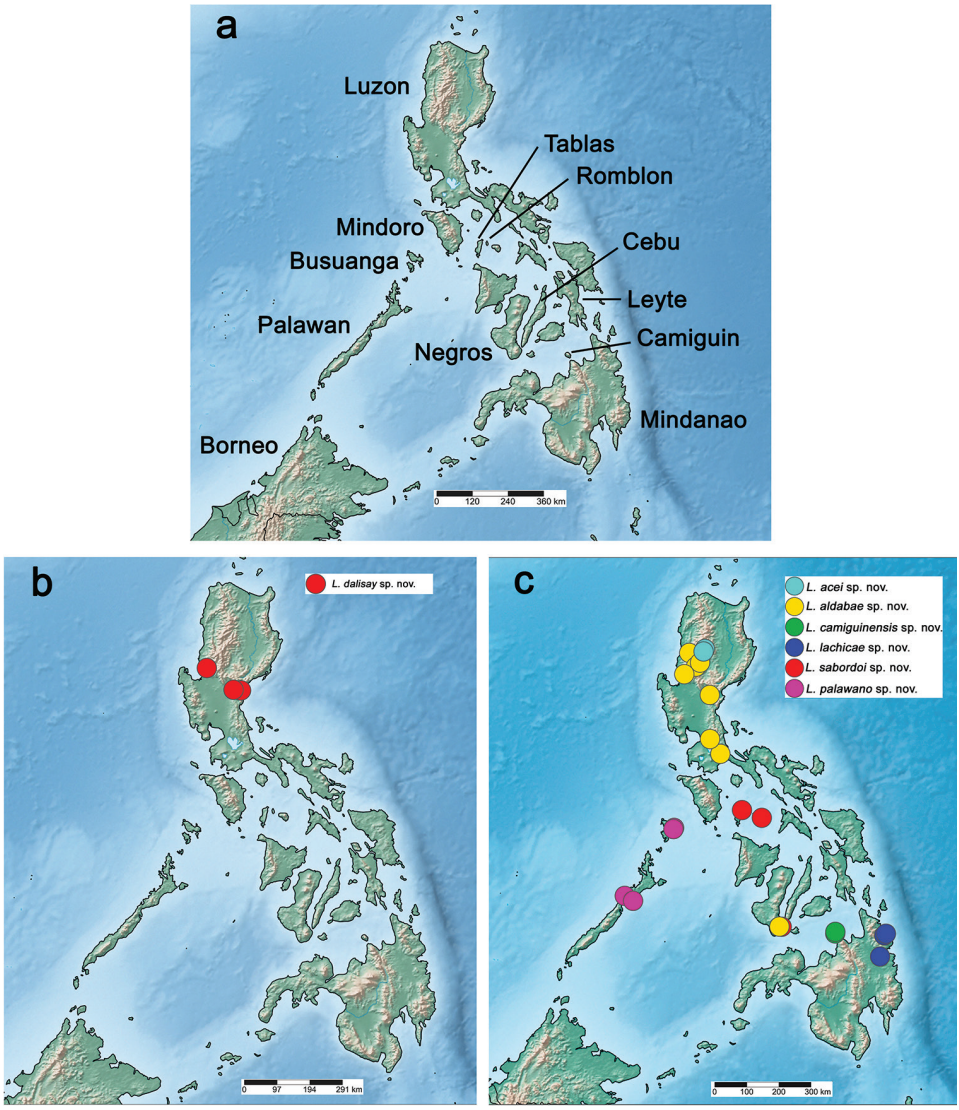

Figure 48. Distribution of *Labiobaetis* in the Philippines **a** Philippines, overview **b** Group *dendrisetis* **c** Group *numeratus*.

characterized by a number of derived characters, some of which are not found in other taxa (Kluge and Novikova 2014): antennal scape sometimes with a distolateral process (Fig. 2h); maxillary palp two segmented with excavation at inner distolateral margin of segment II, excavation may be poorly developed or absent (Fig. 2n–p); labium with paraglossae widened and glossae diminished; labial palp segment II with distomedial protuberance (Fig. 2i–m). All these characters vary and may be secondarily lost (Kluge and Novikova 2014). The concept of *Labiobaetis* is also based on additional characters, summarized and discussed in Kaltenbach and Gattolliat (2018, 2019).

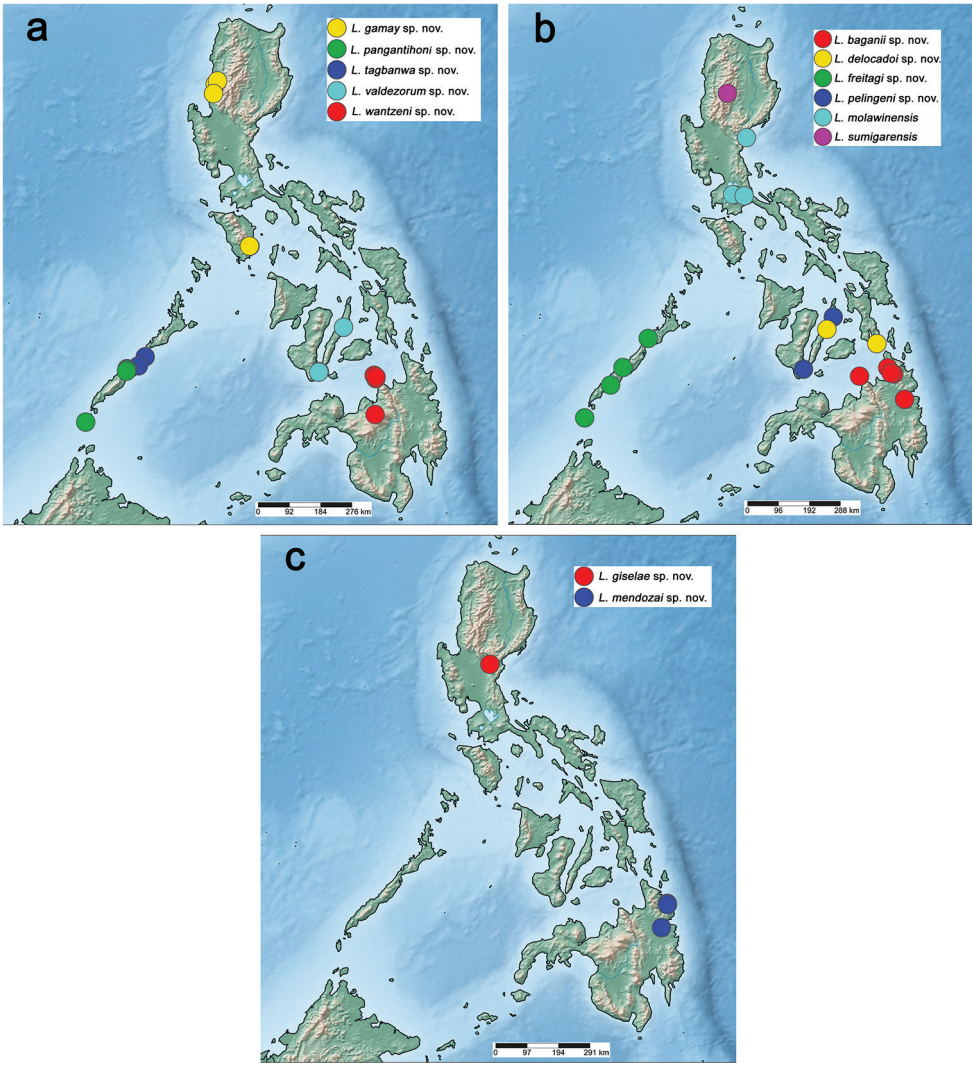

Figure 49. Distribution of *Labiobaetis* in the Philippines **a** Group *operosus* **b** Group *sumigarensis* **c** Group *vallus*.

From the 16 species of *Labiobaetis* (or previously assigned to *Pseudocloeon*) only known at the imaginal stage, one was described from the Philippines (Mindanao; *Pseudocloeon boettgeri Ulmer*, 1924). As the identification of the imaginal stage of *Labiobaetis* is generally very difficult, we consider it unrealistic to safely associate the larval stage with old type material at the imaginal stage. In this case, rearing material will provide little help. Furthermore, the generic assignment of the species remains questionable. Therefore, we did not take this species into account in our study and wait for an eventual clarification of its status in the future by using ancient DNA methods.

Species groups

The morphological groups within *Labiobaetis* are primarily a working tool but could also serve as a basis for future studies on the generic delimitation and phylogeny of this genus. The inclusion of nuclear gene sequences may prove that some are natural groups. Most of the species in the Philippines belong to three different groups only, six to the *numeratus* group, five to the *operosus* group, and six to the *sumigarensis* group. These groups are widespread and highly diversified in Asia. Species of the *numeratus* group are also known from Sri Lanka, Malaysia, Indonesia and China, species of the *operosus* group from Malaysia and Indonesia and species of the *sumigarensis* group from India, Sri Lanka, Malaysia, Indonesia, Brunei, China and Taiwan (Müller-Liebenau 1984; Müller-Liebenau and Hubbard 1985; Kang et al. 1994; Shi and Tong 2014; Kubendran et al. 2015; Kaltenbach and Gattolliat 2019, 2020). None of these groups are known from New Guinea (Kaltenbach and Gattolliat 2018).

Interestingly, a few of these newly described species share characters with the fauna of New Guinea. *Labiobaetis dalisay* sp. nov. shares the dendritic setae on the dorsal surface of the labrum with *L. dendrisetis* Kaltenbach & Gattoliat from New Guinea; it also has a similar labial palp and maxillary palp and seven pairs of gills (Kaltenbach and Gattolliat 2018). So far, *L. dendrisetis* is the only species with seven pairs of gills in New Guinea. Therefore, we erect the *dendrisetis* group of species including these two species. However, there are also important differences between the two species: *L. dalisay* sp. nov. has a well-developed scape process, hind protoptera and a femoral patch, while *L. dendrisetis* is missing these characters. Because of these important differences, especially the absence of a femoral patch in *L. dendrisetis*, we consider this group to be preliminary. Further species with dendritic setae either from the Philippines or from New Guinea may clarify the validity of this group in the future.

Labiobaetis giselae sp. nov. and *L. mendozai* sp. nov. share the lanceolate setae on the dorsal surface of the labrum with *L. vallus* Kaltenbach & Gattolliat from New Guinea, have a similar labial palp and also no scape process, no hind protoptera and six pairs of gills (Kaltenbach and Gattolliat 2018). We therefore erect the *vallus* group of species to include these three species. The lanceolate, apically pointed setae on the dorsal surface of the labrum as well as the short paracercus (unknown in *L. vallus*) are unusual in *Labiobaetis*, but the protogonostyli developing under the larval cuticle of male late instar larvae of *L. mendozai* sp. nov. are folded as in the *Labiobaetis* type (Kluge 2004: fig. 29I) and all three species have a distolateral protuberance on segment II of the labial palp, which is an important character of *Labiobaetis*. Therefore, we have no doubt concerning the assignment of these species to *Labiobaetis*.

Genetic distance

In general, the genetic distances between the different species of *Labiobaetis* in the Philippines are rather high, between 15% and 27% (K2P, Table 3), which is in line with the genetic distances found in New Guinea (average 22%; Kaltenbach and Gat-

tolliat 2018), Indonesia (11%–24%; Kaltenbach and Gattolliat 2019) and Borneo (19%–25%; Kaltenbach and Gattolliat 2020). Ball et al. (2005) reported a mean interspecific, congeneric distance of 18% for mayflies from the United States and Canada. The intraspecific distances are mostly very low as expected, ranging from 0 % to 3% (K2P). This result is certainly biased as it is based on a limited number of sequenced specimens per species, which were often from a single population. The exception is *L. aldabae* sp. nov. with up to 5% genetic distance between different locations on the same island (Luzon) and 6% between locations on Luzon and Negros (Fig. 48c). Here, the larger genetic distance may be explained by a possible isolation of some locations in northern mountainous areas of Luzon, while others may be connected between themselves and to other locations in the South, as well as by the geographic distance and probably stronger isolation between the islands of Luzon and Negros. Interestingly, the location with a genetic distance of 5% to other locations in Luzon has a genetic distance of only 2% to the sequenced specimen in Negros. Intraspecific distances of 4%–6% were also reported in some cases for *Labiobaetis* species in New Guinea, Indonesia and Borneo (Kaltenbach and Gattolliat 2018, 2019, 2020), as well as in aquatic beetles in the Philippines (Komarek and Freitag 2020). Ball et al. (2005) also reported a case with 6% intraspecific distance in a mayfly in North America and intraspecific K2P distances of more than 3.5% are not uncommon within Plecoptera as well (Gill et al. 2015; Gattolliat et al. 2016).

In addition to the species described in this paper, we obtained nine COI sequences with clearly interspecific genetic distance to other specimens with the same morphology. To give a more complete view on the diversity, including this cryptic diversity, we are presenting them as Molecular Operational Taxonomic Units (MOTUs) based on genetic evidence only (COI; Table 4). MOTUs were originally defined and used to investigate and cluster the enormous diversity of small organisms like nematodes or foraminifera (Floyd et al. 2002, Blaxter et al. 2005, Morard et al. 2016). All identified MOTUs of *Labiobaetis* belong to the dominant species groups of the Philippines (group *numeratus*, *operosus*, and *sumigarensis*). Because of the absence of morphological support, they remain as species hypotheses for now without further treatment in this paper. Additional material and investigations will be necessary to confirm their status in the future.

Biogeography and endemicity

As mentioned above, of the 21 species of *Labiobaetis* known from the Philippines, six belong to the *numeratus* group, five to the *operosus* group and six to the *sumigarensis* group. All these groups are widespread and highly diversified in Southeast Asia. Members of *sumigarensis* and *operosus* group are also known from Borneo (Kaltenbach and Gattolliat 2020) and members of *numeratus* group from Sumatra and Sulawesi (Kaltenbach and Gattolliat 2019). From Taiwan only one species of the *sumigarensis* group and other species without relation to the Philippines are known (Kang et al. 1994; Kang and Yang 1996) and none of these groups are represented in New Guinea

Table 4. Molecular Operational Taxonomic Units (MOTUs) of *Labiobaetis* in the Philippines.

MOTU denomination	Species group	Locality	Specimens catalog #	GenBank # (COI)	GenSeq Nomenclature
L. cf. *lachicae* sp. nov. I	*numeratus* group	Philippines: Mindanao	GBIFCH 00654893	MT830932	genseq-4 COI
L. cf. *aldabae* sp. nov. I	*numeratus* group	Philippines: Luzon	GBIFCH 00654905	MT830934	genseq-4 COI
L. cf. *wantzeni* sp. nov. I	*operosus* group	Philippines: Mindanao	GBIFCH 00654876	MT830931	genseq-4 COI
L. cf. *wantzeni* sp. nov. II	*operosus* group	Philippines: Mindanao	GBIFCH 00763665	MT830937	genseq-4 COI
L. cf. *wantzeni* sp. nov. III	*operosus* group	Philippines: Mindanao	GBIFCH 00763666	MT830938	genseq-4 COI
L. cf. *baganii* sp. nov. I	*sumigarensis* group	Philippines: Camiguin	GBIFCH 00654887	MT830933	genseq-4 COI
L. cf. *delocadoi* sp. nov. I	*sumigarensis* group	Philippines: Negros	GBIFCH 00654890	MT830935	genseq-4 COI
L. cf. *pelingeni* sp. nov. I	*sumigarensis* group	Philippines: Luzon	GBIFCH 00763654	MT830936	genseq-4 COI
L. cf. *molawinensis* I	*sumigarensis* group	Philippines: Mindanao	GBIFCH 00763673	MT830939	genseq-4 COI

(Kaltenbach and Gattolliat 2018). This points to the direction of a single or very limited colonisation events for each of these groups in the past from Southeast Asia, probably facilitated by the at least partial land bridges between the Philippines and Borneo during Pleistocene (Brown and Diesmos 2010), and followed by local radiation in the Philippines. Additionally, there could have been a limited stepping-stone exchange between the Philippines and New Guinea, as we found members of the group *vallus* and *dendrisetis* on both these archipelagos (Kaltenbach and Gattolliat 2018) and both groups are not known from anywhere else.

Based on the present data, all the Philippine *Labiobaetis* species are endemic to the Philippines. Moreover, most species (14) are restricted to one island. Although partly due to localities missing in this study, island endemics are quite common among aquatic insect species of the Philippines (Freitag and Balke 2011; Freitag 2013; Freitag and Zettel 2013; Komarek and Freitag 2014, 2020; Vidal et al. 2017; Garces et al. 2018, 2020; Pelingen and Freitag 2020). This island endemic pattern suggests allopatry as a major driver of speciation, as already discussed for *Labiobaetis* in New Guinea and in Indonesia (Kaltenbach and Gattolliat 2018 and citations therein, Kaltenbach and Gattolliat 2019).

In a few cases, we have more than one species of the same species group occuring on the same island: *L. acei* sp. nov. and *L. aldabae* sp. nov. from *numeratus* group on Luzon; *L. sumigarensis* and *L. molawinensis* from *sumigarensis* group on Luzon. Moreover, we have additional diversity as MOTUs partly sharing the same species groups and islands (Table 4). Although the high diversity in Luzon can be considered as sampling bias given that most expeditions and course projects of the Ateneo laboratory were done in Luzon, it may also be due to the diversity of sampling habitats included. Among the material examined, samples from Luzon have the highest altitudes (up to 1,800 m). This indicates that there are certainly other mechanisms of speciation involved as well, such as differentiation along elevational and environmental gradients or rising and falling sea levels between mid to late Pleistocene with subsequent separation and re-connection of islands (Brown and Diesmos 2010). In a recent study of the structuration of the mayfly community on three neighbouring volcanos in Sumatra,

elevation was found to be the only factor driving the within-species genetic structuring of two species of Baetidae and an important factor for two others (Gueuning et al. 2017). On the same volcanos, Kaltenbach et al. (2020) reported two different species of *Procerobaetis* Kaltenbach & Gattolliat, 2020, at different elevations and ecological conditions, which points to the direction that these factors could be drivers of speciation. In the caddisfly genus *Hydropsyche* Pictet, 1834 Mey (2003) reported adaptive radiation of the *hamifera* group from spring brooks in the highest mountains to the slowly flowing sections in the lowlands in Luzon that gave rise to the high species diversity on the island.

We also have cases of species, which are distributed on more than one island: *L. baganii* sp. nov. and *L. wantzeni* sp. nov. both on Mindanao and Camiguin and with a genetic distance of 2% between the islands; *L. sabordoi* sp. nov. on Negros and Romblon (K2P 1%); *L. aldabae* sp. nov. on Luzon and Negros (K2P 2%–6%); *L. gamay* sp. nov. on Luzon and Mindoro (K2P 0%–1%); *L. pelingeni* sp. nov. on Negros and Cebu (K2P 3%); *L. delocadoi* sp. nov. on Cebu and Leyte (K2P 2%). Based on the small genetic distances and the mostly close geographic distances, these cases suggest either current or remnant intra-archipelagic dispersal crossing sea channels. Interestingly, most of these island pairs do not belong to the same intra-Philippine biogeographic region (Greater Luzon, Greater Mindoro, Romblon, West Visayas, Camiguin, and Greater Mindanao) (Ong et al. 2002). Even the smaller islands (Camiguin, Romblon) included here were never connected by aggregate to islands complexes during Pleistocene. We can also expect that additional data may increase the number of species present on more than one island.

Four species in Palawan offer an interesting zoogeographic affinity based on morphology. The morphology of *L. freitagi* sp. nov. (*sumigarensis* group) is closer to *L. delocadoi* sp. nov. than to the species from Borneo (Kaltenbach and Gattolliat 2020). The morphology of *L. palawano* sp. nov. (*numeratus* group) presents more affinities with *L. sabordoi* sp. nov., *L. acei* sp. nov. and *L. aldabae* sp. nov. than with the species from Indonesia (Kaltenbach and Gattolliat 2019). The morphologies of *L. tagbanwa* sp. nov. and *L. pangantihoni* sp. nov. (*operosus* group) do not show more similarities with other species from the Philippines than to *L. dayakorum* Kaltenbach & Gattolliat from Borneo and *L. paraoperosus* Kaltenbach & Gattolliat from Sumatra (Kaltenbach and Gattolliat 2019, 2020). This suggests that at least *L. freitagi* sp. nov. and *L. palawano* sp. nov. are part of the local radiation in the Philippines and are not remaining species from a possible colonisation across the Palawan land bridge during Pleistocene.

The number of sampled localities and different habitats is still limited and there are regions without any collection activities so far (Figs 48, 49). High-altitude gradients can be found on several islands in the Philippines, incl. the under-sampled Mindanao and Palawan. In addition, we have nine species hypotheses based on genetics only (MOTUs, Table 4), which may be confirmed as valid species in the future. Therefore, we can expect that the number of *Labiobaetis* species in the Philippines will continue to increase substantially with further collections.

Acknowledgements

This study was made possible with the Gratuitous Permits (GP 0133-17 and renewals) for the collection of aquatic wildlife as kindly issued by the Bureau of Fisheries and Aquatic Resources (BFAR), Quezon City and the Palawan Council for Sustainable Development, Puerto Princesa City (No. 2019-20). Prerequisite permissions were given by the respective local government units.

We sincerely thank Hendrik Freitag, Emmanuel Delocado, Clister V. Pangantihon, Arthien Lovell Pelingen, Marc Ryan Sabordo, and Kyra Mari Dominique Aldaba (AdMU, Philippines) for the assistance in the field and collection management. Additional precious materials were contributed by Ace Kevin Amarga (Philippines/Taiwan), Joseph Mendoza (Philippines), Wolfram Mey (Germany), and Karl Matthias Wantzen (France). We are deeply thankful to Lars Hendrich (Zoologische Staatssammlung München, ZSM, Germany) and Janice Peters (Florida A&M University, Tallahassee, USA) for the loan of *Labiobaetis* type material from Southeast Asia and Sri Lanka, to Frederico F. Salles for the structure of a DELTA database which we used for the development of our own database of *Labiobaetis*, and to Tanja Schwander (University of Lausanne, UNIL) for the possibility to work in her lab and for her general support. We are also grateful to Michel Sartori (MZL) for his constant interest and support for our project, and to Marion Podolak (MZL) and Maud Liégeois (University of Lausanne, UNIL) for their support with lab work and preparation of the COI barcodes.

