ZooKeys 780: 1–9 (2018)
doi: 10.3897/zookeys.780.26388
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

On a new commensal species of *Aliaporcellana* from the western Pacific (Crustacea, Decapoda, Porcellanidae)

Alexandra Hiller[1], Bernd Werding[2]

1 *Smithsonian Tropical Research Institute, Apartado 0843–03092, Panamá, República de Panamá* **2** *Institut für Tierökologie und Spezielle Zoologie der Justus-Liebig-Universität Giessen, Heinrich-Buff-Ring 29 (Tierhaus), D-35392 Giessen, Germany*

Corresponding author: *Alexandra Hiller* (hillera@si.edu)

Academic editor: *I. Wehrtmann* | Received 3 May 2018 | Accepted 18 July 2018 | Published 8 August 2018

http://zoobank.org/6A7C9B46-8674-44CE-99E7-4F819952E893

Citation: Hiller A, Werding B (2018) On a new commensal species of *Aliaporcellana* from the western Pacific (Crustacea, Decapoda, Porcellanidae). ZooKeys 780: 1–9. https://doi.org/10.3897/zookeys.780.26388

Abstract

Aliaporcellana spongicola **sp. n.** from the Philippines and Indonesia is described. The new species has been frequently photographed by divers because of its striking coloration, but has not been described yet. *Aliaporcellana spongicola* **sp. n.** is in fact a widespread commensal of barrel sponges of the genus *Xestospongia* and other sponges. Morphological characters and ecological information of all described species of *Aliaporcellana,* and of other porcellanids associated with sponges and soft corals, suggest that all members of the genus are commensals, and that similar morphological adaptations to dwelling on these hosts have evolved independently in different evolutionary lines within Porcellanidae.

Keywords

Crustacea, Porcellanidae, *Aliaporcellana*, new species, Indo-West Pacific, commensalism, adaptation, sponge- and octocoral-dwelling

Introduction

The porcellanid genus *Aliaporcellana* was established by Nakasone and Miyake (1969) for a group of Indo-West Pacific species previously assigned to *Porcellana* Lamarck and to one of three natural groups within *Polyonyx* Stimpson, designated by Johnson (1958) as the *P. denticulatus* Paul'son 1875, group. A diagnostic character considered by Nakasone and Miyake (1969) to raise *Aliaporcellana* is the dactylus of all walking legs bearing two or more distinctively well-developed fixed spines. *Aliaporcellana* contained nine species until Haig (1978) restricted the genus to the species of the *Polyonyx denticulatus* group, which now includes the type *A. suluensis* (Dana 1852), *A. pygmaea* (de Man 1902) and *A. telestophila* (Johnson 1958), and the species described by Nakasone and Miyake (1969), *A. kikuchii*. A fifth species, *A. taiwanensis*, was subsequently described by Dong et al. (2011).

Here we describe a new sponge-dwelling species of *Aliaporcellana* from material collected in the Philippines and Indonesia. Despite having been frequently photographed by divers because of its striking coloration and relatively large size, the species has not been described. With the exception of *A. telestophila* , commensalism has never been reported for other congeners. We highlight the characters distinguishing the new species from its congeners, and discuss the morphological traits, present in all *Aliaporcellana* species and other porcellanids associated with sponges, which we interpret as adaptations to living on these hosts.

Material and methods

We found the new species in material collected in the Philippines by G. Paulay [Florida Museum of Natural History, Gainesville, U.S.A. (UF)] and in Indonesia by C.H.J.M. Fransen [Naturalis Leiden, The Netherlands (RMNH)]. The holotype is deposited in the National Museum of Natural History, Philippines (NMCR). Color photographs of the holotype and of the live crab in the field were provided by G. Paulay, and were included in the description. Measurements of carapace length and width (in mm) of type individuals follow collection information.

Results

Systematic account

Family Porcellanidae

Aliaporcellana spongicola sp. n.

http://zoobank.org/21BCF647-FA9C-43C6-B604-5FCBD474643D
Figures 1–5

Material. Holotype: female (ovigerous), NMCR 4966, ex UF 43328, Philippines, Oriental Mindoro Province, Mindoro, Puerto Galera, off Pt W of Bayanar Beach, 13.5118°N 120.9088°E, 10–13 m, sand slope, coll. G. Paulay, 02.04.2015, 6.8 × 7.0 mm. **Paratypes**: 2 females (ovigerous), UF 43328, same collection data as holotype, 7.4 × 7.6 mm, 5.2 × 5.2 mm;1 female (ovigerous), UF 42943, Philippines, Oriental Mindoro Province, Mindoro, Puerto Galera, Batangas Channel, 13.5199°N 120.9604°E,

Figure 1. *Aliaporcellana spongicola* sp. n. Female (ovigerous) paratype, UF 43328 (Photo UF dPHIL 7104), Philippines, Oriental Mindoro Province, Mindoro, Puerto Galera, off Pt W of Bayanar Beach. Scale bar: 3.5 mm.

11 m, lagoon sand slope with sponge, coll. G. Paulay, 12.04.2015, 6.2 × 6.8mm; 2 males, 1 female (ovigerous), RMNH.CRUS.D.57287, Indonesia, SW Sulawesi, Spermonde Archipelago, Bitung, sta. 17, 20 m, from large grey folious sponge, cleaning station, coll. C.H.J.M. Fransen, 30.10.1994, 4.8 × 4.4 mm, 3.3 × 3.0 mm, 5.2 × 4.8 mm.

Description. Carapace rounded (Figures 1, 2), considerably variable in form and in length-width ratio; larger females with carapace broader than long (ratio < 1), smaller individuals with carapace relatively longer than broad (ratio > 1); dorsal surface convex, glossy, with faint, transverse striae on branchial and intestinal regions; cervical grooves gently depressed. Front (Figures 1, 2) broad, slightly produced beyond eyes, weakly trilobate, somewhat deflexed; frontal lobe visible in dorsal view, grooved, overreaching lateral ones. Distal margin of entire front lined with row of rounded, upwardly directed small spines (Figure 3a), the largest on supraocular edges. Outer orbital angles (Figure 2) forming acute, bifid tooth followed by hepatic spine of similar size. Epibranchial margin rounded, produced outwards, marked with epibranchial spine; cervical groove faintly marked. Mesial branchial margins crested, with row of 5 or 6 strong, anteriorly, upwardly directed spines of increasing size posteriorly. Sidewalls entire.

Eyes moderately large (Figures 1, 2, 3a), retracted, ocular peduncles short. First movable segment of antennal peduncle (Figures 2, 3b) with strong, anteriorly curved distal spine, second with smaller, anterodistal, acute protuberance, third one globular. Basal segment of antennular peduncle (Figure 3c) with anterior surface transversely

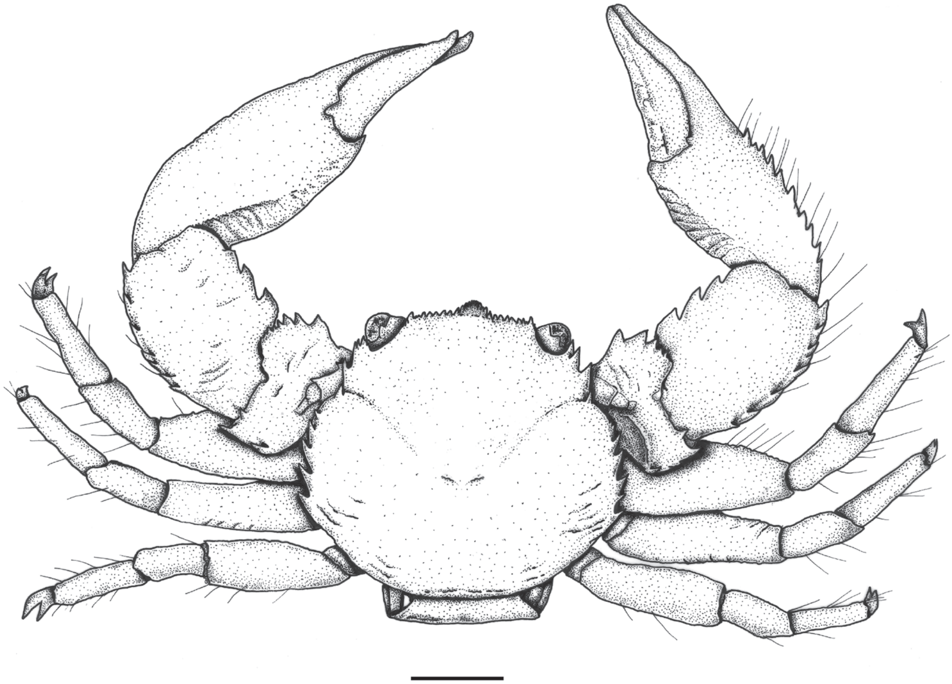


Figure 2. *Aliaporcellana spongicola* sp. n. Female (ovigerous) holotype, UF 43328, Philippines, Oriental Mindoro Province, Mindoro, Puerto Galera, off Pt W of Bayanar Beach. Scale bar: 2 mm.

rugose, surrounded with open ring of strong, conical spines. Third maxilliped (Figure 3d) slightly rugose, ischium sub-quadrate with inner lobe, inner margin of merus semicircular; exopodite long, pyriform, reaching 2/3 of length of merus.

Third thoracic sternite (Figure 3e) broadly elliptic, with triangular, forwardly produced, lateral projections. Telson with 7 plates.

Chelae moderately different in size and form (Figures 2, 4a-c); merus short, dorsal surface faintly rugose, inner margin with strongly projecting, sub-rectangular projection, fringed distally with cockscomb-shaped row of teeth, other large spines on proximal and distal edge of outer margin, one on distal margin; ventral side with two large spines on distal margin. Carpus 1.5 times as long as wide, dorsal surface evenly convex, similarly structured as carapace, with some faint transversal plications; inner margin with 3–5 low or sharply hooked teeth, decreasing in size distally, distal edge rounded. Outer margin with a row of six or seven acute, upwardly directed spines, the last one forming distal edge. Palm slender, surface rounded, similarly structured as carpus, with faint, transverse striae. Smaller chela with outer margin bearing row of approximately ten sharp spines on proximal half, with scattered, long, simple setae; fingers reaching up to half length of chela, dactylus moderately twisted, opening vertically, cutting edges denticulate, without teeth, both fingers with narrow fringe of fine, plumose setae in proximal 2/3 of length. Larger chela somewhat stouter, outer margin with row of

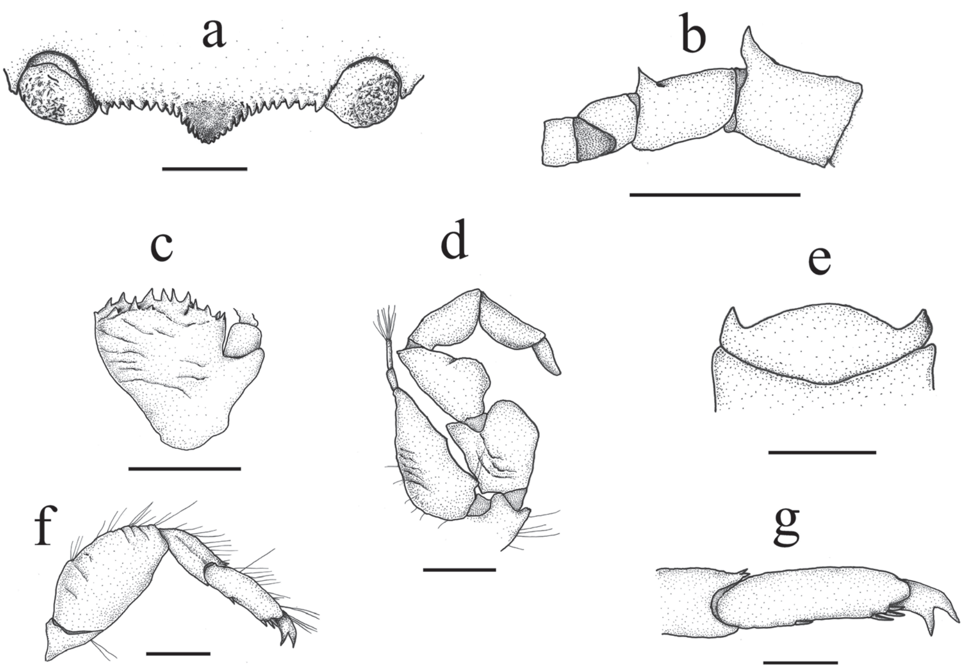


Figure 3. Details of *Aliaporcellana spongicola* sp. n., female (ovigerous) paratype, UF 43328, Philippines, Oriental Mindoro Province, Mindoro, Puerto Galera, off Pt W of Bayanar Beach. **a** Carapace front **b** Dorsal view of left antennae, movable articulations **c** Dorsal view of left antennular peduncle **d** Dorsal view of left third maxilliped **e** Third thoracic sternite **f** Dorsal view of first right walking leg **g** Detailed view of dactylus of first right walking leg. Scale bars: 1 mm (**a–e, g**); 2 mm (**f**).

spines less developed or disappearing in large specimens, with scattered, long, simple setae, fingers relatively shorter as in smaller chela; dactylus moderately twisted, opening vertically, cutting edges in pollex and dactylus with broad, shallow tooth, gape naked.