Lastly, the authors are grateful to Cassandra Caedo (USA) for the corrections and improvements of the English language and to the reviewers for the recommendations and comments on the manuscript.

Expeditions and management of aquatic macroinvertebrate material in the AdMU Biodiversity Laboratory were partly supported by the German Academic Exchange Service (DAAD project BIO-PHIL 57393541) and School of Science and Engineering Industry 4.0 Research Fund (SI4-013).

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ZooKeys 1002: 115–158 (2020)
doi: 10.3897/zookeys.1002.50997
https://zookeys.pensoft.net

RESEARCH ARTICLE

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Snakes of the Pernambuco Endemism Center, Brazil: diversity, natural history and conservation

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Academic editor: R. Jadin | Received 10 February 2020 | Accepted 14 April 2020 | Published 10 December 2020

http://zoobank.org/56565B89-F2AA-4AD4-8012-0CBC274C1365

Citation: França RC, Morais M, França FGR, Rödder D, Solé M (2020) Snakes of the Pernambuco Endemism Center, Brazil: diversity, natural history and conservation. ZooKeys 1002: 115–158. https://doi.org/10.3897/zookeys.1002.50997

Abstract

The Atlantic Forest is one of the largest and richest tropical rainforests on the planet, being one of the 25 world priorities for conservation. The Atlantic Forest portion located north of the São Francisco River corresponds to the Pernambuco Endemism Center (PEC). We describe the snake composition of the PEC, providing information about the diversity, natural history and geographical distribution of the species, based on records from five scientific collections and additional information from the literature. A total of 78 species of snakes distributed in eight families was registered in the Pernambuco Endemism Center. The Caatinga is the Brazilian biome that most shares species with the PEC, followed by Cerrado. On the other hand, seven species are considered endemic of this region. Most of the snake species in the PEC have been registered in forest (94.8%), followed by "Brejos Nordestinos" (46.1%), Tabuleiros (43.5%), Restingas (14.1%) and Mangroves (5.1%). The PEC snake fauna includes mainly terrestrial species (60.2%) and cryptozoic and/or fossorial species (21.7%), but also presents a high richness of semi-arboreal and arboreal species (29.5%). Vertebrates are the main food item consumed by the species (78% of species), among the main prey are mammals, lizards, and amphibians. Most species show a strictly nocturnal activity period (50%), followed by strictly diurnal (38%). The PEC is the most degraded and least known region of the

Atlantic Forest, yet it has revealed a high richness of snake species, including seven endemic species. It is emphasized that regional conservation efforts need to be intensified, because few forests in the region are formally protected, and the majority consist of small and poorly protected fragments, which means that many species in the region may be in risk of extinction.

Keywords
biodiversity, inventory, geographic distribution, natural history, Serpentes, richness

Introduction

The Atlantic Forest is considered one of the 25 priority areas for conservation worldwide (Myers et al. 2000). This biome was one of the largest tropical forests in the Americas, originally covering 150 million hectares along the Brazilian coast and parts of Paraguay and Argentina (Silva and Casteleti 2003). Today, the Atlantic Forest has been reduced to less than 12% of its original coverage (Ribeiro et al. 2009). Even having suffered an extensive fragmentation since long time ago, the Atlantic Forest still presents a great biodiversity, housing one of the highest percentages of endemic species in the world (Morellato and Haddad 2000).

Although practically the entire Brazilian coast was occupied by European colonization, it was in the northeast that the Atlantic Forest was more rapidly degraded, due to the economic cycle of brazilwood and sugar cane (Coimbra-Filho and Câmara 1996). This degradation is even more evident in the portion of the Atlantic Forest located north of the São Francisco River, where an important center of endemism is located in South America – The Pernambuco Endemism Center (hereafter PEC) (Prance 1982, Silva and Casteleti 2003). In this region, sugar cane is the main agricultural crop and other anthropic actions, such as animal and plant extractivism, have contributed to the reduction of biodiversity in the PEC (Coimbra-Filho and Câmara 1996, Tabarelli et al. 2002, 2006a). In the midst of this scenario, the PEC is considered the most devastated, least known and least protected sector of the Atlantic Forest, being one of the regions on the planet where conservation efforts are most urgent (Coimbra-Filho and Câmara 1996, Tabarelli et al. 2002, 2005).

Among reptiles, snakes are the group that currently presents the most underestimated risks of extinction, due to the scarcity of information on the natural history of most species, mainly because they have long periods of inactivity, are difficult to observe and live in low population densities (Seigel 1993). Although some studies carried out on Atlantic forest remnants of the PEC have provided important information about snakes in this region (e.g. Moura et al. 2011, Pereira Filho and Montingelli 2011, França et al. 2012, Roberto et al. 2012, 2015, Rodrigues et al. 2015, Pereira Filho et al. 2017, Mesquita et al. 2018, Sampaio et al. 2018, Freitas et al. 2019a), the knowledge about the diversity, distribution and natural history of PEC snake species remains scarce and fragmented. In this direction, scientific collections perform a fundamental role in obtaining information that is the basis for the description of new species, biodiversity inventories and identification of endemism areas (Rocha et al. 2014).

Herein, we describe the snake composition at the Pernambuco Endemism Center, providing information about the diversity, natural history and geographical distribution of the species, based on records from scientific collections and additional information from the literature.

Materials and methods

Study area

The study area comprises the Atlantic Forest located north of the São Francisco River, which corresponds to the Pernambuco Endemism Center (PEC) (Fig. 1) (Prance 1982, Silva and Casteleti 2003), located between the states of Alagoas and Rio Grande do Norte. This region has a humid tropical climate (Köppen's As'), with autumn-winter rains and rainfall ranging from 750 to 1500 mm per year (Tabarelli et al. 2006a).

The PEC region is composed by different native forest formations and ecosystems associated with the Atlantic Forest domain. A mosaic of ombrophilous and semi-deciduous forests is present in this region (Tabarelli et al. 2006a). Also, PEC comprises the "Brejos de Altitude" or "Brejos Nordestinos", which are "islands" of humid forests established in the semi-arid region, surrounded by Caatinga vegeta-

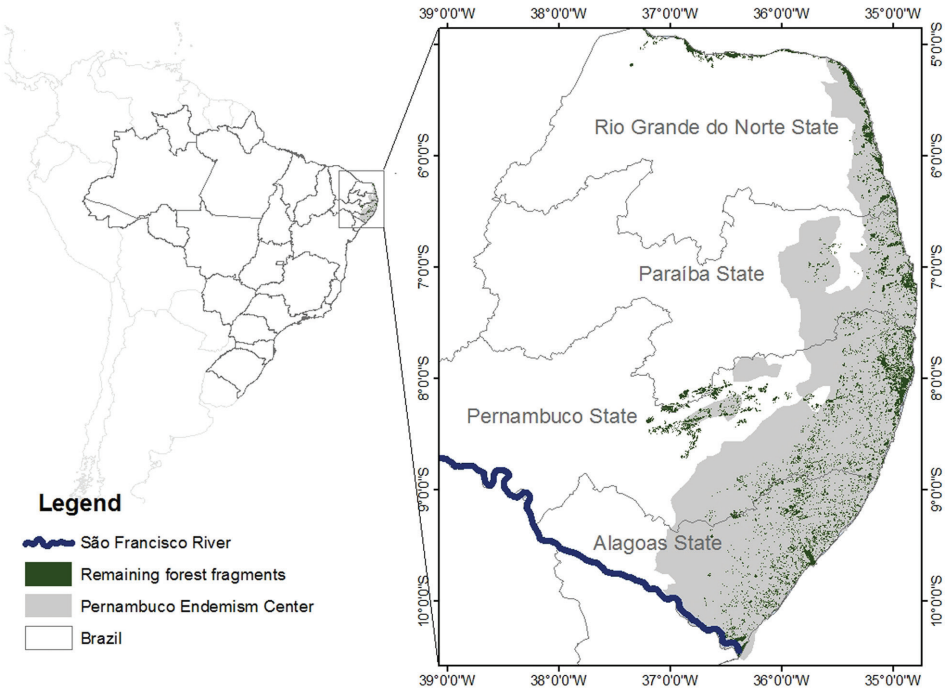

Figure 1. Map of the location of the Pernambuco Endemism Center, with the original coverage of Atlantic Forest (gray), and the actual remnants (green).

tion (Andrade-Lima 1982). Although the vegetation of the PEC is composed mainly of humid tropical forests, we can also find open physiognomies along the coast, which are called "Restingas", and in the interior, which are called "Tabuleiros". The restingas are formed by strips of beaches and dunes covered by herbaceous and shrubby vegetation (Araujo 1992). The Tabuleiros are considered natural enclaves of savannah, characterized by herbaceous vegetation, with scattered trees and shrubs or grouped in patches that are structurally similar to the coastal restingas, but without the marine influence (Andrade-Lima 1982). On the coast along the PEC, we can also find areas of mangroves, with a diversified aggregation of trees and shrubs that form the dominant plant communities in saline solution of the tides (Tabarelli et al. 2006b).

According to Uchoa Neto and Tabarelli (2002), the PEC presents the largest amount of remaining area of Atlantic Forest in the state of Pernambuco (1,363.23 km²), followed by the states of Alagoas (807.95 km²), Rio Grande do Norte (567.67 km²) and Paraíba (566.09 km²).

Data collection

The data presented here is the result of verification of 3,118 snake specimens deposited in five scientific collections (Coleção Herpetológica da Universidade Federal da Paraíba – UFPB; Coleção do Laboratório de Anfíbios e Répteis da Universidade Federal do Rio Grande do Norte - CLAR; Coleção Herpetológica do Museu de História Natural da Universidade Federal de Alagoas – MUFAL; Coleção Herpetológica da Universidade Federal Rural de Pernambuco – CHUFRPE; Coleção Herpetológica da Universidade Federal de Pernambuco – CHUFPE) and literature data.

The information on the distribution and occurrence of species in each environment were obtained through the records of the scientific collections and literature data, and was subsequently georeferenced. We include records of occurrence of species in the literature only when we were able to confirm the record by direct observation, photo or through museum records or documented vouchers. Information on diet, habitat use, and litter size of the species was obtained from personal data, records of scientific collections and literature data. We categorized the snake size considering the mean body size of each species based on published data as small (< 500mm), moderate (501–1000mm) and large (> 1001mm).

In this work, we have differentiated the habitats of the species into five vegetation physiognomies found in this region: Forests (when the species were found in areas with a typical forest physiognomy, with a large vegetation cover, reaching 35 meters high in the canopy, presenting epiphytes, lianas and bromeliads); Coastal Restingas; Mangroves; Tabuleiros; Brejos Nordestinos (remnants of humid forests scattered in the Caatinga) (Fig. 2); and urban areas. In addition, we compared the snake fauna found in the PEC with these of five other natural ecoregions in Brazil (Amazon, Caatinga, Cerrado, Pampas, and Pantanal). These regions are divided on the basis of geomorphology, climate, and vegetation (IBGE 2004).

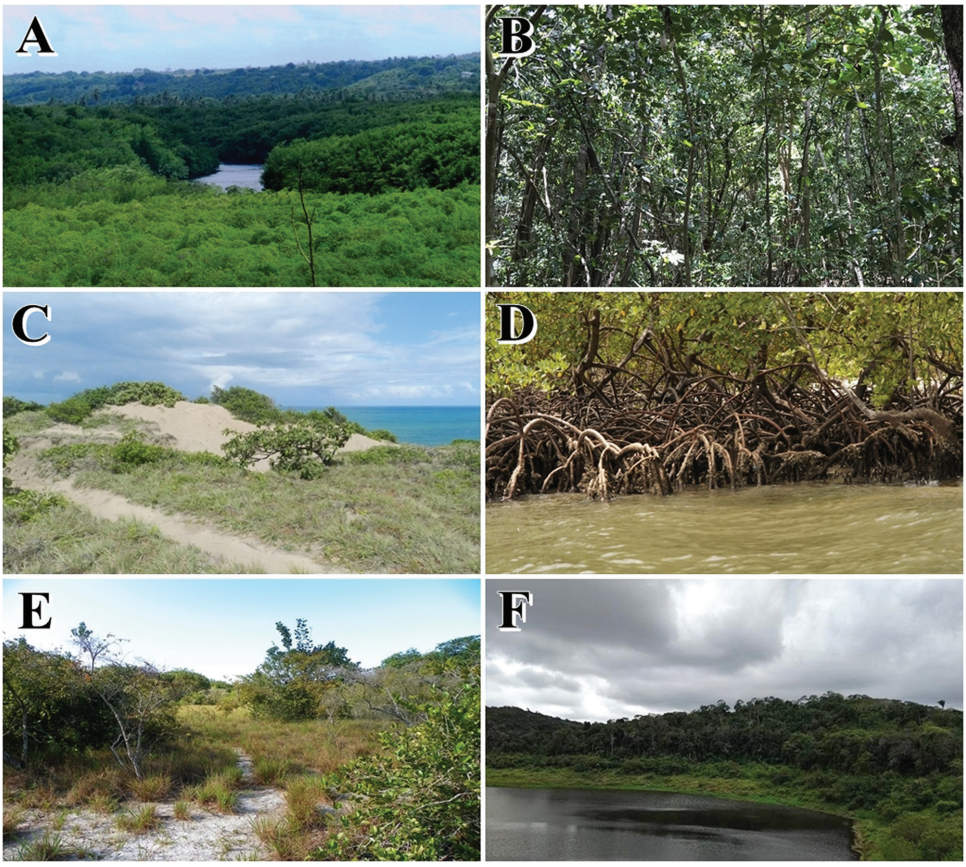

Figure 2. Vegetation physiognomies found in the Pernambuco Endemism Center. **A** forest **B** forest interior **C** Coastal Restingas **D** mangroves, **E** tabuleiros **F** Brejos Nordestinos. Photograph credits: Ivan L. Sampaio, in the Barra de Gramame (**A**), Frederico França, in the APA da Barra do Rio Mamanguape (**B, C**), Marcelo Melo, in the APA da Barra do Rio Mamanguape (**D**), Frederico França, in the Reserva Biológica Guaribas (**E**) and Adonias Teixeira, in the Parque Estadual Mata do Pau-Ferro (**F**).

Taxonomic considerations

The species *Caaeteboia* sp. found in the PEC, differs from *Caaeteboia amarali* (at present the only representative of the genus) mainly because it presents 15 rows of dorsal scales without reduction, while *C. amarali* presents 17 rows of dorsal scales without reduction. In addition, there is a strong variation between the number of ventral and subcaudal scales between the two species (Pereira Filho et al. 2017).

We decided to use the name *Micrurus ibiboboca* according to Silva Jr (2016). Although Silva Jr (2016) affirms that *M. ibiboboca* may be a species complex throughout the distribution of the species, the author still maintains the proper name. Thus, the species designated here as *M. ibiboboca* is the same mentioned in previous works as *Micrurus* aff. *ibiboboca* (e.g. França et al. 2012, Rodrigues et al. 2015, França and França 2019).

Results

We registered a total of 78 species of snakes of eight families, distributed in the PEC (Table 1, Figs 3–7). The most species rich family was Dipsadidae (47 species, 60% of total), followed by Colubridae (12 species, 15.4%), Viperidae (6 species, 7.7%), Boidae and Typhlopidae, both with four species (5.1%), Elapidae (3 species, 3.8 %) and Anomalepididae and Leptotyphlopidae, both with a single species (1.3%).

Figure 3. Snake species from the Pernambuco Endemism Center. **A** *Boa constrictor* **B** *Corallus hortulanus* **C** *Epicrates assisi* **D** *Epicrates cenchria* **E** *Chironius carinatus* **F** *Chironius exoletus* **G** *Chironius flavolineatus,* **H** *Dendrophidion atlantica* **I** *Drymarchon corais* **J** *Drymoluber dichrous* **K** *Leptophis ahaetulla* **L** *Palusophis bifossatus* **M** *Oxybelis aeneus* **N** *Spilotes pullatus* **O** *Spilotes sulphureus*. Photograph credits: Frederico França (**A, B, E, F, G, J, L, M, N, O**), Vanessa Nascimento (**D**), Davi Pantoja (**C, H, I**), Rafaela França (**K**).

Table 1. Summary of the Information of Natural History of the Snakes in the Pernambuco Endemism Center. Abbreviations are: Habitats (BN = Brejos Nordestinos, F = forest, Tb = Tabuleiro, Rt = Restinga, Mg = Mangrove); Diet (abn = amphisbaenians, amp = amphibians, ann = annelids, art = arthropods, bi = birds, fi = fishes, mo = mollusks, li = lizards, mam = mammals, sn=snakes; Activity period (D = Diurnal, N = Nocturnal); Habits (AB = arboreal, SAB = semi-arboreal, AQ = aquatic, SAQ = semi-aquatic, CR = cryptozoic, FS = Fossorial, TE = terrestrial). * Endemic species of the Pernambuco Endemism Center (PEC).

Family/Species	Habitats	Diet	Habits	Diel activity
Anomalepididae				
Liotyphlops trefauti	F	art	FS	N
Boidae				
Boa constrictor	BN, F, Tb, Rt	mam, li, bi	SAB, TE	D, N
Corallus hortulanus	F	mam, bi, li, amp	AB	N
Epicrates assisi	BN, F, Tb	mam, li, bi	TE	N
Epicrates cenchria	F	mam, bi, li, amp	TE, SAB	N
Colubridae				
Chironius carinatus	F	amp, bi, li, mam	TE, AB	D
Chironius exoletus	BN, F, Tb	amp, li	AR, TE	D
Chironius flavolineatus	BN, F, Tb	amp	SAB	D
*Dendrophidion atlantica**	F	–	TE	D
Drymarchon corais	F, Tb	amp, abn li, sn, bi, mam	TE	D
Drymoluber dichrous	BN, F, Tb	li, amp	TE	D
Leptophis ahaetulla	BN, F	amp, li	AB,TE	D
Oxybelis aeneus	BN, F, Tb	li, amp, fi	AB	D
Palusophis bifossatus	F, BN	amp, mam, li	TE	D
Spilotes pullatus	BN, F, Tb	mam, bi	SAB	D
Spilotes sulphureus	F	mam, bi	SAB	D
Tantilla melanocephala	BN, F, Tb, Rt	art	FS	D, N
Dipsadidae				
Apostolepis cearensis	F, Tb	sn, abn	FS	D
Apostolepis longicaudata	F	sn	FS	D
*Atractus caete**	F	ann	FS	N
Atractus maculatus	F	ann	FS	N
Atractus potschi	F	ann	FS	N
Boiruna sertaneja	Tb, F	sn, li, mam	TE	N
Caaeteboia sp.*	F	–	TE	D
Dipsas mikanii	BN, F, Tb	mo	TE	N
Dipsas neuwiedi	F, BN	mo	TE	N
Dipsas sazimai	F	mo	AB, TE	N
Dipsas variegata	F	mo	AB, TE	N
*Echinanthera cephalomaculata**	F	amp	TE	D
Echinanthera cephalostriata	F	amp	TE	D
Erythrolamprus aesculapii	F	sn, li	TE	D
Erythrolamprus almadensis	F	amp	SAQ	D
Erythrolamprus miliaris	F, BN	amp, fi	SAQ	D, N
Erythrolamprus poecilogyrus	BN, F, Tb, Mg	amp, li	TE	D, N
Erythrolamprus reginae	F	amp, li, fi	SAQ	D
Erythrolamprus taeniogaster	F, Tb, Rt	amp, fi	SAQ	D
Erythrolamprus viridis	BN, F	amp, li	TE	D
Helicops angulatus	F, Mg, Rt	fi, amp	AQ	N
Helicops leopardinus	Rt, F	fi, amp	AQ	N
Hydrodynastes gigas	F, Rt	amp, fi, sn, mam	AQ, TE	D
Imantodes cenchoa	F, Tb	li, amp	AB	N
Leptodeira annulata	F, Rt, BN	amp, li	AB, TE	N
Lygophis dilepis	BN, F	amp	TE	D

Family/Species	Habitats	Diet	Habits	Diel activity
Oxyrhopus guibei	BN, F, Tb	mam, li	TE	D, N
Oxyrhopus petolarius	BN, F, Tb	li, mam, bi, amp	TE	N
Oxyrhopus trigeminus	BN, F, Tb, Rt,	li, mam, bi	TE	D, N
Philodryas nattereri	BN, F, Tb	li, mam, amp, sn, bi	TE, SAB	D
Philodryas olfersii	BN, F, Tb, Mg	amp, li, bi, mam	TE, SAB	D
Philodryas patagoniensis	F, Tb, Rt	amp, li, mam, bi, sn	TE	D
Phimophis guerini	F, Tb	li, mam	TE	N
Pseudoboa nigra	BN, F, Tb	li, mam, sn	TE	N
Psomophis joberti	F	amp, li	TE	D
Sibon nebulatus	F, Tb	mo	AB	N
Siphlophis compressus	F, Tb	li, sn	AB, TE	N
Taeniophallus affinis	BN, F, Tb	li, amp, abn, mam	CR	N
Taeniophallus occipitalis	BN, F, Tb	li, amp, abn	CR	N
Thamnodynastes almae	BN	amp, li	AB, TE	N
Thamnodynastes hypoconia	BN	amp, li	TE, AB	N
Thamnodynastes pallidus	F, Tb	amp	TE, AB	N
Thamnodynastes phoenix	BN	amp	TE, AB	N
Xenodon merremii	BN, F, Tb	amp	TE	D
Xenodon rabdocephalus	F	amp	TE	D
Xenopholis scalaris	F	amp	TE	N
Xenopholis undulatus	BN, F	amp	TE	N
Elapidae				
Micrurus corallinus	F	abn, li, sn, amp	CR	D
Micrurus ibiboboca	BN, F, Tb	abn, sn, li	CR	D, N
*Micrurus potyguara**	F, Tb	sn	CR	D, N
Leptotyphlopidae				
Epictia borapeliotes	F, BN, Rt	art	FS	D, N
Typhlopidae				
Amerotyphlops amoipira	Rt	art	FS	N
Amerotyphlops arenensis	BN, F	art	FS	N
Amerotyphlops brongersmianus	F, Tb	art	FS	N
Amerotyphlops paucisquamus	F, Tb	art	FS	N
Viperidae				
Bothrops bilineatus	F	mam, amp, bi, sn, li	AB	N
Bothrops erythromelas	F	li, mam	TE	N
Bothrops leucurus	F, BN, Tb, Mg	amp, li, sn, bi, mam	TE	N
*Bothrops muriciensis**	F	amp, mam	TE	N
Crotalus durissus	BN, F, Rt	mam	TE	N
Lachesis muta	F	mam	TE	N

Many species of snakes that are found in PEC are also found in other Brazilian biomes. The Caatinga (58 species, 74.3% found in PEC) is the Brazilian biome that shares most species with the PEC, followed by Cerrado (44 species, 56.4%), Amazon Forest (35 species, 44.9%), Pantanal (35 species, 44.9%) and Pampas (13 species, 16.6%). On the other hand, some species (*Atractus caete*, *A. maculatus*, *Bothrops muriciensis*, *Caaeteboia* sp., *Dendrophidion atlantica*, *Echinanthera cephalomaculata* and *Micrurus potyguara*) are found only in the PEC and are considered endemic of this region.

Most of the snake species in the PEC have been registered in Forest areas (74 species, 94.8%), followed by Brejos Nordestinos (36 species, 46.1%), Tabuleiros (34 species, 43.5%), Restingas (11 species, 14.1%) and Mangroves (4 species, 5.1%). Six spe-

Figure 4. Snake species from the Pernambuco Endemism Center. **A** *Tantilla melanocephala* **B** *Apostolepis cearensis* **C** *Apostolepis longicaudata* **D** *Atractus maculatus* **E** *Atractus potschi* **F** *Boiruna sertaneja* **G** *Caaeteboia* sp. **H** *Dipsas mikanii* **I** *Dipsas neuwiedi* **J** *Dipsas sazimai* **K** *Dipsas variegata* **L** *Erythrolamprus aesculapii* **M** *Erythrolamprus almadensis* **N** *Erythrolamprus poecilogyrus* **O** *Erythrolamprus reginae*. Photograph credits: Frederico França (**A, B, G, H, I**), Anderson A. Santos (**C, N**), Rafaela França (**D, E, J, K, L, M, O**), Paulo R. S. Freitas (**F**).

cies were found in four different habitats and 31 species were found only in one habitat type (Table 1). Of these, 26 species were collected only in forested areas, three species only in the Brejos Nordestinos and one species was found only in restingas (Table 1).

The majority of snake species found in the PEC use the soil as substrate, of which 47 species (60.2%) are terrestrial and 17 (21.7%) are cryptozoic and/or fossorial. In

Figure 5. Snake species from the Pernambuco Endemism Center. **A** *Erythrolamprus taeniogaster* **B** *Erythrolamprus viridis* **C** *Helicops angulatus* **D** *Helicops leopardinus* **E** *Hydrodynastes gigas* **F** *Imantodes cenchoa* **G** *Leptodeira annulata* **H** *Lygophis dilepis* **I** *Oxyrhopus guibei* **J** *Oxyrhopus petolarius* **K** *Oxyrhopus trigeminus* **L** *Philodryas nattereri* **M** *Philodryas olfersii* **N** *Philodryas patagoniensis* **O** *Phimophis guerini*. Photograph credits: Frederico França (**A, C, F, H, I, K, M, N, O**), Vanessa Nascimento (**B, D**), Ivan L. Sampaio (**E**), Willianilson Pessoa (**G**), Rafaela França (**J, L**).

addition, 23 species are arboreal or semi-arboreal (29.5%) and 16 (20.5%) are aquatic or semi-aquatic. The diet of PEC snakes consists mainly of vertebrates (61 species, 78.2%), of which 23 species are considered generalists, feeding on three or more types of prey, 21 species feed on two types of prey, 23 species are specialists in amphibians, two species are specialists in snakes and two species are specialists in mammals. Only 14 species feed on invertebrates, of which six species feed on arthropods, three species

Figure 6. Snake species from the Pernambuco Endemism Center. **A** *Pseudoboa nigra* **B** *Psomophis joberti*, **C** *Sibon nebulatus* **D** *Siphlophis compressus* **E** *Taeniophallus affinis* **F** *Taeniophallus occipitalis* **G** *Thamnodynastes almae* **H** *Thamnodynastes hypoconia* **I** *Thamnodynastes pallidus* **J** *Thamnodynastes phoenix* **K** *Xenodon merremii* **L** *Xenodon rabdocephalus* **M** *Xenopholis scalaris* **N** *Xenopholis undulatus* **O** *Micrurus corallinus*. Photograph credits: Frederico França (**A, B, C, D, F, H, K, N**), Vanessa Nascimento (**L**), Samuel Cardoso (**G**), Davi Pantoja (**M**), Rafaela França (**I**), Anderson A. Santos (**E**), Paulo R. S. Freitas (**J**), Adrian Garda (**O**).

feed on annelids and five species feed on mollusks (Table 1). As for the period of activity, 39 (50 %) species are nocturnal, 30 (38.4%) species are diurnal and nine (11.5%) species are diurnal and nocturnal (Table 1).

We present below a commented list of species of snakes that occur in PEC, with notes on natural history and distribution. The "N" corresponds to the number of

Figure 7. Snake species from the Pernambuco Endemism Center. **A** *Micrurus ibiboboca* **B** *Micrurus potyguara* **C** *Epictia borapeliotes* **D** *Amerotyphlops arenensis* **E** *Amerotyphlops brongersmianus* **F** *Amerotyphlops paucisquamus* **G** *Bothrops bilineatus* **H** *Bothrops erythromelas* **I** *Bothrops leucurus* **J** *Bothrops muriciensis* **K** *Crotalus durissus* **L** *Lachesis muta*. Photograph credits: Frederico França (**A, B, E, F, H, I, K, L**), Ivan L. Sampaio (**C**), Gentil A. Pereira Filho (**D**), Willianilson Pessoa (**J**), Rafaela França (**G**).

individuals analyzed in the scientific collections. The species *L. trefauti*, *A. caete*, *A. potschi, E. cephalomaculata, E. cephalostriata, T. almae*, *T. hypoconia,* and *T. phoenix* were recorded only by literature data.

Commented list

Family Anomalepididae Taylor, 1939

Liotyphlops trefauti Freire, Caramaschi, Suzart & Argolo, 2007 - A small-sized fossorial species (total length = 366–389 mm; *N* = 3), with nocturnal activity (Freire et al. 2007). It has a restricted distribution, occurring in the Atlantic Forest and Caatinga (Abegg et al. 2017b). In the PEC it occurs in the states of Alagoas and Pernambuco

(Fig. 8A), being found in Forest areas (Freire et al. 2007, Abegg et al. 2017b). *Liotyphlops trefauti*, as observed in other congeneric species, feeds on eggs and arthropod larvae (Marques et al. 2019).

Family Boidae Gray, 1825

Boa constrictor Linnaeus, 1758 - A large semiarboreal species (average SVL = 1023 mm; *N* = 42), with nocturnal activity (Marques et al. 2001). It has a wide distribution, occurring in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 8B), being found in Forest, Brejos Nordestinos, Tabuleiros and Restinga Areas (Pereira Filho and Montingelli 2011, Rodrigues et al. 2015, Pereira Filho et al. 2017, Sampaio et al. 2018). This species can also occur in urban areas (França and França 2019). *Boa constrictor* feeds on mammals, birds and lizards (Pizzatto et al. 2010). Its litter can range from 18 to 60 hatchlings (Vitt and Vangilder 1983, Pizzatto and Marques 2007, Fraga et al. 2013).

Corallus hortulanus (Linnaeus, 1758) - A moderate-sized arboreal snake (SVL = 745 mm; *N* = 11), with nocturnal activity (Marques et al. 2019). It has a wide distribution, occurring in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado and Pantanal (Marques et al. 2005, 2015, 2019, Fraga et al. 2013, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 8B), being found in Forest. *Corallus hortulanus* feeds on mammals, birds, lizards and amphibians (Pizzatto et al. 2010). Its litter can range from 3 to 24 hatchlings (Pizzatto and Marques 2007, Fraga et al. 2013).

Epicrates assisi Machado, 1945 – A moderate-sized terrestrial species (average SVL = 691 mm; *N* = 135), with nocturnal activity (Marques et al. 2019). This species occurs in the Cerrado, Caatinga and Atlantic Forest (Guedes et al. 2014, Marques et al. 2015, 2019). In the PEC it occurs in all states (Fig. 8C), being found in Forest, Brejos Nordestinos, Tabuleiros, Restingas and urban areas (França et al. 2012, Rodrigues et al. 2015, Pereira Filho et al. 2017, Sampaio et al. 2018). *Epicrates assisi* feeds on mammals, birds, and lizards. Its litter can range from 7 to 14 hatchlings (Pizzatto and Marques 2007).

Epicrates cenchria (Linnaeus, 1758) – A large semi-arboreal or terrestrial species (average SVL = 1105 mm; *N* = 6), with nocturnal activity (Marques et al. 2019). It has a wide distribution, occurring in the Atlantic Forest, Amazon Forest, Cerrado and Pantanal (Marques et al. 2005, 2015, 2019, Passos and Fernandes 2008). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 8C), being found in Forest areas, but also in urban areas. *Epicrates cenchria* feeds on mammals, birds, lizards and amphibians (Martins and Oliveira 1998, Pizzatto et al. 2010). Its litter can range from 8 to 25 hatchlings (Pizzatto and Marques 2007).

Family Colubridae Oppel, 1811

Chironius carinatus (Linnaeus, 1758) – A large terrestrial and arboreal species (average SVL = 1001 mm; *N* = 15), with diurnal activity (Marques et al. 2019). It has a disjunct distribution, occurring in the Amazon Forest and Atlantic Forest (Araújo et al. 2019).

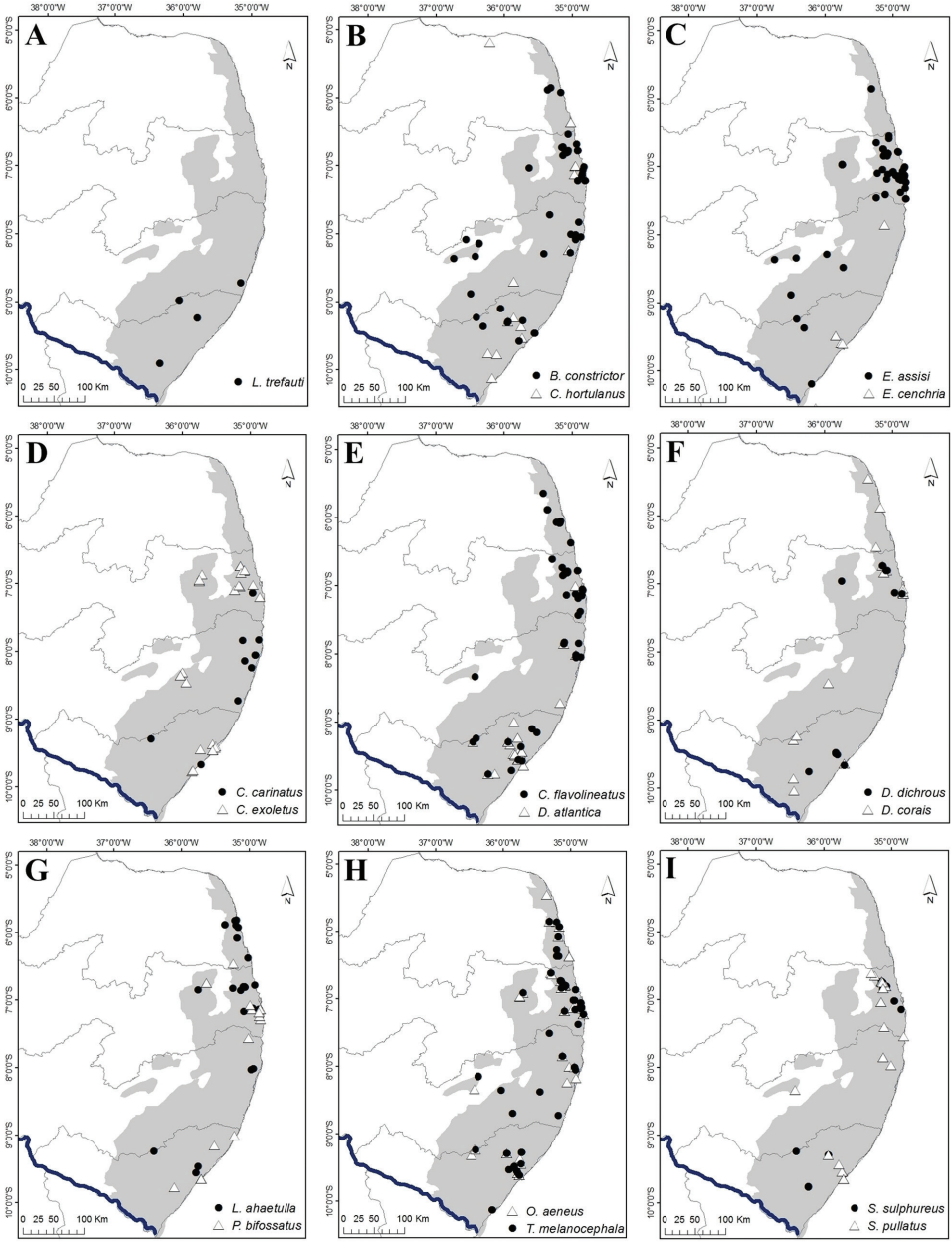

Figure 8. Geographic distribution records for snakes of the Pernambuco Endemism Center (PEC). **A** *Liotyphlops trefauti* **B** *Boa constrictor* and *Corallus hortulanus* **C** *Epicrates cenchria* and *E. assisi* **D** *Chironius carinatus* and *C. exoletus* **E** *Chironius flavolineatus* and *Dendrophidion atlantica* **F** *Drymarchon corais* and *Drymoluber dichrous* **G** *Leptophis ahaetulla* and *Palusophis bifossatus* **H** *Oxybelis aeneus* and *Tantilla melanocephala* **I** *Spilotes sulphureus* and *S. pullatus*.

In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 8D), being found in Forest and urban areas when these are close to forests (Araújo et al. 2019). *Chironius carinatus* feeds on amphibians, birds, lizards and mammals (Dixon et al. 1993, Silva et al. 2010, Rodrigues et al. 2016). Its litter can have 5 to 12 eggs (Dixon et al. 1993, Goldberg 2007).

Chironius exoletus (Linnaeus, 1758) – A moderate-sized arboreal and terrestrial species (average SVL = 614 mm; *N* = 16), with diurnal activity (Marques et al. 2019). It has a wide distribution, occurring in the Atlantic Forest, Caatinga, Cerrado, Pantanal and Amazon Forest (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 8D), being found in Forest, Brejos Nordestinos and Tabuleiro (Pereira Filho and Montingelli 2011, Rodrigues et al. 2015). *Chironius exoletus* feeds mainly on amphibians, but occasionally on lizards (Marques and Sazima 2004, Rodrigues et al. 2016). Its litter can range from 4 to 12 eggs (Dixon et al. 1993, Goldberg 2007).

Chironius flavolineatus (Linnaeus, 1758) – A moderate-sized semi-arboreal species (average SVL = 592 mm; *N* = 60), with diurnal activity (Marques et al. 2019). It presents a wide distribution, occurring in the Atlantic Forest, Cerrado, Caatinga, Pantanal and Amazon Forest (Cunha and Nascimento 1993, Dixon et al. 1993, Marques et al. 2005, 2015, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 8E), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (França et al. 2012, Rodrigues et al. 2015, Sampaio et al. 2018). *Chironius flavolineatus* feeds on amphibians (Pinto et al. 2008, Rodrigues et al. 2016). Its litter can range from 3 to 8 eggs (Dixon et al. 1993, Hamdan and Fernandes 2015).

Dendrophidion atlantica Freire, Caramaschi & Gonçalves, 2010 – A small-sized terrestrial species (average SVL = 366 mm; *N* = 24), with diurnal activity (Marques et al. 2019). *Dendrophidion atlantica* is endemic to the PEC and occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 8E), being found in Forest (Freire et al. 2010, Pereira Filho et al. 2017, Barbosa et al. 2019). *Dendrophidion atlantica* feeds on amphibians (Marques et al. 2019). Its litter can have 3 eggs (Lima et al. 2019).

Drymarchon corais (Boie, 1827) – A large terrestrial species (average SVL = 1288 mm; *N* = 7), with diurnal activity (Marques et al. 2019). It presents a wide distribution, being registered in the Amazon Forest, Cerrado, Caatinga and Pantanal (Cunha and Nascimento 1993, Strussmann and Sazima 1993, Guedes et al. 2014, Marques et al. 2015, 2019). In the PEC it occurs in all states (Fig. 8F), being found in Forest, Tabuleiros and urban areas (Rodrigues et al. 2015, Mesquita et al. 2018). *Drymarchon corais* feeds on amphibians, amphisbaenians, lizards, snakes, birds and mammals (Prudente et al. 2014). Its litter can range from 3 to 15 eggs (Prudente et al. 2014).

Drymoluber dichrous (Peters, 1863) – A small-sized terrestrial species (average SVL = 348 mm; *N* = 15), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest, and Caatinga (Cunha and Nascimento 1993, Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in the states of Alagoas and Paraíba (Fig. 8F), being found in Forest, Brejos Nordestinos, Tabuleiros and urban areas (Rodrigues et al. 2015, Pereira Filho et al. 2017, Mesquita et al. 2018, França

and França 2019). *Drymoluber dichrous* feeds on lizards and amphibians (Martins and Oliveira 1998, Borges-Nojosa and Lima 2001). Its litter can range from 2 to 6 eggs (Martins and Oliveira 1998, Fraga et al. 2013).

Leptophis ahaetulla (Linnaeus, 1758) – An arboreal and terrestrial, moderate-sized species (average SVL = 582 mm; *N* = 42), with diurnal activity (Marques et al. 2019). This species occurs in Atlantic Forest, Amazon Forest, Caatinga, Cerrado, Pantanal, and Pampas (Strussmann and Sazima 1993, Bérnils et al. 2007, Guedes et al. 2014, Marques et al. 2015, 2019). In the PEC it can be found in all states (Fig. 8G) in Forest, Brejos Nordestinos and urban areas (Pereira Filho and Montingelli 2011, França and França 2019). *Leptophis ahaetulla* feeds on amphibians and lizards (Albuquerque et al. 2007). Its litter can range from 3 to 12 eggs (Vitt and Vangilder 1983, Mesquita et al. 2009).

Oxybelis aeneus (Wagler, 1824) – An arboreal, moderate-sized species (average SVL = 780 mm; *N* =46), with diurnal activity (Marques et al. 2019). It presents a wide distribution, being found in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado, and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 8H), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (Pereira Filho and Montingelli 2011, Rodrigues et al. 2015, França and França 2019). *Oxybelis aeneus* feeds on lizards, amphibians, and occasionally fishes (Henderson 1982, Hetherington 2006, Grant and Lewis 2010, Mesquita et al. 2013, Franzini et al. 2018). Its litter can range from 4 to 9 eggs (Vitt and Vangilder 1983, Mesquita et al. 2009, Fraga et al. 2013).

Palusophis bifossatus (Raddi, 1820) – A moderate-sized terrestrial species (average SVL = 801 mm; *N* = 5), with diurnal activity (Marques et al. 2019). It presents a wide distribution, occurring in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado, Pampas, and Pantanal (Cunha and Nascimento 1993, Strussmann and Sazima 1993, Lema 2003, Bérnils et al. 2007, Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in all states (Fig. 8G), being found in Forest and Brejos Nordestinos (Pereira Filho and Montingelli 2011, Pereira Filho et al. 2017). *Palusophis bifossatus* feeds on amphibians, mammals, and lizards (Leite et al. 2007). Its litter can range from 4 to 24 eggs (Costa et al. 2010).

Spilotes pullatus (Linnaeus, 1758) – A large, semi-arboreal species (average SVL = 1442 mm; *N* = 21), with diurnal activity (Marques et al. 2019). It presents a wide distribution, being found in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado, and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC, it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 8I), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (Pereira Filho et al. 2017, Mesquita et al. 2018, França and França 2019). *Spilotes pullatus* feeds on mammals and birds (Silva et al. 2010, Marques et al. 2014). Its litter can range from 2 to 5 eggs (Hauzman et al. 2005, Fraga et al. 2013).

Spilotes sulphureus (Wagler, 1824) – A moderate-sized semi-arboreal species (average SVL = 911 mm; *N* =20), with diurnal activity (Marques et al. 2019). It presents a wide distribution, being found in the Atlantic Forest, Amazon Forest, Caatinga and Cerrado (Cunha and Nascimento 1993, Guedes et al. 2014, Marques et al. 2015,

2019). In the PEC, it occurs in the states of Alagoas and Paraíba (Fig. 8I), being found in Forest and urban areas (Morais et al. 2018). *Spilotes sulphureus* feeds on mammals and birds (Beebe 1946, Cunha and Nascimento 1993, Rufino and Bernardi 1999). Its litter can range from 7 to 15 eggs (Good 1989, Fraga et al. 2013, Morais et al. 2018).

Tantilla melanocephala (Linnaeus, 1758) – A small-sized fossorial species (average SVL = 233 mm; *N* = 172), with diurnal and nocturnal activity (Marques et al. 2019). It presents a wide distribution, occurring in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado, Pampas, and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Bérnils et al. 2007, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 8H), being found in Forest, Brejos Nordestinos, Tabuleiros, and restingas (Pereira Filho and Montingelli 2011, Mesquita et al. 2018, Sampaio et al. 2018). *Tantilla melanocephala* feeds on arthropods. Its litter can range from 1 to 3 eggs (Mesquita et al. 2009, Fraga et al. 2013)

Dipsadidae Bonaparte, 1838

Apostolepis cearensis Gomes, 1915 – A small-sized fossorial species (average SVL = 329 mm; *N* = 44), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga and Cerrado (Guedes et al. 2014, Marques et al. 2015, Mesquita et al. 2018). In the PEC it occurs in the states of Rio Grande do Norte, Paraíba and Pernambuco (Fig. 9A), being found in Forest, Tabuleiros, and urban areas (Mesquita et al. 2018, França and França 2019). *Apostolepis cearensis* feeds on small elongated reptiles (Mesquita et al. 2009, Amorim et al. 2015, Marques et al. 2019).