Walking legs (Figures 2, 3f, g) stout, merus with some transversal striae, with scattered, long, simple setae, increasing in number towards dactylus; carpus in first and second leg ending dorsodistally in two minute spines, propodus ventrally with 1 movable spine in addition to terminal triplet; dactylus terminating in bifurcate, curved claw.

Coloration. The background color of carapace and extremities is bright orange (hexadecimal color #e86700), overlain with a reticulate bright blue (hexadecimal color #000de8) pattern (Figures 1, 5). A broad, black band crosses the carapace transversely at the level of the hepatic region; it is fringed on both sides by a small, blue line and a broad, orange band. A similar band extends along the outer border of the chelipeds from the carpus to the tip of the pollex. In a number of individuals the blue color prevails over the orange, and the entire crab appears blue.

Ecology. *Aliaporcellana* currently consists of six species. Of all species, *A. spongicola* sp. n. is by far the most strikingly colorful, and has, therefore, become popular among underwater photographers and marine aquarists. *Aliaporcellana spongicola* sp. n. dwells

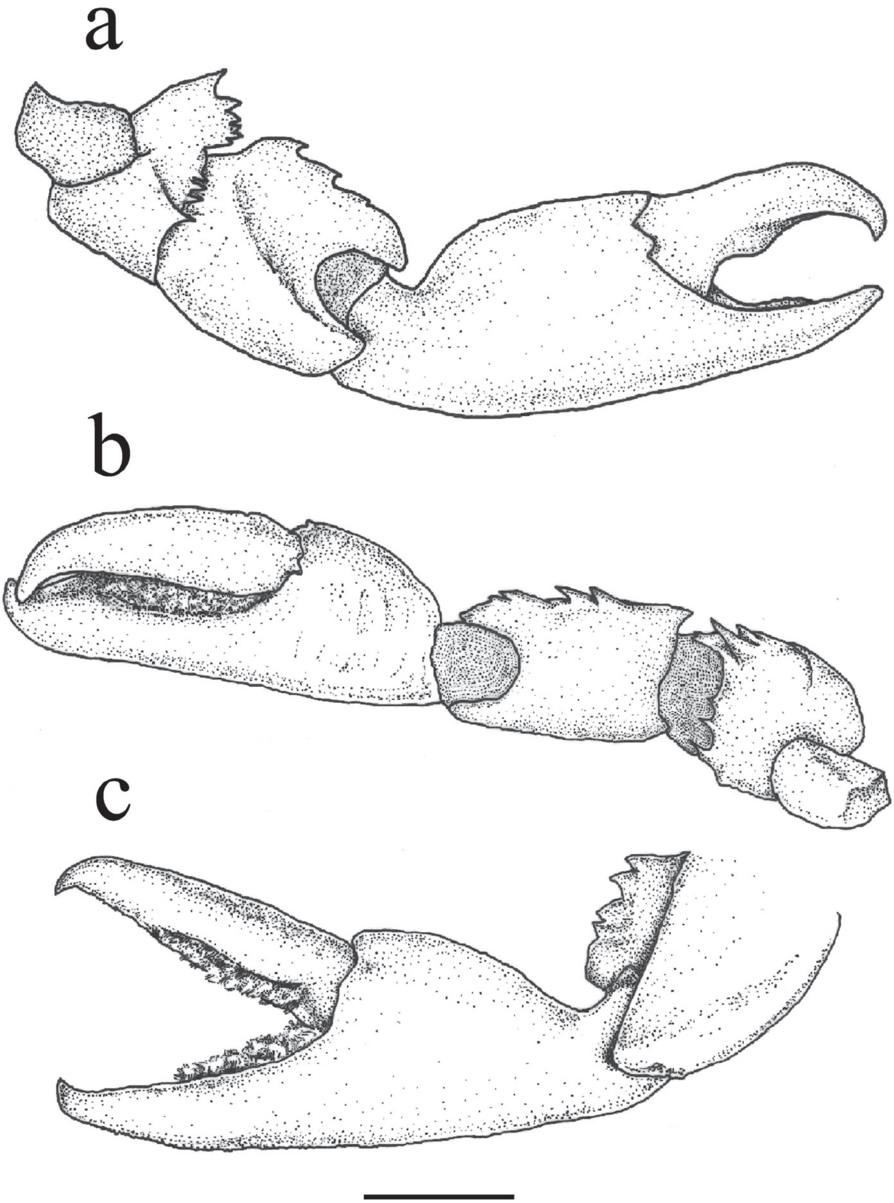


Figure 4. Chelipeds of *Aliaporcellana spongicola* sp. n., female (ovigerous) holotype, UF 43328, Philippines, Oriental Mindoro Province, Mindoro, Puerto Galera, off Pt W of Bayanar Beach. Ventral view of **a** left cheliped **b** right cheliped **c** manus of right cheliped. Scale bar: 2 mm.

on large barrel sponges of the genus *Xestospongia* Laubenfels [family Petrosiidae; e.g., *X. testudinaria* (Lamarck 1815)] and on other types of sponges, like the "large, grey foliose sponge", on which the crabs from Sulawesi included in this study, were found.

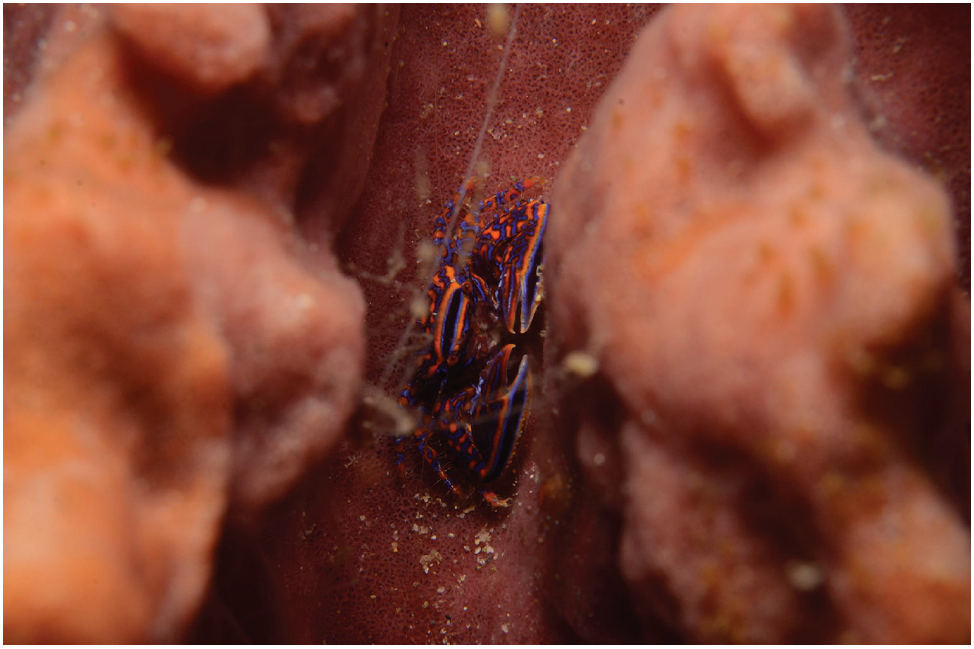


Figure 5. *Aliaporcellana spongicola* sp. n. Live specimen sitting on barrel sponge (photograph UF dPHIL 09927). Same collection data as holotype.

The porcellanid lies in the sponge's folds, where it is most protected from predators (Figure 5).

Distribution. The type specimens come from the central Philippines and northern Sulawesi, Indonesia.

Etymology. The name *spongicola* (from the Latin word *spongia*, meaning sponge, and the Latin suffix *cola*, meaning dwelling) refers to the sponge-dwelling habit of the new species.

Remarks. *Aliaporcellana spongicola* sp. n. is considerably variable in the shape of carapace and the degree of spination on body and extremities. As in other porcellanid species, the spines are more defined in smaller specimens. The new species is distinguished from *A. pygmaea* and *A. kikuchii* by the lack of acute spines on the dactylus of the smaller cheliped (Osawa 2007; Dong et al. 2011), and by its smoother surface of carapace and chelipeds (Lewinsohn 1969; Nakasone and Miyake 1969; Werding and Hiller 2007; Osawa and Chan 2010). *Aliaporcellana spongicola* sp. n. can be distinguished from *A. suluensis*, *A. telestophila* and *A. taiwanensis* by its regularly denticulated front (Figures 2, 3a), which is smooth in the other species, and by the basis of the antennular peduncle, which is crowned with a ring of spines (Figure 3c) and is at most granulate or faintly serrate in the compared species (see Lewinsohn 1969; Werding and Hiller 2007; Dong et al. 2011 for *A. suluensis*; Ng and Goh 1969 for *A. telestophila*; Dong et al. 2011 for *A. taiwanensis*).

Discussion

With the description of *Aliaporcellana spongicola* sp. n., the genus now comprises six species.

Up to now, *A. telestophila* is the only species of the genus reported to live as commensal (Johnson 1958; Ng and Goh 1996). Johnson (1958) described this species based on his own collections and observations, highlighting that *A. telestophila* was found "strictly [in] commensalism with the octocoral *Telesto*". However, Ng and Goh (1996) doubted the identification of the octocoral host and referred to it as *Solenocaulon* Gray (family Anthothelidae Broch), instead. Ng and Goh (1996) and Goh et al. (1999) described the porcellanid as dweller inside of the hollow branches of the octocoral, communicating with the outer medium through the openings of these branches. The species lives in male-female pairs; sometimes two pairs are found in one host colony.

Our own observations of the morphology and ecology of *A. suluensis* collected from sponges in Saudi Arabia, and of all other *Aliaporcellana* species, led us to conclude that perhaps all species of the genus are commensals. We base our conclusions on the well-developed, fixed spines on the dactylus of the walking legs, a character present in all *Aliaporcellana* species (see Figures 3f-g) and other porcellanid commensals that inhabit sponges (e.g., *Pachycheles ackleianus* A. Milne-Edwards, 1880, *Polyonyx hendersoni* Southwell, 1909 and *P. splendidus* Sankolli, 1963; see Haig 1960; Hiller et al. 2010). This morphological trait is probably an adaptation to moving on the surface of this type of host. We hypothesize that all members of the genus *Aliaporcellana* are commensal of sponges or octocorals, and that this morphological trait has evolved independently in different evolutionary lines within Porcellanidae. *Aliaporcellana spongicola* sp. n. probably lives in male-female pairs, as *A. telestophila* does on the octocoral *Solenocaulon* (Ng and Goh 1996; Goh et al. 1999).

The association between crab and sponge may be easily overlooked because sponges are often attached to each other and to rocks, and are damaged when the rocks are lifted. More collection data of other *Aliaporcellana* species are needed to confirm the commensal status of the genus.

Acknowledgements

We are grateful to G. Paulay, A. Bemis, and J. Slapcinsky (Florida Museum of Natural History, Gainesville, U.S.A.) for giving us access to porcellanid material and photographs, and for hosting us. We are also indebted to C.H.J.M. Fransen and K. van Dorp, (Naturalis Leiden) for giving us access to porcellanid material. We also thank S. Sereda for inking our drawings in pencil. We thank H.A. Lessios (STRI), E. Campos (Universidad Autónoma de Baja California, México) and an anonymous reviewer for comments that helped improve this manuscript.

References

Dong D, Li X, Chan TY (2011) A new species of *Aliaporcellana* Nakasone and Miyake, 1969 (Crustacea: Decapoda: Anomura: Porcellanidae) from Taiwan, with redescription of *Aliaporcellana suluensis* (Dana, 1852). Bulletin of Marine Science 87: 485–499. https://doi.org/10.5343/bms.2010.1096

Goh NK, Ng PK, Chou LM (1999) Notes on the shallow water gorgonian-associated fauna on coral reefs in Singapore. Bulletin of Marine Science 65: 259–282.

Haig J (1960) The Porcellanidae (Crustacea Anomura) of the eastern Pacific. Allan Hancock Pacific Expeditions 24: 1–440.

Haig J (1978) Contribution toward a revision of the porcellanid genus *Porcellana* (Crustacea: Decapoda: Anomura). Proceedings of the Biological Society of Washington 91: 706–714.

Hiller A, Harkantra S, Werding B (2010) Porcellanid crabs from Goa, eastern Arabian Sea (Crustacea: Decapoda: Porcellanidae). Journal of the Bombay Natural History Society 107: 201–212.

Johnson DS (1958) The Indo-West Pacific species of the genus *Polyonyx* (Crustacea, Decapoda, Porcellanidae). Annals of Zoology (Agra) 2: 95–118.

Lewinsohn C (1969) Die Anomuren des Roten Meeres (Crustacea Decapoda: Paguridea, Galatheidea, Hippidea). Zoologische Verhandelingen, Leiden 104: 3–213.

Nakasone Y, Miyake S (1969) A new porcellanid crab (Anomura: Porcellanidae) from Japan (*Aliaporcellana kikuchii* gen. et sp. nov.), with description of two species of the new genus. Publications of the Amakusa Marine Biological Laboratory 2: 17–32.

Ng PK, Goh NK (1996) Notes on the taxonomy and ecology of *Aliaporcellana telestophila* (Johnson, 1958) (Decapoda, Anomura, Porcellanidae), a crab commensal on the gorgonian *Solenocaulon*. Crustaceana 69: 652–661. https://doi.org/10.1163/156854096X00655

Osawa M (2007) Porcellanidae (Crustacea: Decapoda: Anomura) from New Caledonia and the Loyalty Islands. Zootaxa 1548: 1–49.