Apostolepis longicaudata Gomes, 1921 – A small-sized fossorial species (average SVL = 235 mm; *N* = 8), with diurnal activity (Marques et al. 2019). This species occurs in the Cerrado, Caatinga and Floresta Atlântica (Curcio et al. 2011, França et al. 2012). In the PEC it occurs only in a conservation unit (Reserva Biológica Guaribas) located in the state of Paraíba (Fig. 9A), being found in Forest. *Apostolepis longicaudata* feeds on small elongated reptiles (Marques et al. 2019). We found two eggs in a female.

Atractus caete Passos, Fernandes, Bérnils & Moura-Leite, 2010 – A small-sized fossorial and cryptozoic species (average SVL = 376 mm, *N* = 1), with nocturnal activity (Passos et al. 2010, Marques et al. 2019). This species is endemic to the PEC and occurs only in the state of Alagoas (Fig. 9B), being found in Forest areas. *Atractus caete* feeds mostly on earthworms (Passos et al. 2010).

Atractus maculatus (Günther, 1858) – A small-sized fossorial and cryptozoic species (average SVL = 326 mm; *N* = 5), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Passos et al. 2010, Abegg et al. 2017a). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 9B), being found in Forest and urban areas, when close to forests. *Atractus maculatus* feeds mostly on earthworms (Passos et al. 2010).

Atractus potschi Fernandes, 1995 – A small-sized fossorial and cryptozoic species (average SVL = 312 mm, *N* = 1), with nocturnal activity (Passos et al. 2010, Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Guedes et al.

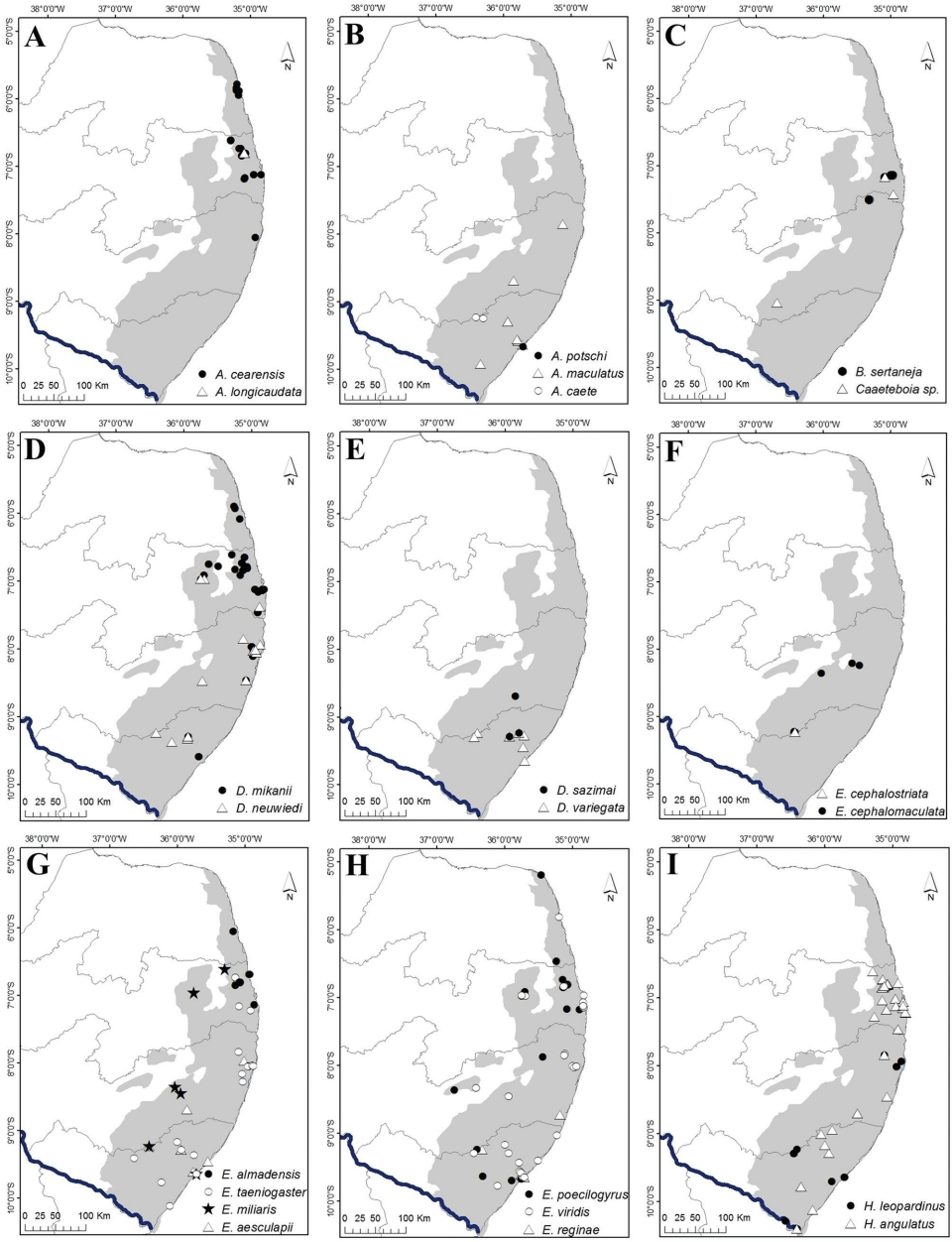

Figure 9. Geographic distribution records for snakes of the Pernambuco Endemism Center (PEC). **A** *Apostolepis longicaudata* and *A. cearensis* **B** *Atractus caete*, *A. maculatus* and *A. potschi* **C** *Boiruna sertaneja* and *Caaeteboia* sp. **D** *Dipsas mikanii* and *D. neuwiedi* **E** *D. sazimai* and *D. variegata* **F** *Echinanthera cephalomaculata* and *E. cephalostriata* **G** *Erythrolamprus almadensis*, *E. taeniogaster*, *E. miliaris*, and *E. aesculapii* **H** *E. poecilogyrus*, *E. viridis* and *E. reginae*. **I** *Helicops angulatus* and *H. leopardinus*.

2014). In the PEC it occurs in the state of Alagoas (Fig. 9B), being found in Forest (Passos et al. 2010). *Atractus potschi* feeds mostly on earthworms (Passos et al. 2010).

Boiruna sertaneja Zaher, 1996 – A large terrestrial species (average SVL = 1358 mm; *N* = 2), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Guedes et al. 2014, Pereira Filho et al. 2017). In the PEC it can be found in the states of Pernambuco and Alagoas (Fig. 9C), in Tabuleiros and Forest (Rodrigues et al. 2015, Pereira Filho et al. 2017). *Boiruna sertaneja* eats snakes, lizards and mammals (Vitt and Vangilder 1983, Gaiarsa et al. 2013). Its litter can range from 4 to 14 eggs (Vitt and Vangilder 1983, Gaiarsa et al. 2013).

Caaeteboia sp. – A small to moderate-sized terrestrial species (average SVL = 411 mm; *N* = 2), with diurnal activity (personal observation). This species is endemic to the PEC and occurs only in the states of Pernambuco and Paraíba (Fig. 9C), being found in Forest.

Dipsas mikanii Schlegel, 1837 – A small-sized terrestrial species (average SVL = 302 mm; *N* = 72), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Cerrado, Caatinga and Pantanal (Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 9D), being found in Forest, Brejos Nordestinos, Tabuleiros and urban areas (França et al. 2012, Pereira Filho et al. 2017, Sampaio et al. 2018). *Dipsas mikanii* feeds on mollusks (Laporta-Ferreira et al. 1986). Its litter can range from 3 to 10 eggs (Pizzatto et al. 2008).

Dipsas neuwiedi (Ihering, 1911) – A small-sized terrestrial species (average SVL = 369 mm; *N* = 17), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 9D), being found in Forest, Brejos Nordestinos and urban areas (Pereira Filho et al. 2017). *Dipsas neuwiedi* feeds on mollusks (Laporta-Ferreira et al. 1986). Its litter can range from 4 to 12 eggs (Pizzatto et al. 2008).

Dipsas sazimai Fernandes, Marques & Argôlo, 2010 – A small-sized arboreal and terrestrial species (average SVL = 299 mm; *N* = 1), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Fernandes et al. 2010, Guedes et al. 2014). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 9E), being found in Forest. *Dipsas sazimai* feeds on mollusks (Fernandes et al. 2010).

Dipsas variegata (Duméril, Bibron & Duméril, 1854) – A small to moderate size arboreal and terrestrial species (average SVL = 464 mm; *N* = 4), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Amazon Forest (Cunha and Nascimento 1993, Marques et al. 2019). In the PEC it occurs only in the state of Alagoas (Fig. 9E), being found in Forest. *Dipsas variegata* feeds on mollusks (Marques et al. 2019).

Echinanthera cephalomaculata Di Bernardo, 1994 – A small to moderate size terrestrial species (average SVL = 297 mm, *N* = 2), with diurnal activity (Di-Bernardo 1994, Marques et al. 2019). This species is endemic to the PEC and occurs only in the states of Alagoas and Pernambuco (Fig. 9F), being found in Forest (Roberto et al. 2015, Freitas et al. 2019b). *Echinanthera cephalomaculata* feeds on amphibians (Marques et al. 2019).

Echinanthera cephalostriata Di Bernardo, 1996 – A moderate-sized terrestrial species, with diurnal activity (Di-Bernardo 1996, Marques et al. 2019). This species only occurs in the Atlantic Forest (Marques et al. 2019). In the PEC it occurs in the state of Alagoas (Fig. 9F), being found only in the Reserva Biológica de Pedra Talhada (Roberto et al. 2015). In the report of this species for the PEC Roberto et al. (2015) provide a photo and a voucher (URCA-H 4103). *Echinanthera cephalostriata* feeds on amphibians (Marques et al. 2009).

Erythrolamprus aesculapii (Linnaeus, 1758) – A moderate-sized terrestrial species (average SVL = 562 mm; *N* = 7), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon forest, Caatinga, Cerrado and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2017a, 2019). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 9G), being found in Forest and urban areas. *Erythrolamprus aesculapii* feeds on snakes and lizards (Marques and Puorto 1992). Its litter can range from 1 to 8 eggs (Marques 1996a).

Erythrolamprus almadensis (Wagler, 1824) – A small-sized semi-aquatic species (average SVL = 298 mm; *N* = 4), with diurnal activity (Marques et al. 2019). This species has a wide distribution, occurring in the Atlantic Forest, Amazon forest, Caatinga, Cerrado, Pantanal and Pampas (Dixon 1989, França et al. 2006, Bérnils et al. 2007, Guedes et al. 2014). In the PEC it occurs in the states of Paraíba and Rio Grande do Norte (Fig. 9G), being found in Forest (Pereira Filho et al. 2017, França and França 2019). *Erythrolamprus almadensis* feeds on amphibians (Bernarde and Abe 2010, Rodrigues et al. 2016). Its litter can have five eggs.

Erythrolamprus miliaris (Linnaeus, 1758) – A small-sized semi-aquatic species (average SVL = 382 mm; *N* = 7), with diurnal and nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon forest, Caatinga and Cerrado (Cunha and Nascimento 1993, Nogueira et al. 2010, Marques et al. 2017a, 2019). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 9G), being found in Forest and Brejos Nordestinos. *Erythrolamprus miliaris* feeds on amphibians and fish (Marques et al. 2019). Its litter can range from 1 to 30 eggs (Pizzatto and Marques 2006).

Erythrolamprus poecilogyrus (Wied-Neuwied, 1825*)* – A small-sized terrestrial species (average SVL = 313 mm; *N* = 35), with diurnal and nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga, Cerrado, Pantanal and Pampas (Marques et al. 2005, 2015, 2019, Bérnils et al. 2007, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 9H), being found in Forest, Brejos Nordestinos, Mangroves, Tabuleiros and urban areas (França et al. 2012, Pereira Filho et al. 2017, Mesquita et al. 2018). *Erythrolamprus poecilogyrus* feeds on amphibians and lizards (Prieto et al. 2012). Its litter can range from 3 to 17 eggs (Vitt and Vangilder 1983, Mesquita et al. 2009). In Figure 4N we show a juvenile that is in the process of changing its coloration to the adult stage. This species has a different color pattern in the region (Pereira Filho et al. 2017) if compared to other populations located more southwards.

Erythrolamprus reginae (Linnaeus, 1758) – A small-sized semi-aquatic species (average SVL = 355 mm; *N* = 4), with diurnal activity (Marques et al. 2019). This species

occurs in the Atlantic and Amazon forests, Caatinga, Cerrado and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 9H), being found in Forest. *Erythrolamprus reginae* feeds on amphibians, lizards, and fish (Martins and Oliveira 1998, Albarelli and Santos-Costa 2010, Silva et al. 2010, Rodrigues et al. 2016). Its litter can range from 1 to 4 eggs (Arzamendia 2016, Marques et al. 2016)

Erythrolamprus taeniogaster (Jan, 1863) – A small-sized semi-aquatic species (average SVL = 364 mm; *N* = 45), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon forest, Caatinga, Cerrado and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 9G), being found in Forest, Tabuleiros, Restingas and urban areas (Rodrigues et al. 2015, Pereira Filho et al. 2017, Mesquita et al. 2018, Sampaio et al. 2018). *Erythrolamprus taeniogaster* feeds on amphibians and fish (Cunha and Nascimento 1993, Rodrigues et al. 2016). Its litter can range from 7 to 10 eggs (Cunha and Nascimento 1993).

Erythrolamprus viridis (Günther, 1862)– A small-sized terrestrial species (average SVL = 243 mm; *N* = 21), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in all states (Fig. 9H), being found in Forest, Brejos Nordestinos and urban areas (Pereira Filho and Montingelli 2011, Pereira Filho et al. 2017). *Erythrolamprus viridis* feeds on amphibians and lizards (Vitt and Vangilder 1983, Mesquita et al. 2009). Its litter can range from 2 to 7 eggs (Vitt and Vangilder 1983, Mesquita et al. 2009).

Helicops angulatus (Linnaeus, 1758) – A small to moderate sized aquatic species (average SVL = 413 mm; *N* = 236), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic and Amazon forests, Caatinga, Cerrado and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 9I), being found in Forest, Mangroves, Restingas and urban areas (França et al. 2012, Pereira Filho et al. 2017, Sampaio et al. 2018). *Helicops angulatus* feeds on fish and amphibians. Its litter can range from 1 to 21 eggs (Braz et al. 2016).

Helicops leopardinus (Schlegel, 1837) – A small-sized aquatic species (average SVL = 324 mm; *N* = 9), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado, Pantanal and Pampas (Strussmann and Sazima 1993, Marques et al. 2005, 2015, 2019, Bérnils et al. 2007, Guedes et al. 2014, Rodrigues et al. 2016). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 9I), being found in Forest, Restingas and urban areas. *Helicops leopardinus* feeds on fish and amphibians (Ávila et al. 2006). Its litter can range from 3 to 31 eggs (Scartozzoni and Almeida-Santos 2006, Braz et al. 2016).

Hydrodynastes gigas (Duméril, Bibron & Duméril, 1854) – A large aquatic and terrestrial species (average SVL = 1296 mm; *N* =10), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest, Cerrado, Pantanal and Pampas (Lema 2003, Marques et al. 2005, 2015, 2019, Rodrigues et al. 2016). In

the PEC it occurs in the states of Paraíba and Rio Grande do Norte (Fig. 10A), being found in Forest and Restingas (Pereira Filho et al. 2017, Sampaio et al. 2018). *Hydrodynastes gigas* feeds on fish, amphibians, mammals and snakes (López and Giraudo 2004). Its litter can range from 14 to 42 eggs (Vogel 1958, Fraga et al. 2013).

Imantodes cenchoa (Linnaeus, 1758) – An arboreal, moderate-sized species (average SVL = 633 mm; *N* = 23), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado and Pantanal (Cunha and Nascimento 1993, Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 10B), being found in Forest and Tabuleiros (Rodrigues et al. 2015, Mesquita et al. 2018). *Imantodes cenchoa* feeds on amphibians and lizards (Martins and Oliveira 1998, Sousa et al. 2014). Its litter can range from 1 to 7 eggs (Martins and Oliveira 1998, Pizzatto et al. 2008, Fraga et al. 2013, Sousa et al. 2014).

Leptodeira annulata (Linnaeus, 1758) – A moderate-sized arboreal and terrestrial species (average SVL = 576 mm; *N* = 6), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado and Pantanal (Ávila and Morais 2007, Guedes et al. 2014, Marques et al. 2015, 2019). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 10B), being found in Forest, Brejos Nordestinos, and Restingas (Pereira Filho and Montingelli 2011, Roberto et al. 2015). *Leptodeira annulata* feeds on amphibians and lizards (Moura 1999, Mesquita et al. 2013, Santos-Silva et al. 2014). Its litter can range from 3 to 13 eggs (Petzold 1969, Pizzatto et al. 2008).

Lygophis dilepis Cope, 1862 – A small-sized terrestrial species (average SVL = 356 mm; *N* = 9), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga and Cerrado (Guedes et al. 2014, Marques et al. 2015, Mesquita et al. 2018). In the PEC it occurs in the states of Pernambuco, Paraíba and Rio Grande do Norte (Fig. 10A), being found in Forest, Brejos Nordestinos, and urban areas (Pereira Filho and Montingelli 2011, França et al. 2012, Mesquita et al. 2018). *Lygophis dilepis* feeds on amphibians (Mesquita et al. 2009). Its litter can range from 4 to 6 eggs (Mesquita et al. 2009).

Oxyrhopus guibei Hoge & Romano, 1977 – A small sized terrestrial species (average SVL = 442 mm; *N* = 10), with diurnal and nocturnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest, Caatinga, Cerrado and Pantanal (Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 10C), being found in Forest, Brejos Nordestinos, and Tabuleiros (Pereira Filho and Montingelli 2011, Mesquita et al. 2018). *Oxyrhopus guibei* feeds on mammals and lizards (Andrade and Silvano 1996, Barbo et al. 2011). Its litter can range from 3 to 20 eggs (Pizzatto and Marques 2002).

Oxyrhopus petolarius (Linnaeus, 1758) – A small size terrestrial species (average SVL = 423 mm; *N* = 36), with nocturnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest, Amazon Forest, Caatinga, Cerrado and Pantanal (Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 10C), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (Pereira Filho et al. 2017, Mesquita et al. 2018, Sampaio et al. 2018, França and França 2019).

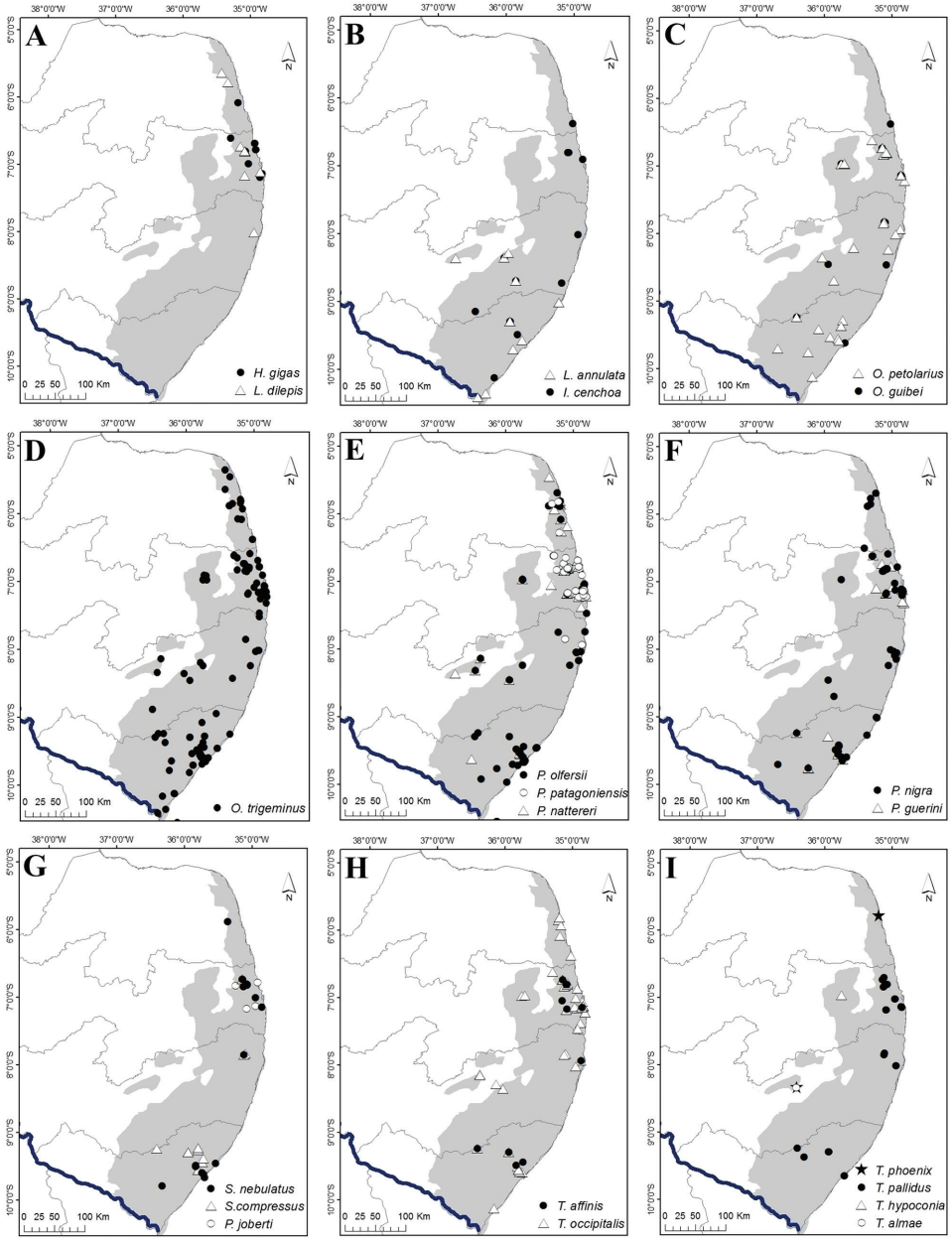

Figure 10. Geographic distribution records for snakes of the Pernambuco Endemism Center (PEC). **A** *Hydrodynastes gigas* and *Lygophis dilepis* **B** *Imantodes cenchoa* and *Leptodeira annulata* **C** *Oxyrhopus guibei* and *O. petolarius* **D** *O. trigeminus* **E** *Philodryas nattereri*, *P. olfersii* and *P. patagoniensis* **F** *Phimophis guerini* and *Pseudoboa nigra* **G** *Psomophis joberti*, *Sibon nebulatus* and *Siphlophis compressus* **H** *Taeniophallus affinis* and *T. occipitalis* **I** *Thamnodynastes almae*, *T. hypoconia*, *T. pallidus* and *T. phoenix*.