Osawa M, Chan TY (2010) Part III. Porcellanidae (Porcelain crabs) In: Chan T-Y (Ed.) Crustacean fauna of Taiwan: Crab-Like Anomurans (Hippoidea, Lithodoidea and Porcellanidae). National Taiwan Ocean University, Keelung, 67–195.

Werding B, Hiller A (2007) The Porcellanidae (Crustacea: Decapoda: Anomura) of the Red Sea with description of a new species of *Petrolisthes*. Zootaxa 1460: 1–24.

ZooKeys 780: 11–34 (2018)
doi: 10.3897/zookeys.780.26753
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

A new genus of Ptiloneuridae, its position within the family, and descriptions of five species (Psocodea, 'Psocoptera')

Ranulfo González-Obando[1], Alfonso N. García Aldrete[2],
Nancy Carrejo-Gironza[1], Julian Mendivil[1]

1 *Grupo de Investigaciones Entomológicas (GIE), Departamento de Biología, Facultad de Ciencias Naturales y Exactas, Universidad del Valle, Santiago de Cali, Colombia* **2** *Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, Apdo. Postal 70-153, CdMx, México*

Corresponding author: *Ranulfo González-Obando* (ranulfo.gonzalez@correounivalle.edu.co)

Academic editor: *K. Yoshizawa* | Received 17 May 2018 | Accepted 5 July 2018 | Published 8 August 2018

http://zoobank.org/91E5F350-66C6-4BB3-87E3-37C3DC17B52F

Citation: González-Obando R, Aldrete ANG, Carrejo-Gironza N, Mendivil J (2018) A new genus of Ptiloneuridae, its position within the family, and descriptions of five species (Psocodea, 'Psocoptera'). ZooKeys 780: 11–34. https://doi.org/10.3897/zookeys.780.26753

Abstract

Upon examination of ptiloneurid specimens recently collected in forests of natural areas and Natural National Parks in Colombia, ten males and seven females were found that represent five species of an undescribed ptiloneurid genus. It differs from the other genera in the family by characters of the wings, hypandrium, phallosome, epiproct, female gonapophyses, and sternum IX. An identification key to the males of the genera of Ptiloneuridae, and a key to the species of the new genus are presented. A test on the validity and monophyly of the new genus, and its position within the family was also conducted.

Keywords

biodiversity, Colombia, neotropics, taxonomy

Introduction

Ptiloneuridae, a family of Psocodea (Psocomorpha: Epipsocetae), presently includes the genera *Brasineura* Silva-Neto & García Aldrete, *Euplocania* Enderlein, *Loneura* Navás, *Loneuroides* García Aldrete, *Omilneura* García Aldrete, *Perucania* New & Thornton, *Ptiloneura* Enderlein, *Ptiloneuropsis* Roesler, *Timnewia* García Aldrete, *Triplocania* Roesler, and *Willreevesia* García Aldrete.

Within the framework of the project "Revisión Taxonómica y Endemismo de los Psócidos (Insecta: Psocodea: 'Psocoptera') de Areas Protegidas de Colombia", 17 specimens of Ptiloneuridae, corresponding to five species that could not be assigned to any of the known ptiloneurid genera were found. These specimens were collected in localities of Valle del Cauca, Meremberg Nature Reserve and La Candelaria (Huila), Planes de San Rafael Nature Reserve (Risaralda), National Natural Park Tamá (Norte de Santander), and Chicaque Nature Reserve (Cundinamarca) (Figure 48). Here we describe and illustrate these new species, erect a new genus for them, and discuss its position within the family.

Materials and methods

Seventeen specimens were available for study, ten males and seven females. Nine specimens were dissected in 80% ethanol, and their parts (head, right legs and wings, and genitals), were mounted in Canada balsam, following standard procedures. Before dissecting, whole specimens were placed in 80% ethanol and observed at 50× to record color. Standard measurements were taken with a filar micrometer, and are given in mm. Abbreviations of parts measured are as follows: FW and HW: right fore- and hind- wing lengths, F, T, t1, t2 and t3: lengths of femur, tibia and tarsomeres 1, 2 and 3 of right hind leg, f1-fn: lengths of flagellomeres 1-n, Mx4: length of fourth segment of right maxillary palp, IO: minimum distance between compound eyes, D and d: antero-posterior and transverse diameter, respectively, of right compound eye, all in dorsal view of head. PO: d/D, H: head length, MxW: maximum head width, Ratio head length (H)/(D), L/W: forewing length/forewing width, lp/wp: pterostigma length/pterostigma width, al/ah: areola postica length/tall, l/w: hindwing length/hindwing width. The specimens studied are deposited in the Entomological Museum, Universidad del Valle (**MUSENUV**), Santiago de Cali, Colombia.

To test the validity and the monophyly of the new genus, and to establish its position within the family, a cladistic analysis was performed, using the free Software TNT 1.1 (Goloboff et al. 2008a) under implied weight schemes, between *K* = 1–9, determines how strongly homoplasious characters are downweighted, lower *K* values indicate that homoplastic characters are more strongly penalized or given less weight (Goloboff 1993) and given the concavity constant value *K* should be calculated as a function of N, which is the ratio of a single extra step at the cost of the most homoplastic character (Goloboff et al. 2008b), we obtained *K* values through a TNT script (setk.run) written by Salvador Arias to calculate an appropriate value for *K*. The script returned a value of *K* = 2 for our data set, which was then employed. Given the purpose of the analysis, only one outgroup, *Spurostigma* Eertmoed (Spurostigmatidae) was used (see Yoshizawa 2002; García Aldrete 2005; Casasola González 2006; Silva-Neto et al. 2016). The characters were treated as nonadditive and the topologies were evaluated with an implicit weight (IW) analysis, using Traditional Search with the algorithm TBR (100 repl/10 TperRp), with1000 replicas and Traditional Search with Bootstrap and Symmetric Resampling (Goloboff et al. 2003). The support of the clades was calculated with ACCTRAN and DELTRAN optimization in WINCLADA ver 1.00.08 (Nixon 2002). The resulting strict consensus tree was exported and the names were edited in CorelDraw X7.

As in Silva Neto et al. (2016b), only one species was used to represent each genus, except for *Triplocania* (two species) and *Colocania* gen. n., in which the males (four species) of each species were included in the analysis. The 17 species included were: *Brasineura diamantina* Silva Neto & García Aldrete, *Colocania candelaria* sp. n., *C. chicaque* sp. n., *C. occidentalis* sp. n., *C. pilosa* sp. n., *Euplocania cerata* New, *Loneura jinotegaensis* García Aldrete, *Loneuroides colombianus* García Aldrete, González & Carrejo, *Omilneura circumvittata* García Aldrete, *Perucania longiareola* New & Thornton, *Ptiloneura bidorsalis* Enderlein, *Ptiloneuropsis diamantina* Silva Neto, García Aldrete & Rafael, *Spurostigma caatinga* Silva Neto & García Aldrete, *Timnewia greeni* (New), *Triplocania cervantesi* García Aldrete, *Triplocania magnifica* Roesler and *Willreevesia dominica* García Aldrete.

The 19 characters used by Silva Neto et al. (2016b), plus four that are diagnostic of the species of *Colocania* gen. n., were used in the analysis, which generated a matrix with 391 cells and only three cells with inapplicable values. The additional characters are:

20. Costal margin, between base and nodus: (0) straight (1) convex (Figures 1, 7, 13, 19, 25, 31, 37).
21. Shape of proximal area of pterostigma (at around 1/3 of its length): (0) not petiolated (Figure 43), (1) little petiolated (Figure 44), (2) strongly petiolated (Figures 1, 7, 13, 19, 25, 31, 37).
22. Anterior region of hypandrium: (0) without ringed, short digitiform process, (1) with vestigial or short ringed digitiform process (Figures 4, 10, 22, 34).
23. Oval cuticular depression on central-median area of clunium: (0) absent, (1) present (Figures 45, 46).

Table 1. Data matrix of morphological characters used for the cladistic analysis of Ptiloneuridae and outgroup (*S. caatinga*). For characters 1–19 see Silva-Neto et al. (2016).

	Character																						
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
S. caatinga	0	0	0	0	0	0	0	0	0	0	0	–	0	0	0	0	0	0	0	0	0	0	0
B. diamantina	1	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0
C. candelaria	0	3	2	0	0	0	0	0	1	0	1	1	0	1	1	1	0	0	0	1	2	1	1
C. chicaque	0	3	2	0	0	0	0	0	–	0	1	1	0	1	1	0	0	0	0	1	2	1	1
C. occidentalis	0	2	1	0	0	0	0	0	–	0	1	0	0	1	1	1	0	0	0	1	2	1	1
C. pilosa	0	2	2	0	0	0	0	0	1	1	1	0	0	1	1	1	0	0	0	1	2	1	1
E. cerata	0	0	1	0	0	0	0	0	1	0	1	1	0	1	0	1	0	0	0	0	1	0	0
L. colombianus	0	3	2	1	0	0	0	1	2	2	1	0	1	1	1	0	1	1	0	0	2	0	0
L. jinotegaensis	0	3	3	0	0	0	0	0	1	2	1	0	1	1	1	0	1	1	0	0	1	0	0
O. circumvittata	0	0	3	0	0	0	0	0	1	1	0	0	0	1	1	1	1	0	0	0	1	0	0
P. bidorsalis	0	4	5	0	0	0	0	0	2	2	1	0	1	1	1	0	1	1	0	0	1	0	0
P. diamantina	0	3	2	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	1	1	0
P. longiareola	0	0	0	0	0	0	0	0	3	3	0	0	0	1	1	0	1	0	0	0	0	0	0
T. cervantesi	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0
T. magnifica	0	0	0	0	0	0	0	0	1	1	0	2	0	1	0	0	0	0	0	0	1	0	0
T. greeni	0	0	1	1	1	1	0	1	2	2	0	1	0	1	0	0	1	0	0	0	0	0	0
W. dominica	0	0	2	0	0	0	0	0	1	4	1	0	0	0	1	1	0	1	0	0	1	0	0

Results

Colocania González, García Aldrete & Mendivil, gen. n.

http://zoobank.org/AC79B1A9-F003-4888-BB01-C9FE4D68CFE5

Type species. *Colocania occidentalis* González, García Aldrete & Mendivil, sp. n.

Etymology. The generic name is a compound word, formed with the root "colo" from Colombia, and the suffix "cania", common in Ptiloneuridae, as in *Euplocania*, *Perucania*, *Triplocania*. It refers to its endemicity in Colombia.

Diagnosis. Forewings with costal margin, between base and nodus, strongly to gently convex, pterostigma elongate, petiolate proximally at around 1/3 of its length, Rs curved strongly towards pterostigma; anterior area of the hypandrium with a short ringed digitiform process. Phallosome most commonly with two separate stems proximally usually projected to the hypandrium (Figures 6, 24, 36). Clunium with oval cuticular depression on central-median area. Females with sternum IX oval to subtrapeziform (Figures 18, 30, 42), with a generally globose or pear-shaped area in the middle.

Key to the genera of Ptiloneuridae (males) modified from García Aldrete (2006), Silva Neto and García Aldrete (2015), and Silva Neto et al. (2016a)

1 Hindwing M one-branched **2**
– Hindwing M two to five-branched **7**
2 Forewing 2A joining wing margin; no crossveins between 2A and wing margin **3**
– Forewing 2A joining 1A; one crossvein between 2A and wing margin; two crossveins between 1A and wing margin .... ***Timnewia* García Aldrete**
3 Forewing areola postica high, with apex rounded **4**
– Forewing areola postica low, very long .... ***Perucania* New & Thornton**
4 Labral sclerites incomplete, not reaching anterior margin of labrum **5**
– Labral sclerites complete, almost reaching anterior margin of labrum .... ***Willreevesia* García Aldrete**
5 Forewing M three-branched, occasionally M3 forked .... ***Triplocania* Roesler**
– Forewing M more than three-branched **6**
6 Forewing M four to five-branched .... ***Euplocania* Enderlein**
– Forewing M six-branched .... ***Omilneura* García Aldrete**
7 Forewing areola postica free, high, with apex rounded **8**
– Forewing areola postica high, rigidly triangular, joined to M by a crossvein .... ***Ptiloneuropsis* Roesler**
8 Forewing 2A without one crossvein to wing margin pterostigma long, smooth **9**
– Forewing 2A with one crossvein to wing margin, pterostigma long, distinctly spurred .... ***Loneuroides* García Aldrete**

9 Forewing with costal margin, between the base and the nodus strongly to gently convex, pterostigma proximally petiolate at around 1/3 of its length, Rs strongly curved towards pterostigma; hypandrium strongly convex, of one piece; anterior area of the hypandrium with a short ringed digitiform process, sometimes visible only by the presence of concentric rings ***Colocania* gen. n.**

– Forewing with costal margin between the base and the nodus almost straight, pterostigma proximally little petiolate; Rs slightly curved towards pterostigma or almost straight; hypandrium simple or with three or more well-defined sclerites **10**

10 Forewing M four to seven-branched; hindwing M two to five-branched **11**

– Forewing M eight-branched; hindwing M five-branched; hypandrium a broad sclerite projected posteriorly to form a wide, three lobed sclerite, with a dense field of setae on each postero-lateral corner, and a dense field of setae on each side of the central projection .... ***Ptiloneura* Enderlein**