Oxyrhopus petolarius feeds on lizards, mammals, birds and amphibians (Alencar et al. 2013). Its litter can range from 2 to 12 eggs (Lynch 2009, Gaiarsa et al. 2013).

Oxyrhopus trigeminus Duméril, Bibron & Duméril, 1854 – A small-sized terrestrial species (average SVL = 360 mm; *N* = 237), with nocturnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest, Caatinga, Cerrado and Pantanal (Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 10D), being found in Forest, Brejos Nordestinos, Restingas, Tabuleiros, and urban areas (Pereira Filho and Montingelli 2011, Sampaio et al. 2018, França and França 2019). *Oxyrhopus trigeminus* feeds on lizards, mammals, and birds (Vitt and Vangilder 1983, Mesquita et al. 2009, Alencar et al. 2012). Its litter can range from 6 to 9 eggs (Vitt and Vangilder 1983, Mesquita et al. 2009).

Philodryas nattereri Steindachner, 1870 – A moderate-sized terrestrial or semi-arboreal species (average SVL = 712 mm; *N* = 76), with diurnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest, Caatinga, Cerrado, Pantanal (Marques et al. 2005, 2015, Guedes et al. 2014, Mesquita et al. 2018). In the PEC it occurs in all states (Fig. 10E), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (França et al. 2012, Pereira Filho et al. 2017, Sampaio et al. 2018). *Philodryas nattereri* feeds on lizards, mammals, amphibians, snakes, and birds (Mesquita et al. 2011b). Its litter can range from 4 to 13 eggs (Vitt and Vangilder 1983, Mesquita et al. 2009).

Philodryas olfersii (Lichtenstein, 1823) – A moderate-sized terrestrial or semi-arboreal species (average SVL = 562 mm; *N* = 123), with diurnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest, Caatinga, Cerrado, Pantanal and Pampas (Marques et al. 2005, 2015, 2019, Bérnils et al. 2007, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 10E), being found in Forest, Brejos Nordestinos, Tabuleiros, Mangroves and urban areas (Pereira Filho and Montingelli 2011, França et al. 2012, Pereira Filho et al. 2017, Sampaio et al. 2018). *Philodryas olfersii* feeds on amphibians, lizards, birds and mammals (Hartmann and Marques 2005). Its litter can range from 1 to 16 eggs (Vitt and Vangilder 1983, Fowler et al. 1998, Mesquita et al. 2009).

Philodryas patagoniensis (Girard, 1858) – A small to moderate sized terrestrial species (average (average SVL = 436 mm; *N* = 68), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga, Cerrado, Pantanal and Pampas (Marques et al. 2005, 2015, 2019, Bérnils et al. 2007, Guedes et al. 2014). In the PEC it occurs in the states of Pernambuco, Paraíba, and Rio Grande do Norte (Fig. 10E), being found in Forest, Tabuleiros, Restingas, and urban areas (França et al. 2012, Pereira Filho et al. 2017, Sampaio et al. 2018). *Philodryas patagoniensis* feeds on amphibians, lizards, mammals, birds, and snakes (Hartmann and Marques 2005). Its litter can range from 3 to 19 eggs (Fowler et al. 1998).

Phimophis guerini (Duméril, Bibron & Duméril, 1854) – A small to moderate sized terrestrial species (average SVL = 497 mm; *N* = 15), with nocturnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest, Caatinga, Cerrado, Pampas and Pantanal (Lema 2003, Marques et al. 2005, 2015, Guedes et al. 2014, Mesquita et al. 2018). In the PEC it occurs in the states of Alagoas and Paraíba (Fig. 10F), being found in Forest and Tabuleiros (Rodrigues et al. 2015, Pereira Filho et al.

2017). *Phimophis guerini* feeds on lizards and mammals (Alencar et al. 2013). Its litter can range from 3 to 7 eggs (Gaiarsa et al. 2013).

Pseudoboa nigra (Duméril, Bibron & Duméril, 1854) – A moderate-sized terrestrial species (average SVL = 543 mm; *N* = 64), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga, Cerrado and Pantanal (Marques et al. 2005, 2015, 2019, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 10F), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (Pereira Filho and Montingelli 2011, França et al. 2012, Pereira Filho et al. 2017, Mesquita et al. 2018). *Pseudoboa nigra* feeds on lizards, mammals, and snakes (Alencar et al. 2012). Its litter can range from 3 to 24 eggs (Orofino et al. 2010, Gaiarsa et al. 2013).

Psomophis joberti (Sauvage, 1884) – A small-sized terrestrial species (average SVL = 285 mm; *N* = 11), with diurnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest, Amazon Forest, Caatinga and Cerrado (Guedes et al. 2014, Marques et al. 2015, Rodrigues et al. 2016, Mesquita et al. 2018). In the PEC it occurs only in the state of Paraíba (Fig. 10G), being found in Forest and urban areas (França et al. 2012, Pereira Filho et al. 2017). *Psomophis joberti* feeds on amphibians and lizards (Strussmann and Sazima 1993, Rodrigues et al. 2016). Its litter can have 7 eggs (Mesquita et al. 2009, 2011a).

Sibon nebulatus (Linnaeus, 1758) – A small-sized arboreal species (average SVL = 377 mm; *N* = 21), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest and can also be found on relict moist forests in Caatinga (Cunha and Nascimento 1993, Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in all states (Fig. 10G), being found in Forest, Tabuleiros, and urban areas (França et al. 2012, Rodrigues et al. 2015). *Sibon nebulatus* feeds on mollusks (Duellman 2005). Its litter can have 5 eggs (Boos 2001).

Siphlophis compressus (Daudin, 1803) – A moderate-sized arboreal and terrestrial species (average SVL = 527 mm; *N* = 13), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Amazon Forest (Cunha and Nascimento 1993, Marques et al. 2019). In the PEC it occurs in the states of Alagoas, Pernambuco, and Paraíba (Fig. 10G), being found in Forest and Tabuleiros (Roberto et al. 2015, Rodrigues et al. 2015, Pereira Filho et al. 2017). *Siphlophis compressus* feeds mainly on lizards, but may also feed on snakes (Martins and Oliveira 1998, Alencar et al. 2013). Its litter can range from 3 to 12 eggs (Martins and Oliveira 1998, Fraga et al. 2013, Gaiarsa et al. 2013).

Taeniophallus affinis (Günther, 1858) – A small-sized cryptozoic species (average SVL = 172 mm; *N* = 9), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in the states of Alagoas, Pernambuco, and Paraíba (Fig. 10H), being found in Forest, Brejos Nordestinos, and Tabuleiros (Rodrigues et al. 2015, Pereira Filho et al. 2017). *Taeniophallus affinis* feeds on lizards, amphibians, amphisbaenians, and mammals (Sousa and Cruz 2000, Barbo and Marques 2003, Zacariotti and Gomes 2010, Gomes 2012). Its litter can range from 5 to 7 eggs (Amaral 1978).

Taeniophallus occipitalis (Jan, 1863) – A small-sized cryptozoic species (average SVL = 272 mm; *N* = 63), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga, Cerrado and Pampas (Bérnils et al. 2007, Guedes et al. 2014, Marques et al. 2015, 2019). In the PEC it occurs in all states (Fig. 10H), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (Pereira Filho and Montingelli 2011, Rodrigues et al. 2015, Pereira Filho et al. 2017, França and França 2019). *Taeniophallus occipitalis* feeds on lizards, amphibians, and snakes (Balestrin and Di-Bernardo 2005, Gomes 2012). Its litter can have two eggs.

Thamnodynastes almae Franco & Ferreira, 2003 – A moderate-sized arboreal and terrestrial, with nocturnal activity (Franco and Ferreira 2002, Marques et al. 2019). This species occurs in the Atlantic Forest and Caatinga (Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs only in Brejos Nordestinos in the state of Pernambuco (Fig. 10I) (Freitas et al. 2019a). *Thamnodynastes almae* feeds on amphibians and lizards (Marques et al. 2017a).

Thamnodynastes hypoconia (Cope, 1860) – A moderate-sized arboreal and terrestrial, with nocturnal activity (Marques et al. 2017a). This species occurs in the Atlantic Forest, Caatinga, Cerrado and Pampas (Bérnils et al. 2007, Guedes et al. 2014, Marques et al. 2015, 2019). In PEC it occurs only in the Parque Estadual Mata do Pau-Ferro, state of Paraíba, a Brejo Nordestino (Fig. 10I) (Pereira Filho et al. 2017). *Thamnodynastes hypoconia* feeds on amphibians and lizards (Bellini et al. 2013). Its litter can range from 4 to 13 hatchlings (Bellini et al. 2013).

Thamnodynastes pallidus (Linnaeus, 1758) – A small-sized arboreal and terrestrial (average SVL = 325 mm; *N* = 92), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest and Caatinga (Bailey et al. 2005, Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 10I), being found in Forest and Tabuleiros (Rodrigues et al. 2015, Pereira Filho et al. 2017). *Thamnodynastes pallidus* feeds on amphibians (Guedes et al. 2014, Protázio et al. 2017). Its litter can range from 3 to 6 hatchlings (Cunha and Nascimento 1981, Araújo et al. 2018).

Thamnodynastes phoenix Franco, Trevine, Montingelli & Zaher, 2017 – A small to moderate size arboreal and terrestrial, with nocturnal activity (Franco et al. 2017, Marques et al. 2017a). This species occurs in the Atlantic Forest, Caatinga and Cerrado (Guedes et al. 2014, Franco et al. 2017, Freitas et al. 2019a). In the PEC it occurs only in Brejos Nordestinos of the state of Pernambuco (Fig. 10I) (Freitas et al. 2019a). *Thamnodynastes phoenix* feeds on amphibians (Pergentino and Ribeiro 2017).

Xenodon merremii (Wagler, 1824) – A small to moderate size species (average SVL = 446 mm; *N* = 97), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga, Cerrado, Pampas Pantanal (Marques et al. 2005, 2015, 2019, Bérnils et al. 2007, Guedes et al. 2014). In the PEC it occurs in all states (Fig. 11A), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (Pereira Filho and Montingelli 2011, França et al. 2012, Rodrigues et al. 2015). *Xenodon merremii* feeds on amphibians (Vitt and Vangilder 1983, Mesquita et al. 2009). Its litter can range from 4 to 30 eggs (Gaiarsa et al. 2013).

Xenodon rabdocephalus (Wied-Neuwied, 1824) – A moderate-sized terrestrial species (average SVL = 630 mm; *N* = 2), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Amazon Forest and Cerrado (Cunha and Nascimento 1993, Marques et al. 2015, 2019). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 11A), being found in Forest. *Xenodon rabdocephalus* feeds on amphibians (Martins and Oliveira 1998). Its litter can range from 6 to 8 eggs (Martins and Oliveira 1998).

Xenopholis scalaris (Wucherer, 1861) – A small-sized terrestrial species (average SVL = 167 mm; *N* = 10), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Amazon Forest (Marques et al. 2015, 2019, França et al. 2019). In the PEC it occurs in the states of Alagoas and Pernambuco (Fig. 11B), being found in Forest. *Xenopholis scalaris* feeds on amphibians (Martins and Oliveira 1998, Bernarde and Abe 2010). Its litter can range from 2 to 3 eggs (Martins and Oliveira 1998).

Xenopholis undulatus (Jensen, 1900) – A small-sized terrestrial species (average SVL = 268 mm; *N* = 2), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga and Cerrado (Guedes et al. 2014, Marques et al. 2015, 2019). In the PEC it occurs in the states of Alagoas, Pernambuco, and Paraíba (Fig. 11B), being found in Forest and Brejos Nordestinos (Pereira Filho et al. 2017). *Xenopholis undulatus* feeds on amphibians (Cunha and Nascimento 1993, Kokobum and Maciel 2010). Its litter can have 3 eggs (Costa et al. 2013).

Elapidae Boie, 1827

Micrurus corallinus (Merrem, 1820) – A small to moderate size cryptozoic species (average SVL = 465 mm; *N* =1), with diurnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest (Marques et al. 2019). In the PEC it occurs only in the state of Rio Grande do Norte (Fig. 11C), being found in Forest. *Micrurus corallinus* feeds on amphisbaenians, lizards, snakes, and caecilians (Marques and Sazima 1997). Its litter can range from 2 to 12 eggs (Azevedo 1961, Marques 1996b).

Micrurus ibiboboca (Merrem, 1820) – A moderate-sized cryptozoic species (average SVL = 533 mm; *N* =391), with diurnal and nocturnal activity (Marques et al. 2017). This species occurs in the Atlantic Forest and Caatinga (Marques et al. 2017a, 2019). In the PEC it occurs in all states (Fig. 11C), being found in Forest, Brejos Nordestinos, Tabuleiros, and urban areas (Pereira Filho and Montingelli 2011, França et al. 2012, Rodrigues et al. 2015, Pereira Filho et al. 2017). *Micrurus ibiboboca* feeds on amphisbaenians, snakes, and lizards (Vitt and Vangilder 1983, Mesquita et al. 2009). We found 9 to 14 vitellogenic follicles in females.

Micrurus potyguara Pires, Da Silva Jr, Feitosa, Prudente, Preira-Filho & Zaher, 2014 – A moderate-sized cryptozoic species (average SVL = 523 mm; *N* = 14), with diurnal and nocturnal activity (Marques et al. 2019). *Micrurus potyguara* is endemic to the PEC, occurring in the states of Pernambuco, Paraíba, and Rio Grande do Norte (Fig. 11C), being found in Forest, Tabuleiros, and urban areas (Pires et al. 2014, Rodrigues et al. 2015, França and França 2019).

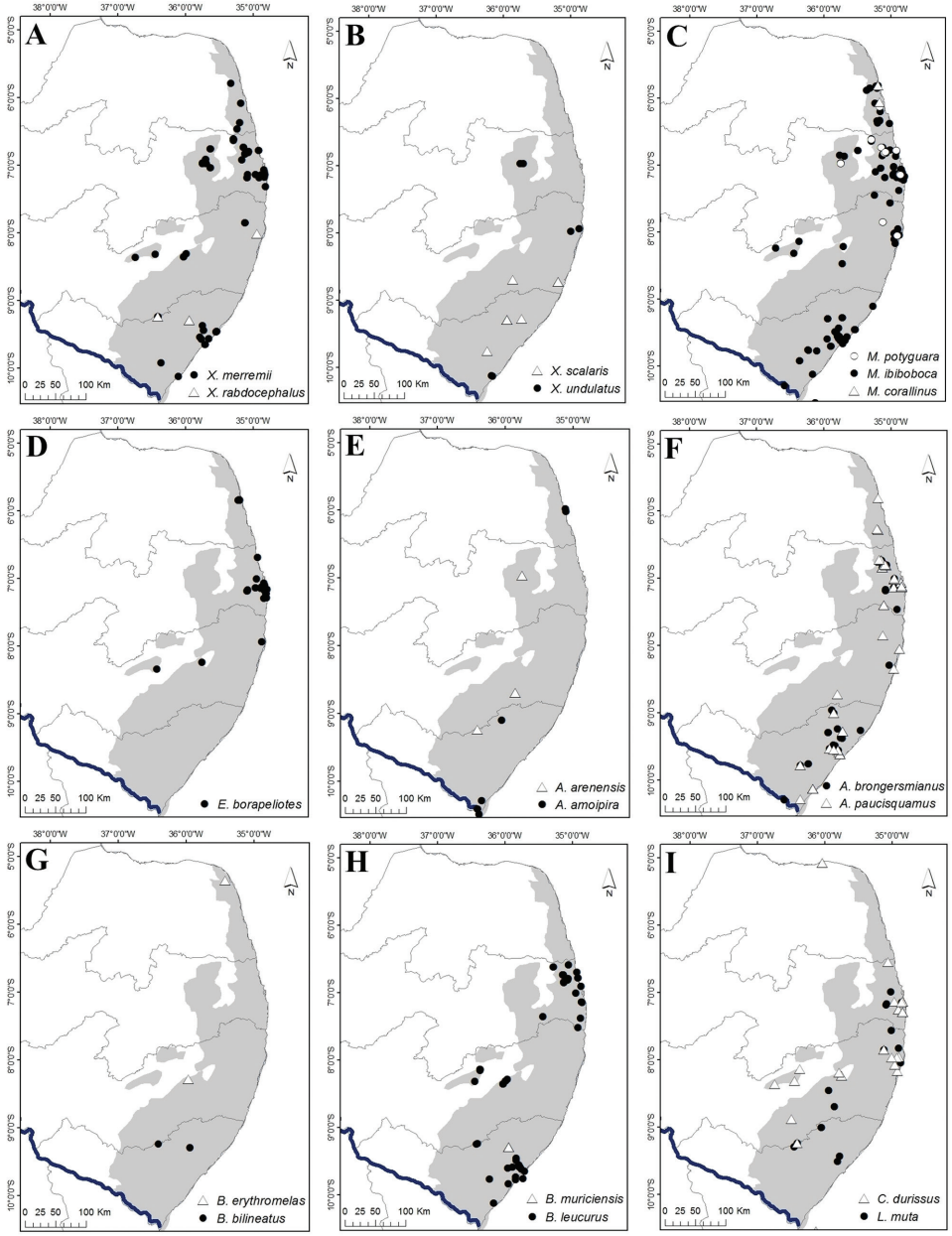

Figure 11. Geographic distribution records for snakes of the Pernambuco Endemism Center (PEC). **A** *Xenodon merremii* and *X. rabdocephalus* **B** *Xenopholis scalaris* and *X. undulatus* **C** *Micrurus corallinus*, *M. ibiboboca* and *M. potyguara* **D** *Epictia borapeliotes* **E** *Amerotyphlops amoipira* and *A. arenensis* **F** *A. brongersmianus* and *A. paucisquamus* **G** *Bothrops bilineatus* and *B. erythromelas* **H** *B. leucurus* and *B. muriciensis* **I** *Crotalus durissus* and *Lachesis muta*.

Leptotyphlopidae Stejneger, 1891

Epictia borapeliotes (Vanzolini, 1996) – A small-sized fossorial species (average SVL = 111 mm; *N* = 34), with diurnal and nocturnal activity (Guedes et al. 2014). This species occurs in the Atlantic Forest and Caatinga (Guedes et al. 2014, Marques et al. 2019). In the PEC it occurs in the states of Pernambuco, Paraíba, and Rio Grande do Norte (Fig. 11D), being found in Forest, Brejos Nordestinos, and in Restingas (Pereira Filho et al. 2017, Sampaio et al. 2018, Freitas et al. 2019a). *Epictia borapeliotes* feeds on arthropods (Marques et al. 2019).

Typhlopidae Merrem, 1890

Amerotyphlops amoipira (Rodrigues & Juncá, 2002) – A small-sized fossorial species (average SVL = 146 mm; *N* = 3), with nocturnal activity (Marques et al. 2017). This species occurs in the Caatinga and Atlantic Forest (Brito and Freire 2012). In the PEC it occurs in the states of Alagoas and Rio Grande do Norte (Fig. 11E), being found in Restinga (Brito and Freire 2012). *Amerotyphlops amoipira* feeds on arthropods (Marques et al. 2017a).

Amerotyphlops arenensis Graboski, Pereira Filho, Silva, Costa Prudente & Zaher, 2015 – A small-sized fossorial species (average SVL = 148 mm; *N* = 13). This species occurs in the Atlantic Forest and Caatinga (Graboski et al. 2015, 2019). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 11E), being found in Forest and Brejos Nordestinos (Roberto et al. 2012, Graboski et al. 2015). We found 7 to 8 vitellogenic follicles in females.

Amerotyphlops brongersmianus (Vanzolini, 1976) – A small-sized fossorial species (average SVL = 212 mm; *N* = 120), with nocturnal activity (Marques et al. 2019). This species occurs in all Brazilian biomes (Graboski et al. 2019). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 11F), being found in Forest and Tabuleiros (Pereira Filho et al. 2017, Sampaio et al. 2018). This species occurs in the Atlantic Forest (Marques et al. 2019). *Amerotyphlops brongersmianus* feeds on ant larvae (Avila et al. 2006). Its litter can range from 4 to 5 eggs (Avila et al. 2006).

Amerotyphlops paucisquamus (Dixon, 1979) – A small-sized fossorial species (average SVL = 133 mm; *N* =153), with nocturnal activity (Marques et al. 2019). This species is endemic to the PEC, occurring in all states (Fig. 11F), being found in Forest and Tabuleiros (Rodrigues et al. 2015, Pereira Filho et al. 2017). We found four eggs in one female and another individual laid three eggs after being collected.

Viperidae Laurenti, 1768

Bothrops bilineatus (Wied-Neuwied, 1821) – A small to moderate sized arboreal species (average SVL = 495 mm; *N* = 5), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Amazon Forest (Bernarde et al. 2011, Marques et al. 2019). In PEC occurs only in Alagoas state (Fig. 11G), being found in

Forest. *Bothrops bilineatus* feeds on mammals, amphibians, birds, snakes, and lizards (Cunha and Nascimento 1993, Martins et al. 2002, Turci et al. 2009). Its litter can range from 4 to 16 hatchlings (Dixon and Soini 1986, Campbell and Lamar 2004, Grego et al. 2012, Almeida et al. 2019).