11 Hypandrium simple, of one sclerite; hindwing M two to four-branched; phallosome with external parameres distally forked or rounded, enclosing a membrane with numerous pores .. ***Brasineura* Silva Neto & García Aldrete**

– Hypandrium simple or formed by a central sclerite and one or two smaller ones on each side; hindwing M two to five-branched; phallosome with external parameres without a membranous region with numerous pores ...... ***Loneura* Navás**

Position of *Colocania* gen. n. in Ptiloneuridae

From 88 most parsimonious cladograms, obtained for each K value analyzed (K = 1–9), 17 consensus topologies were retained (L = 75–76, CI = 48–49, RI = 61–62). In all of them the clade formed by the species of *Colocania* was maintained, although between K = 5–9 the relations of this with the rest of the genera is unstable. This however, remains constant between K = 1–4 (L = 76, CI = 48, RI = 61), which includes the value calculated as appropriate (K = 2) through the use TNT script (setk.run) on the data set. In this way, the strict consensus topology obtained in the cladistic analyses with different optimality criteria of parsimony, showed that *Colocania* is a monophyletic group, supported by high symmetric resampling (88%) and Bootstrap (82%) (Figure 47). This monophyly is supported by two unambiguous synapomorphies: costal margin, between base and nodus, convex (char. 20:1), and clunium with oval cuticular depression on central-median area (char. 23:1), present in both males and females (Figures 45, 46). This genus is also supported by the homoplasic condition: pterostigma proximally petiolate for around 1/3 of its length (char. 21:2), external parameres stout (char. 17:0); and absence of a mesal transverse endophallic sclerite (char. 18:0). It is related to *Ptiloneuropsis diamantina*, forming a clade supported by one unambiguous synapomorphy: anterior region of hypandrium with vestigial or short ringed digitiform process (char. 22:1) and by a homoplasic condition: marginal area of the forewing from R4+5 to Cu1a hyaline (char. 10:0). The clade above is related to a clade conformed by *Loneura*, *Loneuroides* and *Ptiloneura*, forming a clade supported by one unambiguous synapomorphy: hindwing with four primary branches in vein M, which could change in future analyzes if we consider all the possible variations that can be observed in the species of these three genera. Furthermore, this clade, as well as the related to the other genera, showed unstable arrangements when the characters tend to have the same weight (K = 5–9) (cladograms not shown). Silva Neto et al. (2016) recognized two distinct clades that group the genera of Ptiloneuridae; one of them includes *Belicania*, *Euplocania*, *Omilneura*, *Perucania*, *Timnewia*, and *Triplocania*. The other clade includes *Brasineura, Loneura, Loneuroides, Ptiloneura, Ptiloneuropsis*, and *Willreevesia*. In the latter, *Brasineura* and *Loneuroides* are recognized as monophyletic, while in the first, the sub-clade formed by *Omilneura*, *Perucania*, *Timnewia*, and *Triplocania*, that according to our results and given the high frequency of homoplasic characters seem to require additional phylogenetic analysis, within the family Ptiloneuridae, including in each genus a greater number of species and evaluating a greater number of characters.

Colocania candelaria **García Aldrete, González & Carrejo, sp. n.**

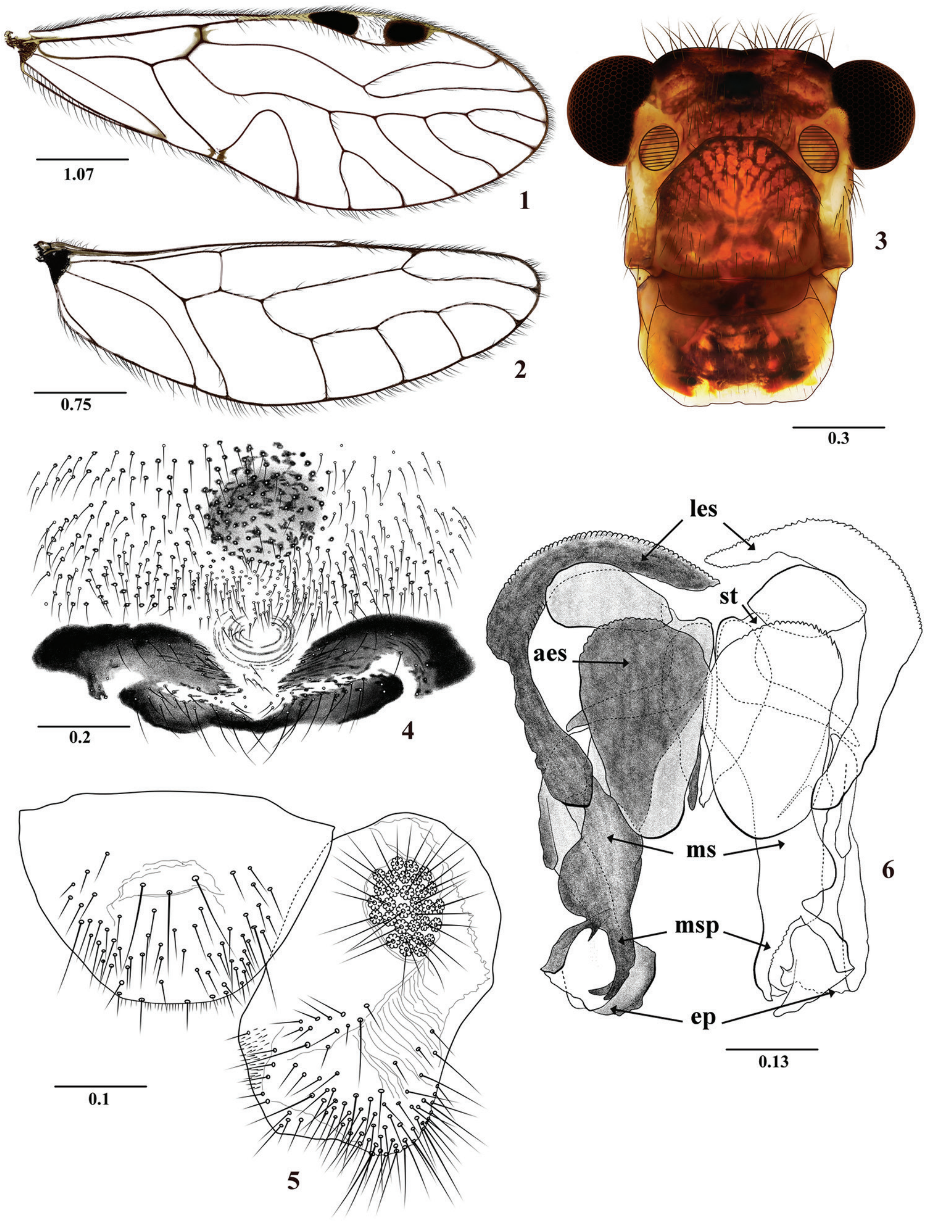
http://zoobank.org/D0D430EE-7F4A-4284-9E61-261830D9559E
Figures 1–6

Type locality. COLOMBIA. Huila. Belén, La Candelaria, 2128 m. 02°13'36.0"N, 76°07'27.4"W.

Type material. Holotype male. 18.IV.2015. On tree trunk. R. González. Deposited in Entomological Museum, Universidad del Valle (MUSENUV, slide code 29033).

Diagnosis. Forewings hyaline, without marginal bands as in *C. chicaque* sp. n., and *C. occidentalis* sp. n., differing from them by wing characters, phallosome, and details of hypandrium and epiproct. Unlike the above species, the pterostigma has large pigmented bands proximally and distally (Figure 1); phallosome with mesal endophallic sclerite widened, apically narrow and with two elongated teeth, one of them curved outwards (Figure 6).

Description. Color (in 80% ethanol). Body pale brown, with pigmented dark brown areas as indicated below. Compound eyes black, ocelli hyaline, with ochre centripetal crescents. Vertex with three dark brown areas, a central one and two lateral ones between the compound eyes. Front with brown area between ocellar group and epistomal sulcus, as illustrated (Figure 3). Postclypeus brown, with diagonal dark brown stripes. Genae, anteclypeus, labrum, mandibles, maxillae, and labium brown to pale brown. Antennae brown, scape pale brown, flagellomeres distally cream. Maxillary palps pale brown, Mx4 dark brown distally. Tergal lobes of meso- and metathorax brown. Thoracic pleura pale brown. Mesopleura with dark brown spots. Legs: coxae, trochanter, and femora pale brown, tibiae and tarsi brown. Wings hyaline, forewing pterostigma with a large dark brown band proximally and distally. Abdomen cream, with subcuticular brown spots; clunium, hypandrium, and phallosome dark brown; epiproct and paraprocts brown.



Figures 1–6. *Colocania candelaria* sp. n. Male. **1** Forewing **2** Hindwing **3** Front view of head **4** Hypandrium **5** Left paraproct and epiproct **6** Phallosome. Abbreviations: (aes) anterior endophallic sclerites, (ep) external parameres, (les), lateral endophallic sclerite, (ms) mesal sclerite, (msp) mesal sclerite processes, (st) side struts. Scale bars in mm.

Morphology. As in diagnosis, plus the following: Head elongate: H/MxW: 1.52; small compound eyes, H/d: 4.24; H/D: 3.1, IO/MxW: 0.80. Upper ends of compound eyes almost reaching the level of the vertex. Outer cusp of lacinial tip broad, with six denticles. Mx4/Mx2: 1.13. Forewing (Figure 1): L/W: 2.72. Pterostigma: lp/wp: 5.97, areola postica tall, triangular; al/ah: 1.27, R_{4+5} almost straight, M five-branched, M_5 distally forked. Hindwings (Figure 2): l/w: 3.08. M four branched. Hypandrium (Figure 4), with three pigmented areas, two antero-lateral, curved, backwards and a central, posterior one, wide and narrow, setose as illustrated; phallosome with side struts independent, with two separate basal stems anteriorly wide, narrowing distally and curved outwards, basally articulated to a mesal process that projects to the hypandrium; external parameres laminar, dilated distally, apex rounded, bearing pores (Figure 6); anterior pair of endophallic sclerites oval, antero-lateral pair curved as illustrated, rounded distally and overlapping with the basal part of the external parameres (Figure 6). Paraprocts (Figure 5) broad, elliptic, with distal setal field as illustrated, sensory fields oval, with 34 trichobothria on basal rosettes. Epiproct (Figure 5) broadly trapeziform, with a group of three mesal macrosetae and a setal field distally on each side; posterior border with a field of microsetae and a row of four-five setae.

Measurements. FW: 6250, HW: 4075, F: 1470, T: 2560, t1: 900, Mx4: 360, ctt1: 26, f1: 1230, f2: 1240, f3: 1000, f4: 760, f5: 480, f6: 410, f7: 320, f8: 295, f9: 210, f10: 200, IO: 580, D: 360, d: 260, IO/d: 2.23, PO: 0.72.

Etymology. The specific epithet refers to the town of La Candelaria (La Plata, Huila) where the holotype was collected.

Colocania chicaque González, García Aldrete & Carrejo, sp. n.

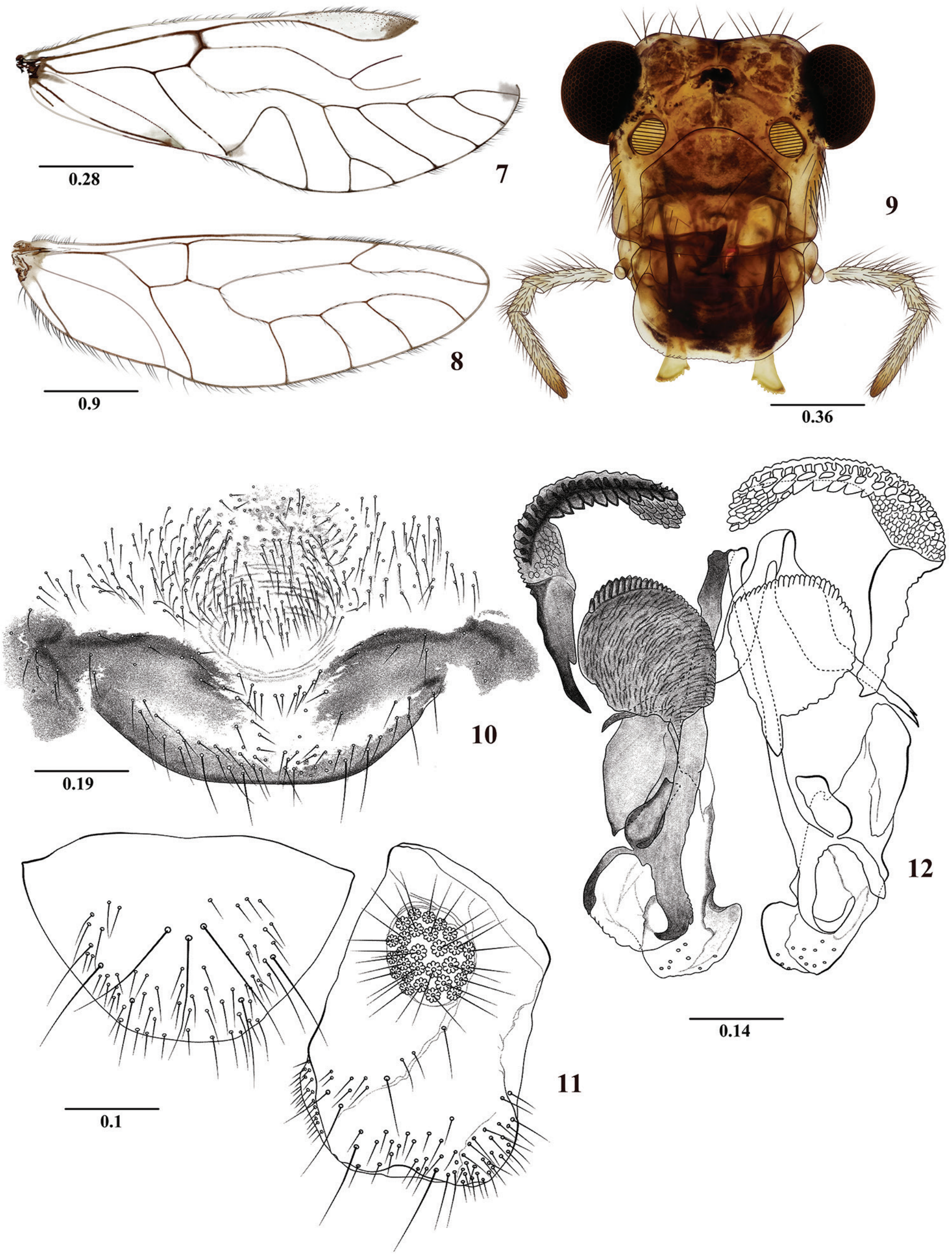
http://zoobank.org/3A56FDF4-B85B-4F86-88E8-0F535E8A5B5A
Figures 7–12

Type locality. COLOMBIA. Cundinamarca. Soacha, Chicaque Natural Reserve, Tirolesa, 2240 m. 04°36'40.38"N, 74°18'41.7"W.