Bothrops erythromelas Amaral, 1923 – A small to moderate size terrestrial species (average SVL = 445 mm; *N* = 3), with nocturnal activity (Marques et al. 2017). This species occurs in the Caatinga, but can also be found in transitional areas with the Atlantic Forest (Guedes et al. 2014). In the PEC it occurs in the states of Pernambuco and Rio Grande do Norte (Fig. 11G), being found in Forest. *Bothrops erythromelas* feeds on arthropods when juveniles, and frogs, lizards, and mammals when adults (Martins et al. 2002). Its litter can range from 2 to 21 hatchlings (Barros et al. 2014, Reis et al. 2015).

Bothrops leucurus Wagler, 1824 – A moderate-sized terrestrial species (average SVL = 589 mm; *N* =207), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest (Marques et al. 2019). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 11H), being found in Forest, Brejos Nordestinos, Tabuleiros, mangroves, and urban areas when near forest areas (Pereira Filho and Montingelli 2011, Rodrigues et al. 2015, Pereira Filho et al. 2017, França and França 2019). *Bothrops leucurus* feeds on amphibians, lizards, snakes, birds, and mammals. Its litter can range from 5 to 7 hatchlings (Lira-da-Silva et al. 1994).

Bothrops muriciensis Ferrarezzi & Freire, 2001 – A moderate-sized terrestrial species (average SVL = 512 mm; *N* = 6), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest (Marques et al. 2019). This species is endemic to the PEC, occurring only in the Estação Ecológica de Murici (Fig. 11H), located in the state of Alagoas, being found in Forest. See Freitas et al. (2012) for additional information on this species. As observed in other congenerics, it probably feeds on anurans and small mammals.

Crotalus durissus Linnaeus, 1758 – A moderate-sized terrestrial species (average SVL = 790 mm; *N* = 13), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest, Caatinga, Cerrado, Pampas, and Pantanal (Marques et al. 2005, 2015, 2019, Bérnils et al. 2007, Guedes et al. 2014). In the PEC it occurs in the states of Alagoas, Pernambuco, and Paraíba (Fig. 11I), being found in Forest, Brejos Nordestinos, and Restingas (Lira-da-silva et al. 2009, Pereira Filho and Montingelli 2011). *Crotalus durissus* feeds on mammals (Vitt and Vangilder 1983, Strussmann and Sazima 1993, Rodrigues et al. 2016). Its litter can range from 21 to 31 hatchlings (Vitt and Vangilder 1983).

Lachesis muta (Linnaeus, 1766) – A large size terrestrial species (average SVL = 1217 mm; *N* = 4), with nocturnal activity (Marques et al. 2019). This species occurs in the Atlantic Forest and Amazon Forest (Cunha and Nascimento 1993, Marques et al. 2019). In the PEC it occurs in the states of Alagoas, Pernambuco and Paraíba (Fig. 11I), being found in Forest (Pereira Filho et al. 2017). *Lachesis muta* feeds on mammals (Cunha and Nascimento 1993, Martins and Oliveira 1998). Its litter can range from 1 to 18 eggs (Martins and Oliveira 1998, Souza 2007, Alves et al. 2014).

Discussion

Our results show a broad view of PEC's snake fauna, including distribution data, natural history, and diversity. According to Marques et al. (2019), about 142 species of snakes occur in the Brazilian Atlantic Forest, the 78 species recorded in the PEC represent 51.3% of this total, which we can consider a high richness. In addition, new species are still being discovered in this region, for example, the species *D. atlantica* (Freire et al. 2010), *M. potyguara* (Pires et al. 2014), and *A. arenensis* (Graboski et al. 2015) have been described in the last ten years and at least one new species (*Caaeteboia* sp.) is being described at the moment (Pereira Filho et al. 2017).

The mixed composition of snake species that inhabit the Atlantic Forest located north of the São Francisco River can be considered a remarkable characteristic of this fauna (Pereira Filho et al. 2017). We can highlight that the main difference between the PEC and other portions of the biome is due to the large number of species of open areas and also of wide distribution that are present in this region. The PEC shares more species with the Caatinga and the Cerrado (74.3% and 56.4% of the shared species, respectively) than with the southern and southeastern regions of the Atlantic Forest (30% of the species are shared). This may be due to the fact that the PEC presents different physiognomic features, such as patches of Tabuleiros, which are natural enclaves of savannah found even in the middle of forests and which may provide adequate conditions for the establishment of populations of species from open areas (Mesquita et al. 2018). In addition, the proximity to the Caatinga may also have favoured the penetration and establishment of these populations (Pereira Filho et al. 2017). These arguments are supported by historical factors that are based on the expansion and retraction of the boundaries of dry and open habitat ecoregions, due to climatic fluctuations over geological time, which have reached coastal areas of northeastern Brazil (Ab'Saber 1977, Pennington et al. 2006). Thus, species considered previously endemic to the Caatinga, for example, *E. borapeliotes* and *E. assisi* (Guedes et al. 2014), and species considered endemic to the Cerrado, for example *C. flavolineatus* (Nogueira et al. 2010), are also abundant in the PEC.

Most reptiles are considered habitat specialists, which means that many species can only survive in one or a few distinct environments (Martins and Molina 2008). In the PEC, the great majority of snake species were found in forest areas and 26 species were collected only in this environment. Due to the occupation of the area for agriculture and urbanization, most of the forest in the PEC was lost or reduced to small fragments, mostly smaller than ten hectares, which represent less than 2% of the original coverage of the Center (Ranta et al. 1998, Tabarelli et al. 2005). This is especially worrying because species that do not use the surrounding matrix as part of their area of use or that cannot use these environments to move between the fragments, can become extinct regionally as the populations are becoming isolated, making them unviable in the long term, due to the reduced population size (Nunney and Campbell 1993). On the other hand, some species seem to be generalists in terms of habitat and can be found in different physiognomies of the PEC and even urban areas, as is the case of *B. constrictor*, *P. olfersii*, *B. leucurus* and *O. trigeminus*.

Most snake species found in the PEC mainly use soil as substrate, as well as snakes in other regions of Brazil, such as the Caatinga (Guedes et al. 2014), Atlantic Forest (Marques et al. 2017b), Cerrado (França and Braz 2013), Pantanal (Strussmann and Sazima 1993) and Amazon (Martins and Oliveira 1998, Bernarde and Abe 2006). However, PEC also harbours a great variety of semi-arboreal and arboreal species, which is a characteristic of forest biomes, such as the Atlantic Forest and Amazon (Martins and Oliveira 1998, Argôlo 2004, Marques and Sazima 2004, Bernarde and Abe 2006).

More than half of PEC snakes feed on lizards or amphibians. These types of prey are commonly found in the snake diet, although other vertebrates like mammals, birds, and snakes are also important preys (Bernarde and Abe 2006, Hartmann et al. 2009, Mesquita et al. 2009). Some species of the PEC are generalists, as boids and snakes of the genus *Philodryas* and *Oxyrhopus*. Snakes belonging to the genera *Apostolepis*, *Dipsas*, and *Atractus* have specialized diet, feeding on snakes, mollusks and earthworms, respectively, as well as the genera *Xenodon* and *Xenopholis*, which are specialists in amphibians. (Vitt and Vangilder 1983, Laporta-Ferreira et al. 1986, Cunha and Nascimento 1993, Martins and Oliveira 1998, Mesquita et al. 2009, Bernarde and Abe 2010, Fernandes et al. 2010, Kokubum and Maciel 2010).

It is important to emphasize that the PEC presents at least seven endemic species (*A. caete*, *A. maculatus, B. muriciensis*, *Caaeteboia* sp., *D. atlantica*, *E. cephalomaculata*, and *M. potyguara*) of which basic information on natural history and ecology are scarce. Most of these species have a very restricted distribution, have been little recorded in nature and consequently are poorly represented in scientific collections. For example, *B. muriciensis* has only nine records and was found only in a single location (Freitas et al. 2012), the *E. cephalomaculata* has seven known records and was found only in four locations (Freitas et al. 2019b) and *Caaeteboia* sp., which has only three records and should be a new species for the region (Pereira Filho et al. 2017). Moreover, some species have confused taxonomy, such as *M. ibiboboca* and *D. neuwiedi*, being a complex of different taxa. Some of these taxa could figure as endemic species in PEC in the future. Besides the endemic species, other PEC species deserve special attention due to the absence of information on natural history and ecology, for being rare in the region and for presenting a restricted distribution in the PEC, for example, *L. trefauti, A. potschi, D. sazimai, D. variegata, E. cephalostriata,* and *A. arenensis.*

The conservation status of PEC snake species is still little known. Of the 78 species registered in the region, only 25 species have been evaluated by the IUCN (International Union for Conservation of Nature) to date. On the Brazilian list of threatened species, some PEC species are present, they are: *A. amoipira*, *A. caete, and B. muriciensis* as "endangered" and *A. paucisquamus* and *E. cephalomaculata* as "vulnerable" (ICMBio 2018). Given the high richness of snake species, the number of endemic species and the fragmented conditions of the region's forests, regional conservation efforts need to be intensified, because few forests north of the São Francisco River are formally protected, and the majority are small, which means that many species in the region may be threatened with extinction (Ranta et al. 1998, Uchoa Neto and Tabarelli 2002, Tabarelli et al. 2006a).

In general, many studies still need to be developed in the PEC region, so that we can better understand the snake fauna of this region. Fauna inventories in areas that are not well sampled, population dynamics studies and distribution patterns are important for better conservation planning of PEC snake species.

Acknowledgements

RCF thanks FAPESB for a PhD scholarship (BOL0353/2016) and CNPq for Doutorado Sanduíche no Exterior (SWE) scholarship (208442/2017-0). FGRF thanks the financial support from CNPq (Universal grant 404671/2016-0). MS acknowledges funding from CNPq (Productivity grant 304999/2015-6) and CAPES/Alexander von Humboldt Foundation (BEX 0585/16-5). We further thank Fausto Erritto Barbo, an anonymous reviewer and the editor Robert Jadin for detailed and constructive comments that greatly improved our manuscript.

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ZooKeys 1002: 159–185 (2020)
doi: 10.3897/zookeys.1002.53988
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Amphibians and reptiles of Parque Nacional da Serra das Lontras: an important center of endemism within the Atlantic Forest in southern Bahia, Brazil

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Academic editor: Anthony Herrel | Received 6 May 2020 | Accepted 5 June 2020 | Published 10 December 2020

http://zoobank.org/F664DE71-2E42-4016-9FF8-17126D6BD55F

Citation: Rojas-Padilla O, Menezes VQ, Dias IR, Argôlo AJS, Solé M, Orrico VGD (2020) Amphibians and reptiles of Parque Nacional da Serra das Lontras: an important center of endemism within the Atlantic Forest in southern Bahia, Brazil. ZooKeys 1002: 159–185. https://doi.org/10.3897/zookeys.1002.53988

Abstract

Information gaps about species distribution hamper the evaluation of conservation status and decisions on biodiversity conservation, affecting to a greater extent, areas with high species richness and endemism. In this context, biological inventories are an important tool to fill these gaps by providing data on the composition, richness, and abundance of species in each locality. The Parque Nacional da Serra das Lontras (PNSL) protects various mountain range just up 1000 m. in altitude, and, together with other conservation units, forms an ecological corridor in the southern part of the state of Bahia, within the Atlantic Forest hotspot. We conducted systematic samplings on transects, and opportunistic records in ponds and streams, in order to record amphibian and reptile species in the PNSL. We complement the sampling with the information available in the literature and in scientific collections. A total of 100 species (49 amphibians and 51 reptiles) was recorded, 53 of them endemic to the Atlantic Forest, 13 to the state of Bahia, and two known only from the PNSL. Hylidae was the most diverse family of amphibians (22 spp.) and Colubridae of reptiles (33 spp.). New information on the distribution and natural history of these species is provided, many of which have not yet been assessed by the IUCN while others have already been categorized as at risk of extinction at the regional level. Results confirm the high species richness and rates of endemism in southern Bahia and highlight the importance of protecting high altitude areas for the preservation of evolutionary and ecological processes within the Atlantic Forest.

Keywords
Anura, Reptilia, Herpetofauna, biological inventory, species distribution

Introduction

Biodiversity inventories are crucial in megadiverse countries, particularly in those that still have areas that are poorly sampled or without information about the species that inhabit them (Trindade-Filho et al. 2012; Verdade et al. 2012). These inventories provide data on natural history, behavior and make it possible to find taxa previously unknown to the region or still undescribed (Verdade et al. 2012; Oliveira et al. 2017). At the same time, they provide updated data on the state of conservation of the locality sampled and the threats present for the reported populations.

Deforestation, climate change, pollution, invasive species and diseases are among the main threats to biodiversity (Lips et al. 2005; Butchart et al. 2010). According to IUCN (International Union for Conservation of Nature), 41% of amphibian species and 22% of reptiles are included in some threat category (Hoffmann et al. 2010). In fact, many species of reptiles still lack enough information to allow their categorization (Böhm et al. 2013) making it even more difficult to implement effective actions for their conservation.

The Atlantic Forest biome stands out for having a high species richness and endemism rate. Despite harboring species not yet described and discovered (Morellato and Haddad 2000), it is estimated that it houses half of the endangered species of Brazil, 38.5% of which are endemic to this biome (ICMBio 2018a). However, the biome has also shown high rates of deforestation and is considered one of the biodiversity hotspots in the world (Myers et al. 2000). The south of the state of Bahia, located in Northeastern Brazil, is still home to the largest forest remnants of the Atlantic Forest in this part of the country, most of them associated with slopes or altitude zones (Thomas et al. 1998; Oliveira-Filho and Fontes 2000; Amorim et al. 2009). In these zones, high levels of plant richness and endemism (Amorim et al. 2009) and the second largest number of amphibian species for the entire biome have been recorded (Dias et al. 2014).

The Parque Nacional da Serra das Lontras (PNSL), together with two more conservation units, the Refúgio de Vida Silvestre Una and the Reserva Biológica Una, form an ecological corridor which protects from low areas of the Atlantic coast to mountain peaks of just over 1000 m. in altitude. From the PNSL the presence of 709 species of angiosperms has been documented, the largest number of species reported for an altitude area in southern Bahia (Amorim et al. 2009). Also, 295 species of birds have already been recorded, 18 of them threatened with extinction (Silveira et al. 2005). For amphibians, 16 species were reported (Silvano and Pimenta 2003). However, the sampling effort was very low and there is no list of reptiles available for the region. Even so, new species of birds, amphibians and reptiles have been described with material collect in the PNSL (see Pacheco et al. 1996; Recorder et al. 2010; Teixeira et al. 2013). In order to provide information that can help in the elaboration of species management

plans, conservation plans and aid the categorization of species, we complement and update the list of amphibians and present, for the first time, a list of reptiles for this conservation unit.

Materials and methods

Study area

The PNSL (Fig. 1) is a federal conservation unit located in the municipalities of Arataca and Una, in the southern region of Bahia, Brazil (15.16979°S, 39.35047°W). It is located 56 km away from Ilhéus and 265 km from Salvador, the state capital and has an extension of 113.43 km^2 with an altitudinal gradient from 300 to just over 1000 m. of altitude. The climate is classified as equatorial rainforest, fully humid (Af) (Kottek et al. 2006).

The vegetation of the PNSL is formed by a mosaic of forest cover, with predominance of primary and late secondary forests, areas in recovery and areas of "cabruca" (cocoa crops shaded by native trees). The altitude gradient facilitates the presence of different plant formations, where thin tall trees with a closed canopy and shrubby vegetation predominate up to 750–800 m altitude, and smaller trees with epiphytes and a more open canopy dominate in higher altitudes (Fig. 2).

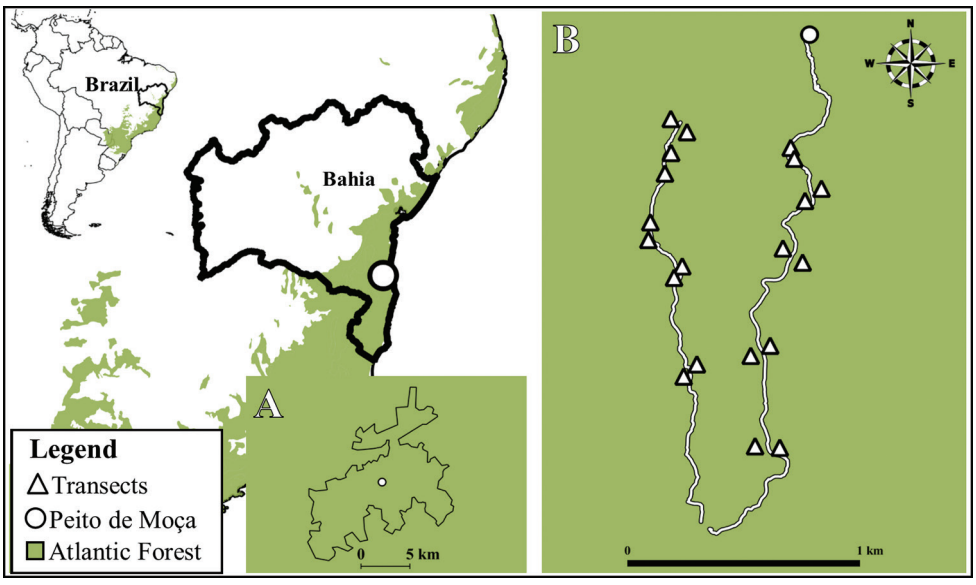

Figure 1. Location of the Parque Nacional da Serra das Lontras and the evaluated transects. **A** The Parque Nacional da Serra das Lontras **B** trails and transects sampled during 2017 and 2018.

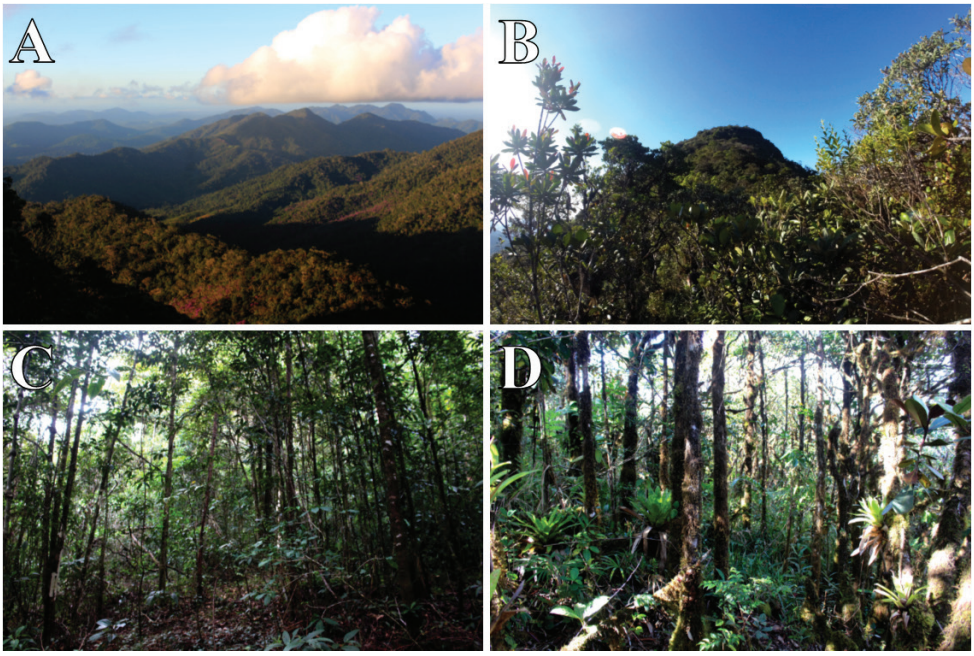

Figure 2. General and detail view of the change of vegetation in the Parque Nacional da Serra das Lontras. **A** Panoramic view from "Peito de Moça" (930 m altitude) **B** view of the "Peito de Moça" **C** primary vegetation with thin and tall trees with closed canopy below 750–800 m altitude **D** smaller vegetation with epiphytes and canopy more open in the peaks.

Data collection

We used the following methodologies for the sampling of the herpetofauna in the PNSL: i) visual and acoustic active search in transects in the forest (Heyer et al. 1994), ii) active search in water bodies: streams, temporary and permanent ponds (Heyer et al. 1994), iii) opportunistic records during our displacement, and iv) review of material deposited in the Museu de Zoologia of the Universidade Estadual de Santa Cruz. To complement the list of recorded species, we included the records of other studies carried out in the PNSL (Silvano and Pimenta 2003; Recoder et al. 2010; Teixeira et al. 2013).

Fieldwork was carried out during 44 sampling days during seven sampling campaigns: December 9–11 2014; March 9 and 10 2015; October 23–26 2017; and February 19–29, March 6–12, October 8–15, and December 10–18 in 2018.

In the years 2014 and 2015 we sampled 14 transects of 50 meters in length, localized between 700 and 900 m of altitude inside the primary forest. Each transect was sampled by two researchers only once for 40 minutes, totaling a sampling effort of 9.3 man hours. This sampling was complemented with active non-standard searches in streams and temporary ponds inside the forest.

In 2017, we conducted non-standardized searches in the interior of the forest during the opening of trails and definition of places for the installation of com-

plementary transects. Active searches without time limits were also carried out in streams and ponds.

In 2018, we installed two new 50 m long transects in each of the following altitudes: 450, 550, 650, 750, and 850 m in two mountains. Ten transects were installed on each mountain, totaling 20 transects. Each was sampled for 50 minutes by two researchers only once per campaign. In this period, each transect was evaluated three times, adding up to a sampling effort of 50 man hours. By the end of the study, we completed 59.30 man hours of sampling in the PNSL.