Type material. Holotype male. 24–28.II.2014. Malaise trap. D. Forero. Deposited at the Pontífica Universidad Javeriana Museum (MPUJ). Bogotá, Colombia.

Diagnosis. Forewings hyaline, without marginal bands as in *C. candelaria* sp. n., and *C. occidentalis* sp. n., differing from them by characters of the forewing, phallosome and details of hypandrium and epiproct. Unlike *C. candelaria* the pterostigma has only a distal pigmented band, sometimes with a median, little defined, small pigmented area (Figure 7); phallosome with narrow mesal endophallic sclerite, with distal processes curved as illustrated. Unlike *C. occidentalis*, the forewing has M five-branched, with M5 distally forked (Figure 7).

Color (in 80% ethanol). Body pale brown, with pigmented dark brown areas as indicated below. Compound eyes black, ocelli hyaline, with ochre centripetal crescents. Vertex with brown areas, central and lateral, between compound eyes. Front brown as illustrated (Figure 9). Postclypeus brown, with diagonal dark brown bands. Genae, anteclypeus, labrum, mandibles, maxillae and labium pale brown. Maxillary palps pale brown, Mx4 distally dark brown. Tergal lobes of meso- and metathorax brown. Thoracic pleura creamy to pale brown. Legs pale brown. Wings hyaline, forewing pter-



Figures 7–12. *Colocania chicaque* sp. n. Male. **7** Forewing **8** Hindwing **9** Front view of head **10** Hypandrium **11** Left paraproct and epiproct **12** Phallosome. Scale bars in mm.

ostigma as in diagnosis, veins brown. Abdomen pale brown, with subcuticular spots brown; clunium brown, clearer dorsally, with tubercle brown, hypandrium, phallosome, epiproct, and paraprocts brown.

Morphology. As in diagnosis, plus the following: Head elongate: H/MxW: 1.48, H/D: 3.0; H/d: 4.0; IO/MxW: 0.74. Vertex slightly emarginated; upper ends of compound eyes almost reaching the level of the vertex. Outer cusp of lacinial tip broad, with eight denticles. Mx4/Mx2: 1.09. Forewing (Figure 7): L/W: 2.73. Pterostigma elongate: lp/wp: 5.88, areola postica tall, triangular: al/ah: 1.24, asymmetric; hindwings (Figure 8): l/w: 3.10, M four-branched. Hypandrium (Figure 10), setose as illustrated. Phallosome with side struts V-shaped, distally with arms curved outward; external parameres laminar, dilated distally, apex rounded, bearing pores (Figure 12); anterior pair of endophallic sclerites laminar-oval, with anterior margin serrate; antero-lateral pairs boomerang-shaped, curved inward proximally and with a series of laminar teeth, distally without teeth and reaching near the basal part of the external parameres (Figure 12). Paraprocts (Figure 11) robust, almost elliptic, with distal setal field as illustrated, sensory fields oval, with 26 trichobothria on basal rosettes. Epiproct (Figure 11) trapeziform, with a group of three mesal macrosetae and a setal field distally.

Measurements. FW: 6700, HW: 4500, F: 1610, T: 2760, t1: 1240, t2: 100, t3: 152, Mx4: 380, ctt1: 42, f1: 1480, f2: 1380, IO: 600, D: 400, d: 300, IO/d: 2, PO: 0.75.

Etymology. The specific epithet refers to the Chicaque Natural Reserve, where the holotype was collected.

Colocania norsantanderina Carrejo, Mendivil & González, sp. n.

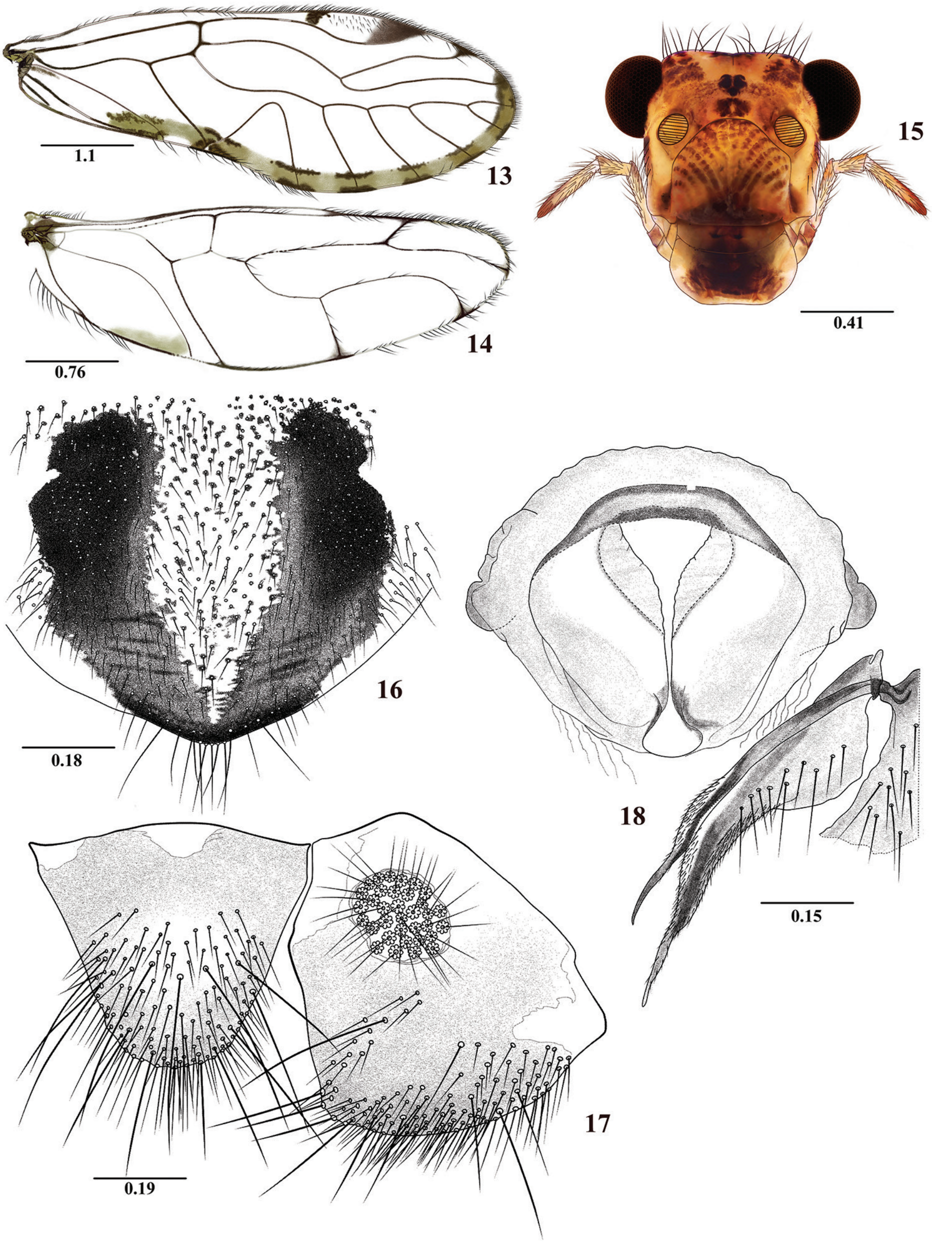
http://zoobank.org/DDB056B0-536F-43B6-AEAD-3E9D62DE29E5
Figures 13–18

Type locality. COLOMBIA. Norte de Santander. National Natural Park Tamá. Orocue Station, 2433 m. 07°25'27.6"N, 72°26'31.8"W.

Type material. Holotype female. 2.VII.2016. On wood beam with mosses and fungi. R. González, N. Carrejo. Deposited in Entomological Museum, Universidad del Valle (MUSENUV, slide code 29034), Santiago de Cali, Colombia.

Diagnosis. Related to *C. pilosa* sp. n. in having the forewing with similarly pigmented pattern and shape of the areola postica. It differs from the female of *C. pilosa* by having the hindwing M widely forked, by the shape of sternum IX, and by the shape and pilosity of the epiproct, without distally curved setae.

Color (in 80% ethanol). Body pale brown, with pigmented dark brown areas as indicated below. Compound eyes black, ocelli hyaline, with ochre centripetal crescents. Vertex and front with brown spots, central and lateral between the compound eyes (Figure 15). Postclypeus pale brown, with diagonal bands dark brown. Genae, anteclypeus, mandibles, maxillae, and labium pale brown, labrum brown. Antennae brown, scape and pedicel pale brown, flagellomeres cream apically. Maxillary palps pale brown, Mx4 brown distally. Tergal lobes of meso- and metathorax brown. Thoracic pleura creamy to pale brown with brown spots. Legs: coxae dark brown, fore- coxae pale brown, trochanters cream to pale brown, femora pale



Figures 13–18. *Colocania norsantanderina* sp. n. Female. **13** Forewing **14** Hindwing **15** Front view of head **16** Subgenital plate **17** Epiproct and right paraproct **18** Sternum IX and left gonapophyses. Scale bars in mm.

brown, with brown spots, tarsi 1 brown apically, tarsi 2–3 brown. Forewing with marginal brown band from apex of R4+5 to A1; M five branched; pterostigma with a dark brown band proximally and distally. Abdomen pale brown, with subcuticular brown spots; clunium brown, paler dorsally, with tubercle brown, subgenital plate with V-shaped pigmented area (Figure 16); gonapophyses, paraprocts, and epiproct dark brown.

Morphology. As in diagnosis, plus the following: Head elongate (Figure 15): H/MxW: 1.41; H/D: 3.0, H/d: 4.0: IO/MxW: 0.78. Outer cusp of lacinial tip broad, with seven denticles. Mx4/Mx2: 1.14. Forewing (Fig 13), L/W: 2.83. Pterostigma elongate: lp/wp: 5.73, areola postica triangular, al/ah: 1.35, M five branched. Hindwings (Figure 14): l/w: 2.89, M two branched. Subgenital plate (Figure 16) broad, slightly pointed posteriorly, setose, with macrosetae posteriorly. Gonapophyses (Figure 18): v1 elongate, pilose, distally acuminate; v2+3 pilose distally, with a row of 10 setae on v3; distal process acuminate, with microsetae on surface. Paraprocts (Figure 17) triangular, rounded apically, distal setal field with abundant setae as illustrated, sensory fields with 35 trichobothria on basal rosettes. Epiproct (Figure 17) triangular, rounded apically, with abundant setae and macrosetae distally as illustrated.

Measurements. FW: 6075, HW: 3975, F: 1460, T: 2700, t1: 1170, t2: 105, t3: 160, Mx4: 375, ctt1: 46, f1: 1320, f2: 1330, f3: 1030, IO: 620, D: 370, d: 273, IO/d: 2.27, PO: 0.74.

Etymology. The specific epithet refers to the Colombian Department Norte de Santander, where the holotype was collected.

Colocania occidentalis González, García Aldrete & Mendivil, sp. n.

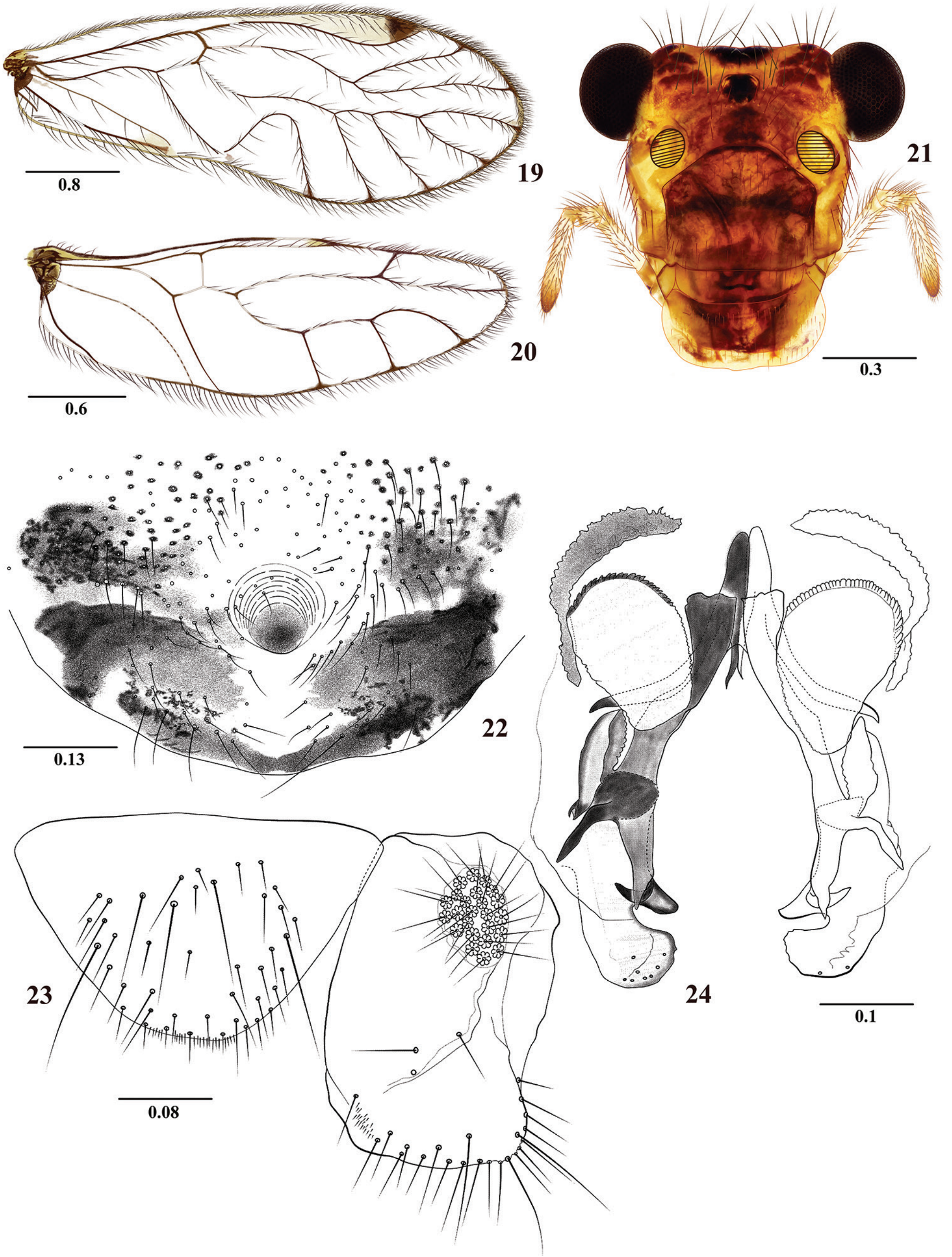
http://zoobank.org/3991BED3-1F9B-4406-9035-19D8CBF63D6D
Figures 19–30

Type locality. COLOMBIA. Valle del Cauca. Santiago de Cali, El Saladito, San Antonio, 2142m. 03°29'23.5"N, 76°37'39.4"W.

Type material. Holotype male. 27.I.2012. On tree trunks covered with lichens and mosses. R. González. Deposited in Entomological Museum, Universidad del Valle (MUSENUV, slide code 29035), Santiago de Cali, Colombia. Paratypes: 2 males, same data as the holotype, J. Mendivil & R. González. 1 male, 2 females, Valle del Cauca, Santiago de Cali, Los Andes-Charco Azul, 1687 m. 03°25'21.7"N, 76°37'0.1"W, 23.I.2013. R. González (Female: MUSENUV, slide code 29036). 2 males, 2 females, Los Andes-Quebrada Honda, 1900 m. 03°26'01.8"N, 76°38'40.3"W, 23.I.2013. R. González. 1 male, 1 female, Risaralda, Santuario, Planes de San Rafael, 2092 m. 05°07'13.9"N, 76°00'04.5"W, R. González (male: MUSENUV, slide code 29037). All paratypes on tree trunks covered with lichens and mosses.

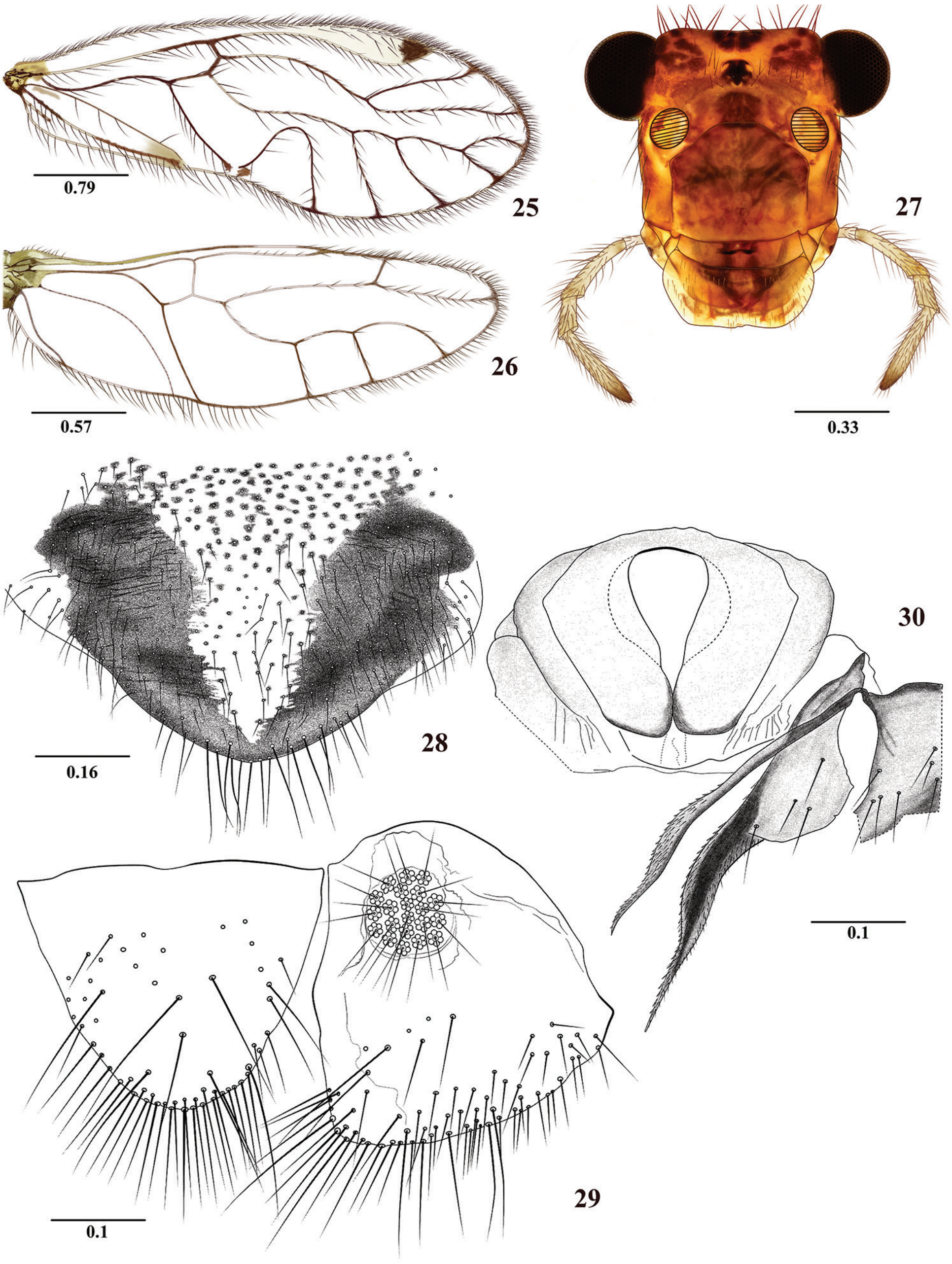
Diagnosis. Forewings hyaline, without marginal pigmented band as in *C. candelaria* sp. n., and *C. chicaque* sp. n., differing from them by having the forewing M four-branched (Figure 19), and the hindwing M three-branched (Figure 20), and by details of the phallosome and hypandrium.

Male. Color (in 80% ethanol). Body cream to pale brown, with pigmented dark brown areas as indicated below. Compound eyes black, ocelli hyaline, with ochre centripetal crescents. Vertex with dark brown spots, central and lateral between com-



Figures 19–24. *Colocania occidentalis* sp. n. Male. **19** Forewing **20** Hindwing **21** Front view of head **22** Phallosome **23** Epiproct and right paraproct **24** Hypandrium. Scale bars in mm.

pound eyes. Front with brown spots between ocellar group and epistomal sulcus, as illustrated (Figure 21), with pale cream band parallel to the antennal sockets. Postclypeus brown, with diagonal pale brown bands. Anteclypeus and labrum pale brown.



Figures 25–30. *Colocania occidentalis* sp. n. Female. **25** Forewing **26** Hindwing **27** Front view of head **28** Subgenital plate **29** Epiproct and right paraproct **30** Sternum IX and left gonapophyses. Scale bars in mm.

Genae brown. Postgena pale cream. Antennae brown, flagellomeres cream apically. Maxillary palps pale brown, Mx4 dark brown distally. Tergal lobes of meso- and metathorax dark brown; thoracic pleura dark brown with pale spots. Legs pale brown, coxae with brown spots basally, femora with gray-brown ring basally and gray-brown spots widely distributed; tibiae with gray-brown spot, tarsi 1 brown apically; tarsi 2–3 brown. Wings hyaline, forewing pterostigma with one distal large dark brown band, some with additional proximal spot (not illustrated). Abdomen pale cream, with subcuticular bands brown; clunium and hypandrium brown; clunium with pale central area, hypandrium anteriorly cream; phallosome brown, with sclerites dark brown; epiproct and paraprocts brown.

Morphology. As in diagnosis, plus the following: Head elongate (Figure 21): H/MxW: 1.44; H/D: 3.1, H/d: 4.19; IO/MxW: 0.78. Outer cusp of lacinial tip broad, with nine denticles. Mx4/Mx2: 1.10. Forewings (Figure 19): L/W: 2.69. Pterostigma elongate: lp/wp: 6.91, areola postica tall, triangular, with apex rounded: al/ah: 1.52; M four-branched. Hindwings (Figure 20): l/w: 3.02; M three branched. Hypandrium with three pigmented, setose areas, the two anterior widely separated and weakly connected to the posterior area, the latter narrow and extended laterally as a boomerang of little curvature (Figure 22). Phallosome (Figure 24) with laminar external parameres, wide, with apically rounded lobe bearing pores, curved inwards; mesal sclerite process with curved outwards apical teeth as illustrated. Side struts V-shaped, basally with an attached complex structure that projects over the hypandrium, distally curved outwards. Anterior endophallic sclerites laminar and oval, with serrate anterior margin, lateral sclerites curved as illustrated. Paraprocts (Figure 23) almost elliptic, with a distal setal field; sensory fields with 24 trichobothria on basal rosettes. Epiproct (Figure 23) semi-oval, rounded posteriorly, setal field with setae and macrosetae, posterior margin with small setae as illustrated.

Measurements. FW: 4375, HW: 2987, F: 1310, T: 2050, t1: 990, t2: 96, t3: 135, Mx4: 320, ctt1: 38, f1: 1000, f2: 990, f3: 770, f4: 510, f5: 355, f6: 300, f7: 240, f8: 200, f9: 176, f10: 150, f11: 180, IO: 535, D: 320, d: 235, IO/d: 2.28, PO: 0.73.

Female. Color (in 80% ethanol). Body, head, legs, epiproct, paraprocts, and wings as in the male, plus the following: Subgenital plate with pigmented area V-shaped, arms wider proximally. Clunium, epiproct and paraprots brown. Gonapophyses dark brown. Sternum IX cream yellowish, darker on the edges.

Morphology. As in diagnosis, plus the following: Head elongate (Figure 27): H/MxW: 1.46; H/D: 3.3, H/d: 4.43; IO/MxW: 0.81. Outer cusp of lacinial tip broad, with eight denticles. Mx4/Mx2: 1.14. Wings (Figures 25 and 26) as in the male, L/W: 2.72. Pterostigma: lp/wp: 5.08, areola postica: al/ah: 1.23. Hindwings (Figure 26): l/w: 3.00. Subgenital plate (Figure 28) broad, posteriorly rounded, setose, with apical macrosetae as illustrated. Gonapophyses (Figure 30): v1 elongate, acuminate, distally with microsetae; v2+3 with short anterior heel, with four setae on v3; distal process sinuous, acuminate, bearing microsetae. Sternum IX broad, convex anteriorly, with a median concavity posteriorly, and a central, rounded mesal area as illustrated (Figure 30). Paraprocts (Figure 29) triangular, distal setal field with abundant setae and macrosetae as illustrated, sensory fields with 22–24 trichobothria on basal rosettes. Epiproct (Figure 29) triangular, with rounded apex, with abundant macrosetae distally, particularly on posterior margin as illustrated.

Measurements. FW: 4350, HW: 2925, F: 1300, T: 2050, t1: 940, t2: 104, t3: 124, Mx4: 330, ctt1: 35, f1: 1130, f2: 1100, f3: 820, f4: 580, f5: 365, f6: 290, f7: 210, IO: 570, D: 312, d: 230, IO/d: 2.48, PO: 0.74.