For the nomenclature of amphibian species, we follow Frost (2020). Regarding *Adelophryne* spp. we follow Lourenço-de-Moraes et al. (2018), and for *Adenomera* we follow Fouquet et al. (2014). For reptiles we follow Uetz and Hošek (2020); and for the particulary case of *Thamnodynastes*, we follow the sugestions by Franco and Ferreira (2002). We identified the endemic species of the Atlantic Forests and for Bahia state. Each recorded species was identified according to the proposals made for the biome by Rossa-Feres et al. (2017) and Tozetti et al. (2017) for amphibians and reptiles, respectively. Regarding the state; we revised the distribution sections in Frost (2020) for the amphibians, and the detailed list provided by Costa and Bérnils (2018) for reptiles.

Sampling of specimens and conservation status

All individuals collected in this work were covered by a license issued by the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio 59889-1) and they were deposited in the herpetological collection of the Museu de Zoologia of the Universidade Estadual de Santa Cruz (**MZUESC**) in Ilhéus, Bahia, Brazil. We identified the conservation status of each species at the state, federal and international scale using reference lists from the Secretaria de Meio Ambiente do Estado da Bahia – SEMA (2017), from the Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio (2018b, 2018c), and the IUCN (2019). The SEMA and ICMBio list provide only the categorization of species considered to be at risk of extinction. The categories of the identified species are as follows: DD, data deficient; LC, Least Concern; NT, Near Threatened; VU, Vulnerable; and EN, Endangered.

Results

We recorded 100 species, 49 of amphibians, and 51 of reptiles in the PNSL (Table 1, Figs 3–5). Ten families of amphibians, being the most diverse Hylidae (22 spp.), followed by Craugastoridae (06 spp.), Centrolenidae and Bufonidae (04 spp. each), Brachycephalidae and Leptodactylidae (03 spp. each), Eleutherodactylidae, Phyllomedusidae and Hemiphractidae (02 spp. each), and Hylodidae (01 sp.). In turn, we report 13 families of reptiles: Colubridae (33 spp.), Viperidae (04 spp.), Amphisbaenidae, Boidae, and Gymnophthalmidae (02 spp. each), and a species each of the families Chelidae, Dactyloidae, Elapidae, Gekkonidae, Leiosauridae, Polychrotidae, Teiidae, and Tropidophiidae.

Table 1. Amphibians and reptiles in the Parque Nacional da Serra das Lontras, Bahia, Brazil. Key: **C.S.**– Conservation Status, DD: Data Deficient, LC: Least Concern; EN: Endangered, VU: Vulnerable, according: 1: Secretaria de Meio Ambiente – Bahia state, 2: Instituto Chico Mendes de Biodiversidade, 3: International Union for Conservation of Nature. **EN.**– endemism, AF: Atlantic Forest, BA: Bahia. **S.M**– sampling method, AS: Active search, Tr: visual and acoustic active search in transects, Op: opportunistic records, Bi: bibliographic revision, Mu: individuals deposited in the herpetological collection of the Museu de Zoologia of the Universidade Estadual de Santa Cruz.

Class / Order / Family / Species	C.S.	EN.	S.M.
Amphibia			
Anura			
Brachycephalidae			
Brachycephalus pulex Napoli, Caramaschi, Cruz & Dias, 2011		AF, BA	Tr, AS, Mu
Ischnocnema verrucosa (Reinhardt & Lütken, 1862)	EN[1]	AF	AS
Ischnocnema cf. *parva*		AF	Tr, AS
Bufonidae			
Dendrophryniscus oreites Recoder, Teixeira, Cassimiro, Camacho & Rodrigues, 2010		AF, BA	Bi
Dendrophryniscus proboscideus (Boulenger, 1882)	DD[3]	AF	AS, Bi
Rhinella crucifer (Wied-Neuwied, 1821)	LC[3]	AF	Op, Mu, Bi
Rhinella hoogmoedi Caramaschi & Pombal, 2006	LC[3]	AF	Op, Bi
Centrolenidae			
Vitreorana baliomma Pontes, Caramaschi & Pombal, 2014		AF	AS
Vitreorana eurygnatha (Lutz, 1925)	EN[1], LC[3]		Tr, AS
Vitreorana sp. nov.		AF	AS
Vitreorana uranoscopa (Müller, 1924)	LC[3]	AF	AS, Mu
Craugastoridae			
"*Eleutherodactylus*" *bilineatus* (Bokermann, 1975)	LC[3]	AF, BA	Op
Haddadus binotatus (Spix, 1824)	LC[3]	AF	Tr, Op, Bi
Pristimantis sp. 1			Tr, AS
Pristimantis sp. 2			Tr, AS
Pristimantis paulodutrai (Bokermann, 1975)	LC[3]	AF, BA	Tr, AS
Pristimantis vinhai (Bokermann, 1975)	LC[3]	AF, BA	Tr, Op, Mu, Bi
Eleutherodactylidae			
Adelophryne sp. 2 (sensu Lourenço-de-Moraes et al. 2018)		AF	Tr, AS
Adelophryne sp. 8 (sensu Lourenço-de-Moraes et al. 2018)		AF	Tr, AS
Hemiphractidae			
Gastrotheca pulchra Caramaschi & Rodrigues, 2007		AF	Op
Gastrotheca recava Teixeira, Vechio, Recoder, Carnaval, Strangas, Damasceno, Sena & Rodrigues, 2012		AF, BA	Tr, AS, Op
Hylidae			
Aplastodiscus ibirapitanga (Cruz, Pimenta & Silvano, 2003)	LC[3]	AF	Op
Aplastodiscus weygoldti (Cruz & Peixoto, 1987)	NT[3]	AF	Tr, Op
Boana albomarginata (Spix, 1824)	LC[3]	AF	Op
Boana crepitans (Wied-Neuwied, 1824)			Bi, Mu
Boana exastis (Caramaschi & Rodrigues, 2003)	DD[3]	AF	AS
Boana faber (Wied-Neuwied, 1821)	LC[3]		Op, Bi
Boana pombali (Caramaschi, Pimenta & Feio, 2004)	LC[3]	AF	Op
Bokermannohyla lucianae (Napoli & Pimenta, 2003)	DD[3]	AF, BA	Tr, Op, Bi
Dendropsophus bipunctatus (Spix, 1824)	LC[3]	AF	Bi
Dendropsophus branneri (Cochran, 1948)	LC[3]	AF	AS
Dendropsophus aff. *bromeliaceus*		AF	Tr
Dendropsophus elegans (Wied-Neuwied, 1824)	LC[3]	AF	AS, Bi

Class / Order / Family / Species	C.S.	EN.	S.M.
Dendropsophus haddadi (Bastos & Pombal, 1996)	LC[3]	AF	AS
Dendropsophus minutus (Peters, 1872)	LC[3]		Bi
Ololygon strigilata (Spix, 1824)	DD[3]	AF, BA	Op, Bi
Phyllodytes cf. *maculosus*		AF	Tr
Phyllodytes sp. 1		AF	Tr, AS, Op
Phyllodytes sp. 2		AF	Tr, AS, Op
Phyllodytes megatympanum Marciano, Lantyer-Silva & Solé, 2017		AF, BA	Tr, AS
Scinax juncae Nunes & Pombal, 2010		AF, BA	AS, Bi
Scinax eurydice (Bokermann, 1968)	LC[3]	AF	Mu
Scinax cf. *x-signatus*			AS, Op, Bi
Hylodidae			
Crossodactylus sp.			AS
Leptodactylidae			
Adenomera clade M (sensu Fouquet et al. 2014)		AF	AS
Crossodactylodes septentrionalis Teixeira, Recoder, Amaro, Damasceno, Cassimiro & Rodrigues, 2013		AF, BA	AS
Leptodactylus cf. *latrans*			Op, Bi
Phyllomedusidae			
Phasmahyla spectabilis Cruz, Feio & Nascimento, 2008	VU[1], DD[3]	AF	Op
Phyllomedusa burmeisteri Boulenger, 1882	LC[3]	AF	Tr, Bi
Reptilia			
Testudines			
Chelidae			
Hydromedusa maximiliani (Mikan, 1820)	EN[1], VU[3]	AF	Mu
Squamata			
Amphisbaenidae			
Amphisbaena pretrei Duméril & Bibron, 1839	LC[3]		Mu
Leposternon sp.			Mu
Boidae			
Corallus hortulanus (Linnaeus, 1758)	LC[3]		Op, Mu
Epicrates cenchria (Linnaeus, 1758)			Mu
Colubridae			
Cercophis auratus (Schlegel, 1837)	VU[1], DD[3]		Mu
Chironius exoletus (Linnaeus, 1758)			Mu
Chironius foveatus Bailey, 1955	LC[3]	AF	Mu
Chironius fuscus (Linnaeus, 1758)			Tr, Op, Mu
Chironius laevicollis (Wied-Neuwied, 1824)	LC[3]	AF	Mu
Coronelaps lepidus (Reinhardt, 1861)	LC[3]	AF	Mu
Dipsas catesbyi (Sentzen, 1796)	LC[3]		AS, Mu
Dipsas indica Laurenti, 1768			Mu
Dipsas neuwiedi (Ihering, 1911)	LC[3]	AF	AS, Mu
Dipsas variegata (Duméril, Bibron & Duméril, 1854)			Mu
Drymoluber dichrous (Peters, 1863)	LC[3]		Mu
Echinanthera cephalostriata Di Bernardo, 1996	LC[3]	AF	Mu
Elapomorphus wuchereri Günther, 1861		AF	Mu
Erythrolamprus aesculapii (Linnaeus, 1758)			Mu
Erythrolamprus miliaris (Linnaeus, 1758)	LC[3]		Mu
Erythrolamprus poecilogyrus (Wied-Neuwied, 1825)			Mu
Erythrolamprus reginae (Linnaeus, 1758)			Op, Mu
Erythrolamprus taeniogaster (Jan, 1863)	LC[3]		Mu
Imantodes cenchoa (Linnaeus, 1758)	LC[3]		Tr, Mu
Leptodeira annulata (Linnaeus, 1758)	LC[3]		Mu
Oxybelis aeneus (Wagler, 1824)			Op, Mu

Class / Order / Family / Species	C.S.	EN.	S.M.
Oxyrhopus clathratus Duméril, Bibron & Duméril, 1854	VU[1]		Op
Oxyrhopus formosus (Wied-Neuwied, 1829)	EN[1]		Op, Mu
Oxyrhopus guibei Hoge & Romano, 1977	LC[3]		Tr, Mu
Oxyrhopus petolarius (Linnaeus, 1758)			Mu
Philodryas olfersii (Lichtenstein, 1823)			Mu
Pseudoboa nigra (Duméril, Bibron & Duméril, 1854)			Mu
Siphlophis compressus (Daudin, 1803)	LC[3]		Mu
Spilotes pullatus Linnaeus, 1758			Op, Mu
Spilotes sulphureus (Wagler, 1824)			Mu
Thamnodynastes cf. *nattereri* (Mikan, 1828)	LC[3]		AS, Mu
Xenodon rabdocephalus (Wied-Neuwied, 1824)			Mu
Xenopholis scalaris (Wucherer, 1861)	LC[3]		Op
Dactyloidae			
Anolis fuscoauratus D'Orbigny, 1837			Tr, Op
Elapidae			
Micrurus corallinus (Merrem, 1820)		AF	Mu
Gekkonidae			
Hemidactylus mabouia (Moreau de Jonnès, 1818)			Op
Gymnophthalmidae			
Leposoma nanodactylus Rodrigues, 1997	EN[1],[2]	AF, BA	Tr, AS
Leposoma scincoides Spix, 1825		AF	Op
Leiosauridae			
Enyalius catenatus (Wied-Neuwied, 1821)	LC[3]	AF	Tr, Op, Mu
Polychrotidae			
Polychrus marmoratus (Linnaeus, 1758)	LC[3]		Mu
Teiidae			
Ameiva ameiva (Linnaeus, 1758)			Mu
Tropidophiidae			
Tropidophis grapiuna Curcio, Nunes, Argôlo, Skuk & Rodrigues, 2012	EN[1], VU[2]	AF, BA	Tr
Viperidae			
Bothrops bilineatus (Wied-Neuwied, 1821)	VU[1]		Op, Mu
Bothrops jararaca (Wied-Neuwied, 1824)		AF	Tr, Op, Mu
Bothrops leucurus Wagler, 1824			Mu
Lachesis muta (Linnaeus, 1766)	VU[1]		Mu

Forty amphibians and 13 reptiles are endemic of the Atlantic Forest biome. Of these, eleven species of anurans and two of reptiles are restricted to the state of Bahia; and two anurans, *Dendrophryniscus oreites* and *Crossodactylus septentrionalis*, to the PNSL (Table 1). Although some individuals of amphibian are identified as "sp.", "cf.", or "aff.", individuals of the genus *Phyllodytes* are being considered endemic to the biome, as, until now, they have not been reported from other biomes.

Conservation status

According to SEMA (2017), six of our recorded species are considered endangered at state level: *Ischnocnema verrucosa*, *Oxyrhopus formosus*, *Tropidophis grapiuna*, and *Vitreorana eurygnatha* are categorized as EN, and *O. clathratus* and *Phasmahyla spectabilis* as VU. At federal level, according to ICMBio (2018b, c) *Leposoma nanodactylus* is categorized as EN,

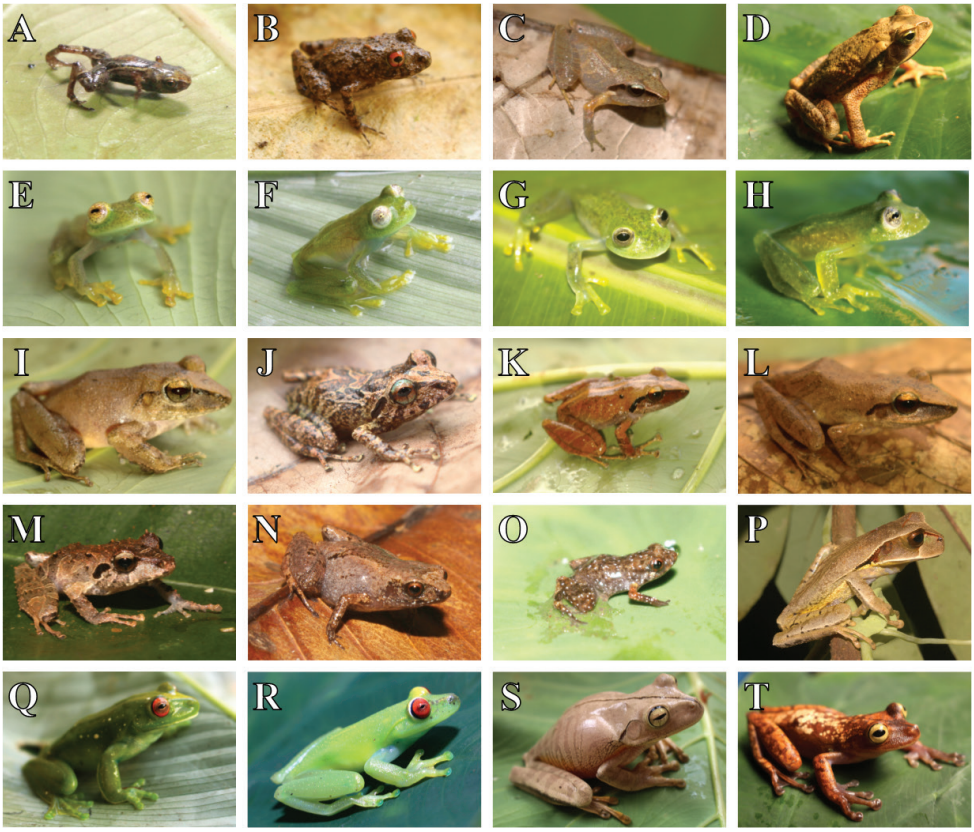

Figure 3. Amphibians recorded in the Parque Nacional da Serra das Lontras: **A** *Brachycephalus pulex* **B** *Ischnocnema verrucosa* **C** *Ischnocnema* cf. *parva* **D** *Rhinella crucifer* **E** *Vitreorana baliomma* **F** *V. eurygnatha* **G** *Vitreorana* sp.nov. **H** *V. uranoscopa* **I** *Haddadus binotatus* **J** *Pristimantis* sp. 1 **K** *Pristimantis* sp. 2 **L** *Pristimantis paulodutrai* **M** *Pristimantis vinhai* **N** *Adelophryne* sp. 8 **O** *Adelophryne* sp. 2 **P** *Gastrotheca recava* **Q** *Aplastodiscus ibirapitanga* **R** *A. weygoldti* **S** *Boana faber* **T** *Bokermannohyla lucianae*.

and *T. grapiuna* as VU. On the other hand, according to IUCN, *Bokermannohyla lucianae* and *P. spectabilis* are considered as DD, *Aplastodiscus weygoldti* as NT, and other 18 species as LC. However, 42 of the recorded species have not been categorized by IUCN (Table 1).

Discussion

Brazil is currently home to 1137 species of amphibians and 795 reptiles (Costa and Bérnils 2018; Segalla et al. 2019). However, new species are constantly being described from different biomes (Ferrão et al. 2017; Orrico et al. 2017; Vörös et al. 2017; Arias et al. 2018; among others), reflecting our scant knowledge about the species richness of these groups. From the state of Bahia, approximately 190 species of amphibians and

Figure 4. Amphibians and reptiles recorded in the Parque Nacional da Serra das Lontras. **A** *Dendropsophus branneri* **B** *Dendropsophus* aff. *bromeliaceus* **C** *D. elegans* **D** *D. haddadi* **E** *Ololygon strigilata* **F** *Phyllodytes* sp. 1 **G** *Scinax* cf. *x-signatus* **H** *Crossodactylus* sp. **I** *Adenomera* clade M **J** *Crossodactylodes septentrionalis* **K** *Leptodactylus* cf. *latrans* **L** *Phasmahyla spectabilis* **M** *Phyllomedusa burmeisteri* **N** *Corallus hortulanus* **O** *Chironius fuscus* **P** *Dipsas catesbyi* **Q** *Dipsas neuwiedi* **R** *Erythrolamprus reginae*, **S** *Imantodes cenchoa* **T** *Oxybelis aeneus.*

278 reptiles with ca. 129 species of snakes (Hamdan and Lira-da-Silva 2012; Dias et al. 2014; Costa and Bérnils 2018) have been reported so far. Here we report 49% of the total amphibian species and 19% of reptiles known for the state from an area slightly larger than 110 km². We believe that this number does not reflect the real diversity of amphibians and reptiles in the PNSL.

The first amphibian inventory undertaken at PNSL recorded 16 species (Silvano and Pimenta 2003). Due to taxonomic changes in different groups after that publication, we updated the binomial names and discuss some of the identifications. In order to avoid under- or overestimation of species richness, we assign the names to the species that were also found in our samples and hypothesize the presence of other species based on other records in nearby areas.

Species of *Bufo* were transferred to the genus *Rhinella* (Frost et al. 2006). *Rhamphophryne proboscidea* is now included in *Dendrophryniscus* (Fouquet et al. 2012a);

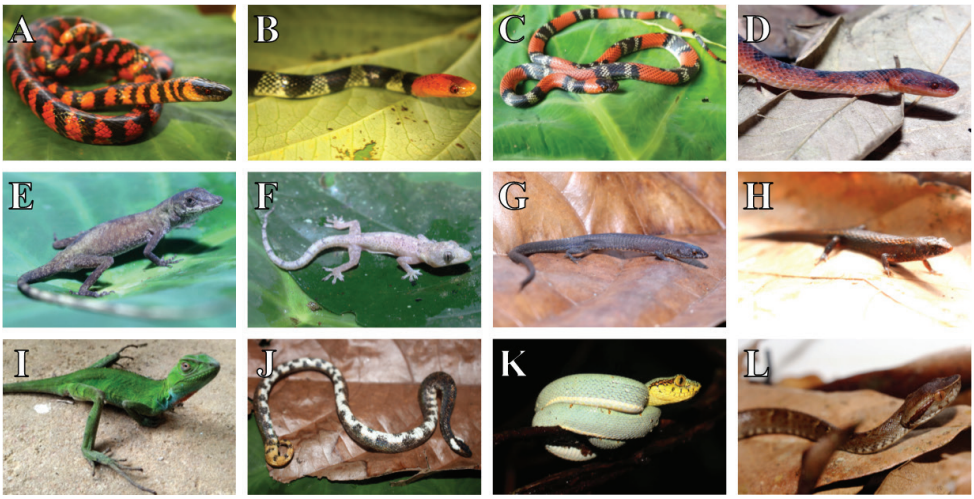

Figure 5. Reptiles recorded in the Parque Nacional da Serra das Lontras. **A** *Oxyrhopus clathratus* **B** *O. formosus* **C** *O. guibei* **D** *Xenopholis scalaris* **E** *Anolis fuscoauratus* **F** *Hemidactylus mabouia* **G** *Leposoma nanodactylus* **H** *L. scincoides* **I** *Enyalius catenatus* **J** *Tropidophis grapiuna* **K** *Bothrops bilineatus* **L** *B. jararaca.*

we did not record this species, but its presence was confirmed in the last revision of the genus (see Cruz et al. 2019) and has also been reported in nearby areas (Silva et al. 2011). The ancient specious genus *Eleutherodactylus* was revised and several of its species have been transferred to other genera, thus *E. binotatus* moved to *Haddadus* (Hedges et al. 2008), and *E. vinhai* first to *Ischnocnema* (Heinicke et al. 2007, Hedges et al. 2008) and later to *Pristimantis* (Canedo and Haddad 2012). Likewise, the six reported species of *Hyla* currently belong to the following binomials: *Boana crepitans*, *B. faber*, *Bokermannohyla lucianae*, *Dendropsophus bipunctatus*, *D. elegans*, and *D. minutus* (Faivovich et al. 2005; Dubois 2017). We note that the record of *Bokermannohyla lucianae* was identified as "*Hyla* sp. n3" (Silvano and Pimenta 2003), with the species being described a year later (see Napoli and Pimenta 2004). We consider the record of *Scinax cuspidatus* as *S. juncae* because we recorded several individuals vocalizing in a pond. In the same way, the record of *S. fuscovarius* is now attributed to *S.* cf. *x-signatus*. Finally, we relate *Leptodactylus ocellatus* to *L.* cf. *latrans*, given that there are species delimitation problems, being barely distinguishable from the species complex including *L. chaquensis* and *L. macrosternum* (de Sá et al. 2014).