Etymology. The specific name refers to the distribution of the species in localities of the western Andean Cordillera in Colombia.

Colocania pilosa González, Carrejo & García Aldrete, sp. n.

http://zoobank.org/5440EA82-CAED-4844-B047-82C2EC811212

Figures 31–42

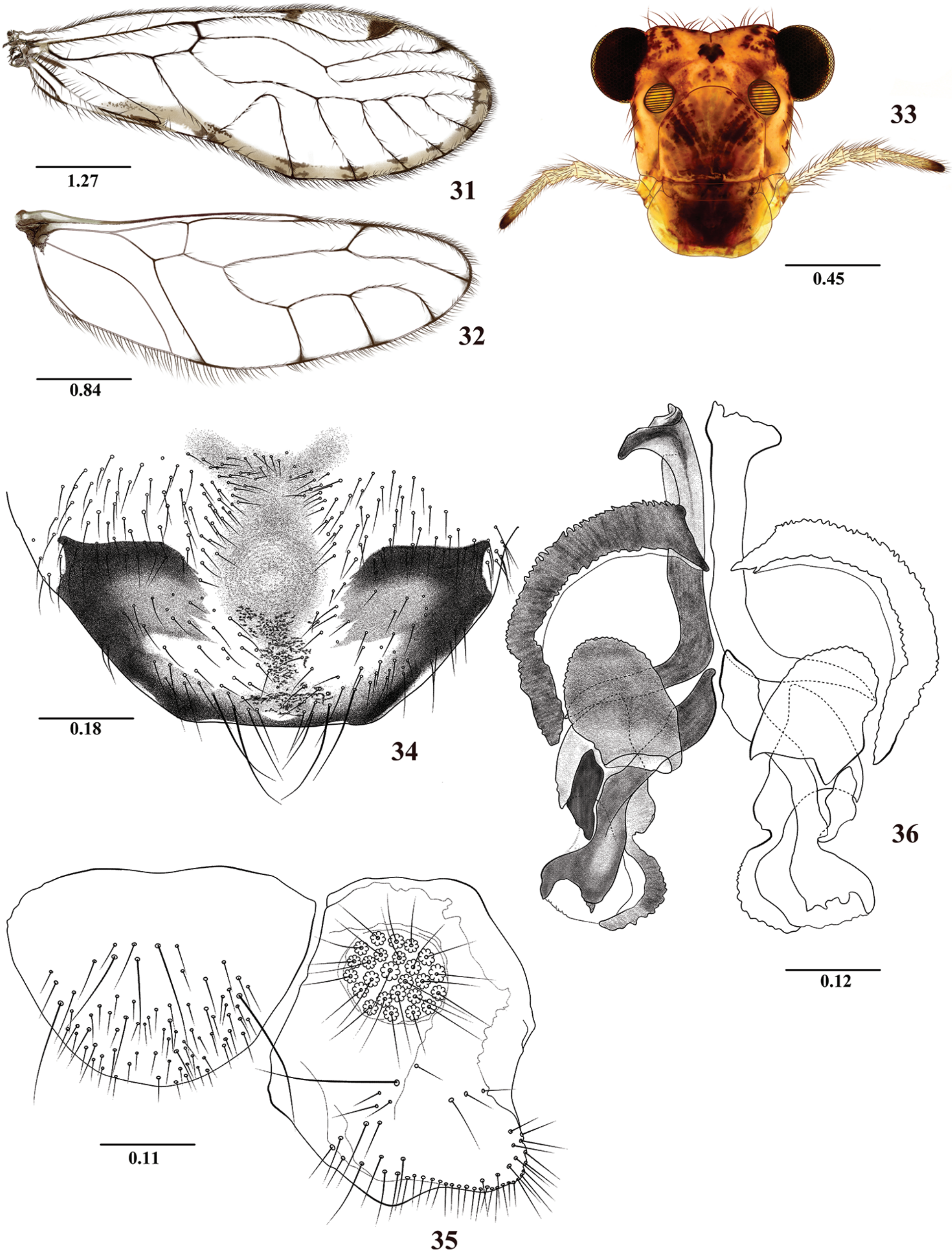
Type locality. COLOMBIA. Huila. La Plata, Belén, Meremberg Nature Reserve, 2352 m. 02°13'06.6"N, 76°07'01.1"W.

Type material. Holotype male. 20.I.2015. On tree trunks covered with lichens and mosses. R. González. Deposited in Entomological Museum, Universidad del Valle (MUSENUV, slide code 29038), Santiago de Cali, Colombia. Paratype female, 28.X.2016. Same data as the holotype (MUSENUV, slide code 29039).

Diagnosis. It is related to *C. norsantanderina* sp. n., described above (see diagnosis of the latter). Both species seem to have a sister-group relationship, to be confirmed when the male of the latter be found. The ninth sterna and gonapophyses in both species are quite similar, but the epiprocts are distinct. The male presents side struts with arms independent, proximally paralell, with processes directed outwards, unique among the species of the genus, distally curved outwards and not fused to the external parameres (Figure 36).

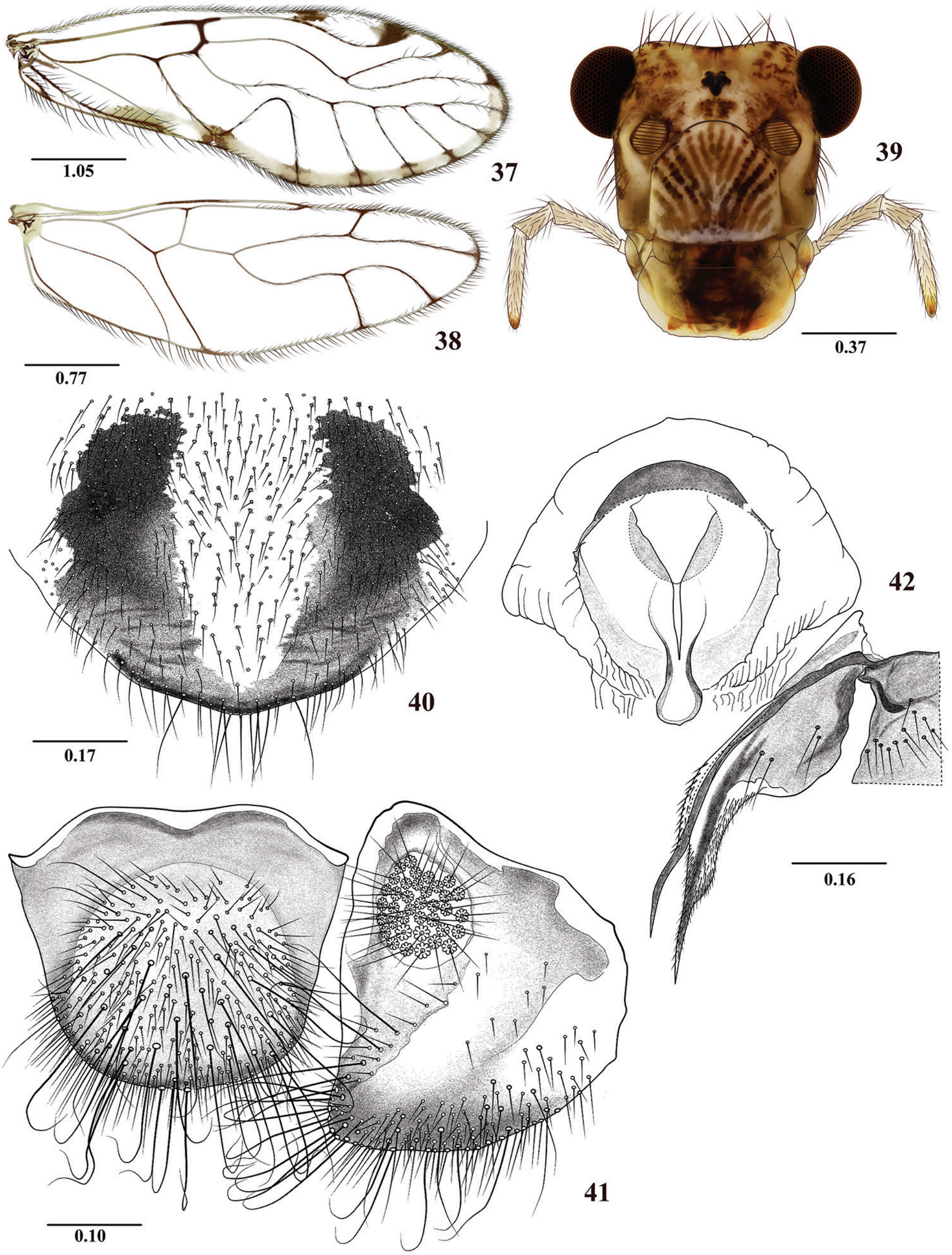
Male. Color (in 80% ethanol). Head pattern (Figure 33). Compound eyes black, ocelli hyaline, with ochre centripetal crescents. Front and postclypeus pale brown, anteclypeus and labrum dark brown centrally, with sides pale brown. Genae pale brown with brown spots. Antennae brown, scape, pedicel and flagellomeres 1–3 pale brown, cream distally. Maxillary palps creamy, Mx4 distally brown. Tergal lobes of meso- and metathorax pale brown, with brown spots. Thoracic pleura creamy to pale brown, with brown spots. Legs pale brown, tarsi 2–3 dark brown, fore- coxae cream, middle- and hind- coxae brown, darker proximally, femora with brown spots. Forewing with marginal brown band from apex of R4+5 to A1; M five-branched; pterostigma with a proximal and a distal brown band. Hindwings hyaline, veins brown. Abdomen pale brown to cream, with subcuticular brown spots; clunium, epiproct, and paraprocts brown, epiproct with large, pale central area. Sclerites of hypandrium and phallosome dark brown.

Morphology. As in diagnosis, plus the following: Head elongate (Figure 33): H/MxW: 1.37; compound eyes small, H/d: 3.94, H/D: 2.9, IO/MxW: 0.78. Outer cusp of lacinial tip broad, with eight denticles. Mx4/Mx2: 0.98. Forewings (Figure 31): L/W: 2.85. Pterostigma elongate: lp/wp: 5.56, areola postica tall, triangular, with rounded apex: al/ah: 1.40. M five-branched. Hindwings (Figure 32): l/w: 2.88. M three-branched. Hypandrium broadly trapeziform, setose, pigmented as illustrated in



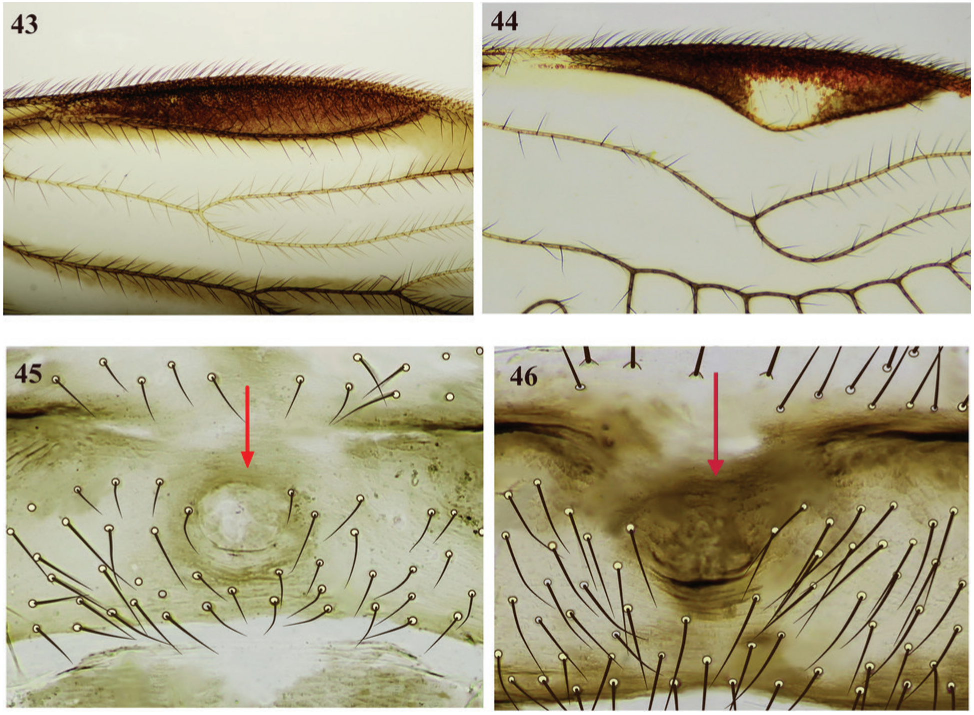
Figures 31–36. *Colocania pilosa* sp. n. Male. **31** Forewing **32** Hindwing **33** Front view of head **34** Hypandrium **35** Left paraproct and epiproct **36** Phallosome. Scale bars in mm.