Dias et al. (2014) carried out an amphibian inventory in an area close to the PNSL, the RPPN Serra Bonita (SB), where they found 80 species. The SB, in addition to being close the PNSL (31.15 km away as a straight line), it shares the same relief characteristics (200–950 m) and vegetation types (Amorim et al. 2009). Our research differs from that developed by Dias et al. (2014) regarding the sampling effort (192 man hours in transects in the forest, versus 59.3 man hours in PNSL), installation of transects close to streams, and installation of pitfall traps. Although we sampled for several days in the rainy season (approximately one week), the presence of seasonal ponds was limited and, when formed, the number of species with expected explosive reproduc-

tion were not found (Duellman and Trueb 1994; Wells 2008). We also highlight that the area sampled in the PNSL represents only a small fraction of the park's extension.

We found 49 species of amphibians that represent more than half of those known from SB, an area considered to harbor the second largest species richness in the Atlantic Forest (Dias et al. 2014). PNSL and SB share 31 species of anurans. We believe that with more sampling efforts in streams, temporary and permanent ponds, and in other areas of the PNSL, we would find several of the species already reported from SB: *Boana semilineata*, *Bokermannohyla circumdata*, *Ceratophrys aurita*, *Chiasmocleis crucis*, *Dendropsophus anceps*, *D. giesleri*, *D. oliverai*, *Leptodactylus cupreus*, *L. mystaceus*, *Physalaemus camacan*, *P. erikae*, *Pipa carvalhoi*, *Pithecopus rhodei*, *Proceratophrys renalis*, *Pr. schirchi*, *Rhinella granulosa*, *R. jimi*, *Ololygon argyreonata*, *Siphonops annulatus*, *Sphaenorhynchus prasinus*, *Stereocyclops histrio*, *S. incrassatus*, and *Trachycephalus mesophaeus* which would increase our list by another 24 species. However, in the PNSL we have recorded four species not yet reported from the SB, *Dendropsophus* cf. *bromeliaceus*, *Gastrotheca recava*, *Vitreorana baliomma*, and *Vitreorana* sp. nov.

Considering the taxonomic uncertainties and the possibility of undescribed entities in the region, we try to assign identifications to the finest possible level. *Pristimantis* sp. 1 differs from all other species of *Pristimantis* found in the PNSL by its eye color, spotted dorsal pattern, and call parameters. *Pristimantis* sp. 2 is the same species reported as *Pristimantis* sp. from the Reserva Ecológica Michelin (Mira-Mendes et al. 2018). Fouquet et al. (2012b) defined *Adelophryne* populations from neighboring areas as *A. pachydactyla* but further research refuted this hypothesis (see Dominato et al. 2018; Lourenço-de-Moraes et al. 2018). In our sampling we found two species of this genus and due to their morphological characteristics, we identified them as *Adelophryne* sp. 2 and *Adelophryne* sp. 8 sensu Lourenço-de-Moraes et al. (2018). Likewise, individuals from *Adenomera* are attributed to clade M, sensu Fouquet et al. (2014).

The flea-toad, *Brachycephalus pulex*, was known only from the upper parts of the type locality in Serra Bonita (Napoli et al. 2011). Our record expands its distribution by 31 km in a straight line. *Bokermannohyla lucianae* appears to have a distribution bounded by the Cachoeira and Jequitinhonha rivers in the southern part of Bahia (Dias et al. 2011), with PNSL being only the fourth known location for the species. *Pristimantis* sp. 2 is distributed in lowland forest of southern Bahia (Mira-Mendes et al. 2018).

Five species of the genus *Vitreorana* are known from the Atlantic Forest biome (Rossa-Feres et al. 2017). Although Rossa-Feres et al. (2017) considered *V. eurygnatha* as endemic to the Atlantic Forest, the species was reported in a locality within the Cerrado biome (Cintra et al. 2013). However, the PNSL, with four syntopic species (*V. baliomma*, *V. eurygnatha*, *V. uranoscopa*, and one species as yet undescribed) is the most diverse site for the genus in the Atlantic Forest, where usually only one or two species are found (see Pontes et al. 2014; Dias et al. 2014; Mira-Mendes et al. 2018). We heard vocalizations of *V. eurygnatha* and *V. uranoscopa* in the months of February and April, and *V. baliomma* only in April, all records being made in 2018. All these species use the vegetation on the banks of streams to vocalize, mate, and for oviposition (Haga et al. 2014; Zaracho 2014), with *V. baliomma* and *V. eurygnatha* sharing vocalization

microhabitats. The new species of *Vitreorana* differs from the others by morphological and genetic characters.

Most of the reptile's records were obtained from material deposited at MZUESC. During our systematic sampling, we did not install pitfall traps, which could have increased the number of lizards and snakes of terrestrial and fossorial habitats in our records (Cechin and Martins 2000). At the same time, the fact that our samplings were carried out mainly at night may have privileged the record of amphibian species (Doan 2003). We emphasize that, in the methodological evaluations, eleven species were recorded by a single individual. In absolute numbers, the PNSL can be considered as the third locality with the greatest reptile richness in the state of Bahia, being only surpassed by the Serra da Jibóia and the Serra do Timbó, with 59 and 54 species, respectively (vs. 51 from PNSL) (Freitas et al. 2018; Freitas et al. 2019).

The rare turtle *Hydromedusa maximiliani* has records associated to water bodies within primary forests in mountainous regions, with previous records from other localities in Bahia (Argôlo and Freitas 2002). Although Tozetti et al. (2017) considered *Oxyrhopus formosus* to be endemic to the Atlantic Forest, its distribution is unclear with records scattered through the Brazilian, Ecuadorian, and Peruvian Amazon (Catenazzi et al. 2013; Wallach et al. 2014; Costa and Bérnils 2018). This taxon is considered a species complex with populations in Guyana, Colombia, and some places in Ecuador having been reidentified as *O. occipitalis* (Lynch 2009; MacCulloch et al. 2009). In the Atlantic Forest, *O. formosus* is considered a rare species categorized as EN in the state of Bahia (Argôlo 2004; SEMA 2017), and reported from four localities within this biome: Almadina and Coaraci (Argôlo et al. 2012; Dias et al. 2014b) and Mucuri, the type locality (sensu Vanzolini and Myers 2015), all in the state of Bahia; and Duas Barras in Espírito Santo state (Tonini et al. 2010). Considering the conservation status and doubts about its geographical distribution, molecular, pholidosic, and other morphological data can help solve the taxonomic problem of this species with disjunct distribution.

Oxyrhopus clathratus inhabits dense coastal ombrophilous and mixed ombrophilous forests from the northeast and southeast of Brazil (Tozetti et al. 2017), and reaches the north of Argentina (Di-Bernardo et al. 2012). Di-Bernardo et al. (2012) suggested that the color patterns of individuals are related to altitude, and the pattern of our individual is consistent with the one most common in lowland areas, although found at ~750 m. Our record represents the third for Bahia, having previously been found in Barra do Choça (Argôlo 2001) and in the SB (Medeiros et al. 2010).

Only two individuals of *Tropidophis grapiuna* are known in the literature, both collected in ombrophilous forest between 725–750 m altitude in the southern portion of Bahia (Curcio et al. 2012). Since its description, no other individuals have been collected. We found an individual in the leaf litter at 550 m, representing the first collected male, the lowest altitudinal record, and the first record inside a conservation area for this species.

The species *Cercophis auratus*, *Echinanthera cephalostriata*, *Hydromedusa maximiliani*, *Oxyrhopus clathratus*, and *Tropidophis grapiuna* represent populations restricted to montane forests in the latitude range of this study (Argôlo and Freitas 2002; Argôlo 2009). In fact, long-term sampling in southern Bahia has never detected any of these species in the

lowlands of the region (Argôlo 2004). The lizards *Leposoma nanodactylus* and *L. puk* are known principally from mountain forests of southern Bahia. *Leposoma nanodactylus* has records in the PNSL and, in view of the known distribution of *L. puk* (Rodrigues et al. 2002; Rodrigues et al. 2013), it is likely that this species also occurs there. This information helps to highlight the importance of the PNSL for biodiversity conservation.

Of the 100 species reported in the PNSL, 53 are endemic to the Atlantic Forest and 13 of these are endemic to the state of Bahia, of which only two, *Crossodactylodes septentrionalis* and *Dendrophryniscus oreites*, are, until now, restricted to the park. One of the theories to explain the large number of endemic species in this biome is that of the Pleistocene refuge hypothesis (Haffer 1997). The PNSL is located inside the "Refúgio da Bahia", identified as the one with the greatest extension in the biome, a zone of climatic stability that allowed the maintenance of different species during the last glacial maximum (Carnaval et al. 2009). In this way, the altitude areas of the region may have functioned as opportune places of climatic stability and, subsequently allowed a diversification of the surviving fauna (Graham et al. 2014).

Climatic conditions in these areas can shape the lives of the amphibians and reptiles that inhabit them (Duellman and Trueb 1994). It has been proposed that small frogs of the genus *Brachycephalus* inhabit areas of altitude due to a dependence on temperature and microclimate that are modulated by mist (Haddad et al. 2008). The scarcity of water bodies in the higher parts of the mountains may have favored these places to be occupied by species of genera with direct development, such as *Adelophryne*, *Brachycephalus*, *Ischnocnema*, and *Pristimantis* (Siqueira and Rocha 2013), and those using bromeliads for tadpole development, *Crossodactylodes* spp. and *Phyllodytes* spp. (Sabagh et al. 2017). In fact, we found species of these genera in the highest locals of the PNSL where bromeliads are more abundant.

Lastly, the expansion of agricultural activities, particularly coffee crops, seems to be a threat to the PNSL. During our fieldwork, we found that areas destined for this cultivation are being expanded between Arataca municipality and the PNSL borders. Within the PNSL, we noted the absence of monkey vocalizations and other mammal footprints on the trails and edges of streams. During the days in the field, although we did not hear shotguns, we did find some traps set up for hunting small mammals. Some residents have reported that hunting activity was frequent in the region. The areas of cabruca are still being utilized and we did not record any expansion of use during our visits. On one of the trails towards a mountain ridge, called "Peito de Moça" by locals, we saw an open area under recovery with abundant ferns and shrub vegetation and the presence of an abandoned wooden house. Among these threats, habitat loss was identified as the most visible and probably the main threat for amphibian and reptile species in Brazil (Rodrigues 2005; Silvano and Segalla 2005).

We conclude that the Parque Nacional da Serra das Lontras harbors a representative number of species of amphibians and reptiles, many of which are endemic to the Atlantic Forest and to the state. The new records of endemic, endangered, and species new to science reveal it as an outstanding area for the conservation and maintenance of ecological and evolutionary processes in this portion of southern Bahia, a region already known for its abundant biodiversity.

Acknowledgements

First of all, we want to dedicate this work to the memory of Zezito; his kindness, hospitality, and advice were of great importance to the fieldwork and the successful completion of this work. We thank Caio V. de Mira-Mendes, Camila Cassano, Carol Barreto, Elaine Macêdo, Gabriel Novaes e Fagundes, Leildo Carilo, Ramon Dominato Renan Nunes Costa, Rudolf von May, Paulo Machado, Pedro Peloso, and Tadeu Medeiros for the support and suggestions in different stages of the work. Pablo Monan, Fernanda Natascha Pimentel Freitas, Laísa Santos, Marcos Vinicius Coutinho Ferreira, Marcelo Sena, Erick Leandro Santos, and Victor Zucchetti for their company during the field trips. To Nathalie Yonow, Pedro Calixto, Pedro Taucce, and Santiago Castroviejo-Fisher for comments on drafts of the manuscript. To Paula and Zirlene for their support and for sharing Zezito's house with us after his unexpected departure. ORP thanks Programa de Alianzas para la Educación y la Capacitación de la Organización de Estados Americanos and the Grupo Coimbra de Universidades Brasileñas (PAEC OEA-GCUB) and the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) – Finance Code 001, to Idea Wild for donation of field equipment, and particularly to Ariadne Angulo and Meri Ushiñahua. MS acknowledges funding by the Brazilian National Council for Scientific and Technological Development (CNPq) (304999/2015-6) and Coordination for the Improvement of Higher Education Personnel (CAPES)/Alexander von Humboldt Foundation (AvH) for an experienced researcher grant (BEX 0585/16-5). VGDO thanks CNPq (Project numbers: 310467/2017-9 and 431772/2018-4). IRD is grateful for the scholarships provided by CNPq (Project: 406899/2017-7, Process: 167387/2017-0 and 155198/2018-1).

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Appendix I

Specimens deposited and examined in the herpetological collection of the Museu de Zoologia of the Universidade Estadual de Santa Cruz.

AMPHIBIA

Brachycephalidae

Brachycephalus pulex – MZUESC 21691–21697.
Ischnocnema verrucosa – MZUESC 21303, 21304, 21359, 21361, 21362.
Ischnocnema cf. *parva* – MZUESC 21306, 21393, 21404, 21405.

Bufonidae

Rhinella crucifer – MZUESC 21300, 21351, 21354, 21389, 21417, 21650, 21652, 21653.

Centrolenidae

Vitreorana baliomma – MZUESC 21037, 21039.
Vitreorana eurygnatha – MZUESC 21034, 21038, 21040, 21042, 21043, 21045.
Vitreorana sp. nov. – MZUESC 21044.
Vitreorana uranoscopa – MZUESC 21035, 21036, 21046.

Craugastoridae

"Eleutherodactylus" bilineatus – MZUESC 17025.
Haddadus binotatus – MZUESC 21298, 21309, 21385, 21387, 21390, 21392, 21394–21396, 21399–21401, 21403, 21408–21411, 21413, 21419, 21424, 21429, 21434.
Pristimantis sp. 1 – MZUESC 20995, 2009–21001, 21004, 21005, 21008, 21009, 21012, 21013, 21015, 21016, 21021, 21024, 21027, 21030, 21032, 21033.
Pristimantis sp. 2 – MZUESC 21443, 21454, 21482, 21495, 21496, 21513, 21535, 21550, 21559, 21577, 21580, 21584, 21588, 21590, 21591, 21594, 21604, 21610–21612, 21632, 21643, 21644, 21647.
Pristimantis paulodutrai – MZUESC 21447, 21485, 21486, 21492, 21497, 21507, 21538, 21539, 21541, 21593, 32452.
Pristimantis vinhai – MZUESC 21020, 21439–21441, 21448–21451, 21453, 21461, 21462, 21484, 21487–21491, 21494, 21494, 21508–21511, 21514–21518, 21525, 21526, 21528, 21531, 21532, 21537, 21540, 21549, 21551–21556, 21563–21567, 21571–21573, 21578, 21579, 21586, 21587, 21603, 21606, 21613, 21618–21622, 21641, 21642, 21648.

Eleutherodactylidae

Adelophryne sp. 2 – MZUESC 21445, 21446, 21502, 21504, 21505, 21519, 21522, 21529, 21575, 21583, 21602, 21638.
Adelophryne sp. 8 – MZUESC 21444, 21450, 21483, 21498, 21499, 21506, 21512, 21520, 21521, 21523, 21524, 21527, 21530, 21533, 21534, 21536, 21557, 21560, 21568–21570, 21576, 21585, 21589, 21596–21601, 21605, 21607–21609, 21615, 21616, 21623–21631, 21634–21637, 21639, 21645, 21646.

Hemiphractidae

Gastrotheca recava – MZUESC 21350, 21353, 21357, 21358.

Hylidae

Aplastodiscus ibirapitanga – MZUESC 21305.
Aplastodiscus weygoldti – MZUESC 21356.
Boana crepitans – MZUESC 2222, 2223.
Boana faber – MZUESC 21388, 21391, 21428, 21651, 21655, 21656.
Boana pombali – MZUESC 21397.
Bokermannohyla lucianae – MZUESC 21299, 21307, 21386, 21406, 21412, 21414, 21415, 21418, 21422, 21423, 21425–21427, 21430, 21431, 21437, 21438.
Dendropsophus branneri – MZUESC 21500, 21592.
Dendropsophus aff. *bromeliaceus* – MZUESC 21041, 21047.
Dendropsophus elegans – MZUESC 21558.
Dendropsophus haddadi – MZUESC 21456–21460, 21501, 21542–21548, 21581, 21582.
Ololygon strigilata – MZUESC 21352, 21402, 21407, 21416, 21433, 21435, 21436.
Phyllodytes sp. 1 – MZUESC 20994, 20996, 20997, 21000, 21002, 21003, 21006, 21007, 21010, 21011, 21014, 21017–21019, 21022, 21023, 21025, 21026, 21028, 21029, 21031, 21442, 21561, 21640.
Scinax cf. *x-signatus* – MZUESC 20408–20410, CFBH 44693.

Hylodidae

Crossodactylus sp. – MZUESC 20965–20971.

Leptodactylidae:

Adenomera clade M. – MZUESC 21713, 21714.
Crossodactylodes septentrionalis – MZUESC 14363, 21668.
Leptodactylus cf. *latrans* – MZUESC 21384, 21654.

Phyllomedusidae

Phasmahyla spectabilis – MZUESC 21301, 21360.
Phyllomedusa burmeisteri – MZUESC 21308, 21363.

REPTILIA

Amphisbaenidae

Amphisbaena petrei – MZUESC 16975.
Leposternon sp. – MZUESC 6707.

Boidae

Corallus hortulanus – MZUESC 1231, 1732, 3151, 3152, 6682.
Epicrates cenchria – MZUESC 2161, 4897, 8891.

Chelidae

Hydromedusa maximiliani – MZUESC 1235, 2189.

Colubridae

Cercophis auratus – MZUESC 1131.
Chironius exoletus – MZUESC 1102, 1122, 1228, 2167, 2236, 2237, 2904, 2905, 8861.
Chironius foveatus – MZUESC 1124, 8864.
Chironius fuscus – MZUESC 1101, 1003, 1125, 1130, 1137, 1138, 1220, 1744, 1755, 2234–2235, 6698, 6700.
Chironius laevicollis – MZUESC 6699.
Coronelaps lepidus – MZUESC 2227.
Dipsas catesbyi – MZUESC 21664, 2166, 4873.
Dipsas indica – MZUESC 1730, 4882.
Dipsas neuwiedi – MZUESC 1104–1106, 1127–1129, 1221–1223, 1232, 1233, 1736–1738, 1750, 2173, 2174, 21398, 2230–2233, 4272, 4425, 4493, 4874, 4875, 6687–6691, 6702, 8867.
Dipsas variegata – MZUESC 1108–1111, 1136, 1739, 1740, 2191, 2192, 4883, 6704, 6705.
Drymoluber dichrous – MZUESC 1528, 2247, 4881, 6683.
Echinanthera cephalostriata – MZUESC 1213.
Elapomorphus wuchereri – MZUESC 4489, 8890.
Erythrolamprus aesculapii – MZUESC 4876, 6692.

Erythrolamprus miliaris – MZUESC 2249.
Erythrolamprus poecilogyrus – MZUESC 2172.
Erythrolamprus reginae – MZUESC 1747, 1748, 21660, 2246, 2895, 6694.
Erythrolamprus taeniogaster – MZUESC 2901.
Imantodes cenchoa – MZUESC 1227, 19220, 21663.
Leptodeira annulata – MZUESC 1107, 1123, 1743, 2190, 2897, 4268, 4270, 4493, 4500, 6703.
Oxybelis aeneus – MZUESC 1224, 21662, 2171, 4427.
Oxyrhopus formosus – MZUESC 19221.
Oxyrhopus guibei – MZUESC 21665, 2226, 3791, 4878, 4879, 6706, 8887.
Oxyrhopus petolarius – MZUESC 1112, 1113, 1218, 1219, 1749, 2170, 2229, 2900, 4275, 4880.
Philodryas olfersii – MZUESC 8892.
Pseudoboa nigra – MZUESC 8862.
Siphlophis compressus – MZUESC 1234, 2168.
Spilotes pullatus – MZUESC 18800, 2164, 8881, 8882.
Spilotes sulphureus – MZUESC 2243, 3153, 4426, 4495, 4503, 4852, 8863.
Thamnodynastes cf. *nattereri* – MZUESC 19722, 2169, 2241, 2242, 2248, 4269, 4271, 4502, 6701.
Xenodon rabdocephalus – MZUESC 1133–1135, 1214, 1215, 1229, 1230, 1529, 1729, 1741, 1742, 2175–2179, 2193–2197, 2228, 2244, 2245, 2902, 2903, 2989, 3792, 4496–4999, 4273, 4274, 4424, 4884–4889, 6684–6686, 6696, 6697.

Dactyloidae

Anolis fuscoauratus – MZUESC 21420, 21421.

Elapidae

Micrurus corallinus – MZUESC 1746, 4877, 6693.

Gekkonidae

Hemidactylus mabouia – MZUESC 21355.

Gymnophtalmidae

Leposoma nanodactylus – MZUESC 21562, 21573, 21595, 21633.
Leposoma scincoides – MZUESC 21614.

Leiosauridae

Enyalius catenatus – MZUESC 1116, 1731, 2165, 21302, 21310, 21311, 21349, 21432, 21657–21659.

Polychrotidae

Polychrus marmoratus – MZUESC 1115, 1117.

Teiidae

Ameiva ameiva – MZUESC 1114, 1139–1140.

Tropidophiidae

Tropidophis grapiuna – MZUESC 19219.

Viperidae

Bothrops bilineatus – MZUESC 1119–1120, 1530, 21661, 2899, 3790, 4428–4430, 4869–4872, 6708.
Bothrops jararaca – MZUESC 1091–1100, 1121, 1126, 1132, 1216, 1225, 1226, 1727, 1728, 1733–1735, 2180–2188, 2198–2203, 3147–3150, 3787–3789, 4265–4267, 4501, 4417–4419, 4421–4423, 4431, 4490–4492, 6709–6721, 6695, 8865, 8866, 8868–8880, 8883–8886, 8888, 17480, 17822, 19719, 21666, 2238–2240, 4890–4896, 6670–6681.
Bothrops leucurus – MZUESC 1217, 2896, 4264, 4416, 4418, 4420.
Lachesis muta – MZUESC 2162, 2163, 4263, 4232–4434, 4504, 4898.