Figure 34. Phallosome (Figure 36), mesal endophallic sclerites elongate, shaped as an inverted V, basally separated, wide apically (mesal sclerite process) and overlapping on the external parameres and with short processes of rounded apices, with ante-apically



Figures 37–42. *Colocania pilosa* sp. n. Female **37** Forewing **38** Hindwing **39** Front view of head **40** Subgenital plate **41** Epiproct and right paraproct **42** Sternum IX and left gonapophyses. Scale bars in mm.

lateral mesal sclerite process as illustrated; anterior endophallic sclerites oval and laminar, antero-lateral sclerites curved, boomerang-shaped as illustrated. Paraprocts (Figure 35) almost elliptic, with abundant setal field distally; sensory fields with 30



Figures 43–46. Pterostigma (**43, 44**) and central area of clunium showing oval cuticular depression (**45, 46**) **43** *Perucania longiareola* **44** *Ptiloneura bidorsalis* **45** *Colocania candelaria* (male) **46** *C. norsantanderina* (female).

trichobothria on basal rosettes. Epiproct (Figure 35) semioval, rounded posteriorly, bearing macrosetae; lateral and mesal macrosetae as illustrated.

Measurements. FW: 6475, HW: 4025, F: 1450, T: 2570, t1: 1180, t2: 120, t3: 160, Mx4: 325, ctt1: 36, f1: 1150, f2: 1120, f3: 900, f4: 690, f5: 410, f6: 360, f7: 260, f8: 230, f9: 200, f10: 173, f11: 200, IO: 610, D: 370, d: 270, IO/d: 2.26, PO: 0.73.

Female. Color (in 80% ethanol). Body, head, legs, wings, epiproct and paraprocts as in the male, plus the following: pigmented area of subgenital plate U-shaped (Figure 40); gonapophyses and paraprocts dark brown, epiproct brown.

Morphology. As in diagnosis, plus the following: Head elongate (Figure 39): H/MxW: 1.43; H/D: 3.2, H/d: 4.48; IO/MxW: 0.79. Outer cusp of lacinial tip broad, with seven denticles. Mx4/Mx2: 1.15. Wings (Figures 37 and 38) as in the male, L/W: 2.78. Pterostigma: lp/wp: 5.13, areola postica: al/ah: 1.31. Hindwings (Figure 38): l/w: 3.02. Subgenital plate (Figure 40) broad, slightly pointed posteriorly, setose. Gonapophyses (Figure 42): v1 elongate, broad, acuminate, distally bearing microsetae; v2+3 pilose, with short proximal heel, 4 setae on v3; distal process sinuous, acuminate, with microsetae on surface distally. Paraprocts (Figure 41), sensory fields with 34 trichobothria on basal rosettes. Epiproct (Figure 41) broad, scutiform, widely rounded distally, setal field with abundant setae as illustrated, macrosetae and abundant setae distally curved, as illustrated.

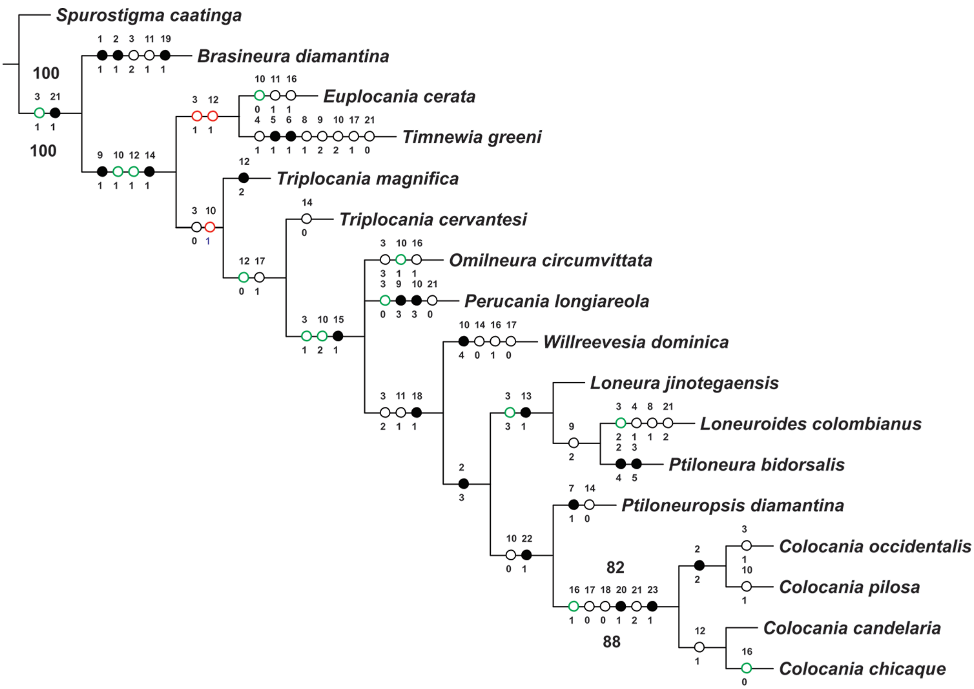


Figure 47. Strict consensus cladogram for 13 genera of Ptiloneuridae under implied weights for K = 2 (L = 76; IC = 48; IR = 61). Full circles (black, red, or green) indicate unique character changes, black circles (unambiguous), color circles (ambiguous); empty circles indicate parallelisms or reversals. ACCTRAN (green circles) and DELTRAN (red circles) optimization. Character number above and character states below each circle. Bootstrap (bold numbers on the branches) and Symmetric resampling (bold numbers under the branches) values>50.

Measurements. FW: 5550, HW: 3775, F: 1440, T: 2530, t1: 1110, t2: 114, t3: 140, Mx4: 380, ctt1: 40, f1: 1090, f2: 1115, f3: 880, IO: 620, D: 350, d: 250, IO/d: 2.48, PO: 0.71.

Etymology. The specific epithet refers to the densely pilose female epiproct.

Key to the species of *Colocania*

1 Females **2**
– Males **4**
2 Forewing with a marginal pigmented band brown to yellowish from R4+5 to A1, M five branched (Figures 13, 37) **3**
– Forewing hyaline, without marginal pigmented band; with apical dark spot in pterostigma (Figure 25); M four branched; sternum IX as in Figure 30 .... ***C. occidentalis* sp. n.**

3 Epiproct and paraprocts strongly setose, macrosetae strongly curved distally (Figure 41); sternum IX as in Figure 42 .... ***C. pilosa* sp. n.**

– Epiproct and paraprocts not as above, macrosetae not strongly curved distally (Figure 17); sternum IX as in Figure 18 .... ***C. norsantanderina* sp. n.**

4 Forewing with a marginal pigmented band, brown to yellowish from R4+5 to A1, M five branched (Figure 31); hindwing M three branched (Figure 32); side struts of phallosome with arms independent, proximally parallel, basally with processes directed outwards (Figure 36) .... ***C. pilosa* sp. n.**

– Forewing hyaline, without marginal pigmented band as above, pterostigma with proximal and distal, or only distal pigmented bands, M four-five branched (Figures 1, 7, 19); hindwing M three-four branched (Figures 2, 8, 20); side struts with arms variable **5**

5 Forewing M four branched (Figure 19), hindwing M three branched (Figure 20); side struts of phallosome V-shaped, proximally with two separate basal elongated arms curved and projects over the hypandrium, with an attached complex structure basally (Figure 24)................ ***C. occidentalis* sp. n.**

– Forewing M five branched, M5 bifurcate (Figures 1, 7); hindwing M four branched (Figures 2, 8); side struts with or without basal elongated arms that projects over the hypandrium (Figures 6, 12) **6**

6 Pterostigma with large proximal and distal pigmented bands (Figure 1); phallosome with mesal endophallic sclerite widened, mesal sclerite processes with two elongated teeth, one of them curved outwards, side struts with two elongated separate basal arms (Figure 6) .... ***C. candelaria* sp. n.**

– Pterostigma with only distal pigmented band (Figure 7); phallosome with narrow mesal endophallic sclerite, mesal sclerite processes apically toothless and curved strongly outwards, side struts V-shaped, fused basally (Figure 12) .... ***C. chicaque* sp. n.**

Comments on the species of *Colocania* gen. n.

Colocania is, so far, endemic to Colombia, its species have been collected between 1687 and 2450 meters of altitude, in Andean and Subandean areas (see Rangel and Aguilar 1995) of Central and East-western mountain ranges (Figure 48). The genus might also be found in Venezuela, as *C. norsantanderina* was found in a montane area near the Merida mountain range in Venezuela.

On basis of the forewing pigmentation pattern, two species groups are recognized, group A, with the forewings having a marginal pigmented band, from R4+5 to distal end of Cu2, including *C. norsantanderina* sp. n. and *C. pilosa* sp. n., and group B, with forewings hyaline, including *C. candelaria* sp. n., *C. chicaque* sp. n. and *C. occidentalis* sp. n. However, *C. candelaria* and *C. chicaque* are related only on the basis of one homoplasic character, the forewings with a ratio of crossvein Rs-M and the portion of vein M before it of 1:2 (char. 12) (Figure 47).

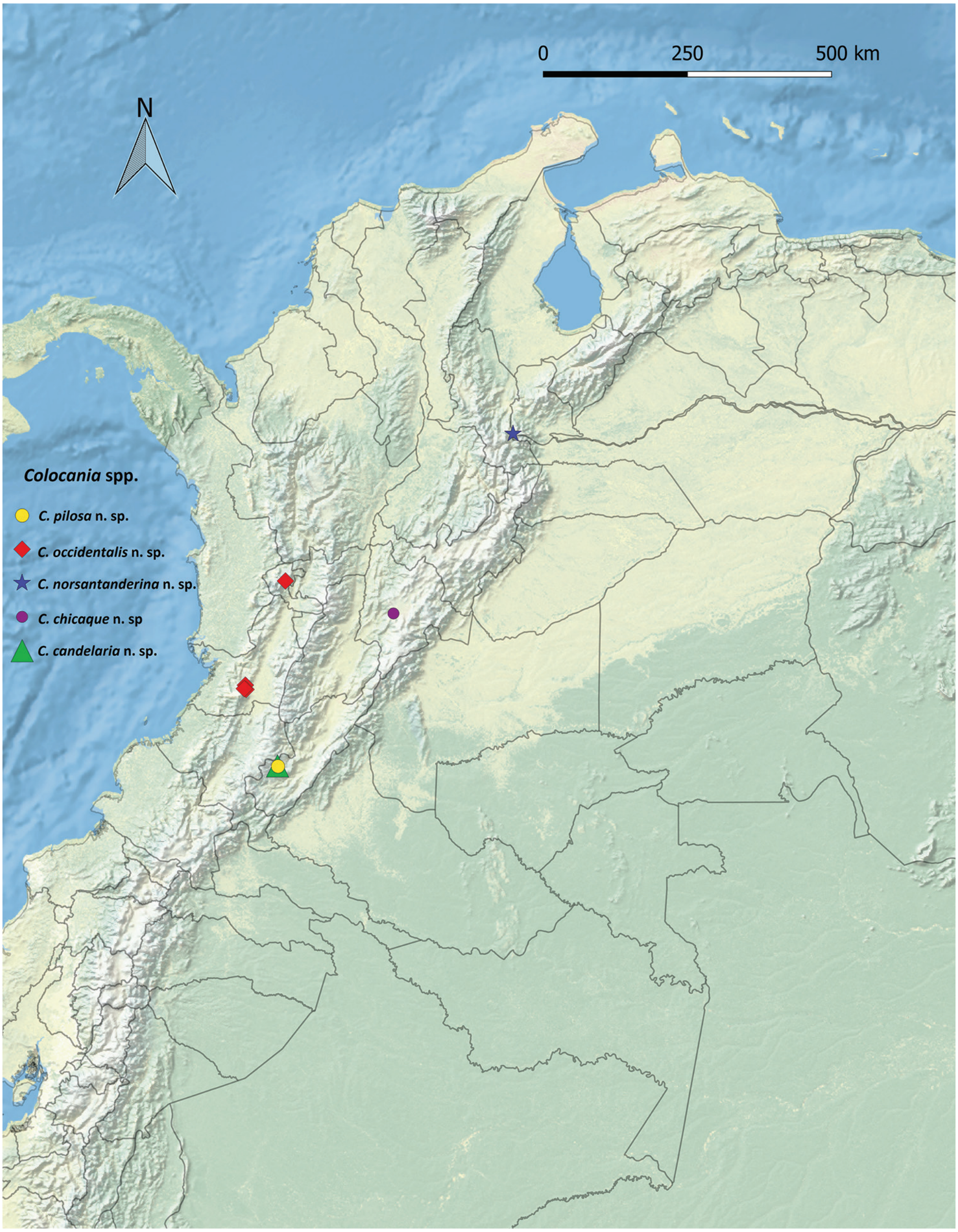


Figure 48. Distribution of the species of *Colocania*.

Acknowledgements

We wish to thank Colciencias and Universidad del Valle, Vicerectoría de Investigaciones, Santiago de Cali, Colombia, for two grants to the authors (Projects Col – CT 550-2014 and CI 7874) to study Psocoptera. We thank Posgrado de Biología, Facultad de Ciencias Naturales y Exactas of Universidad del Valle for sponsoring this publication. We thank Dimitri Forero for the loan of the holotype of *C. chicaque*. We also thank Svanhild Büch and Rubén Luna of the Meremberg Nature Reserve, Ovidio Ledesma, from Planes de San Rafael (Risaralda), Libardo Suárez Fonseca and Orlando Benítez of the National Natural Park Tamá. We thank Oscar Saenz (Universidad del Valle, Santiago de Cali, Colombia) for the phylogenetic analysis. RGO, NSC and JMN thank Departamento de Biología, Facultad de Ciencias Naturales y Exactas, Universidad del Valle, Santiago de Cali, Colombia, for research support. ANGA thanks Instituto de Biología, Universidad Nacional Autónoma de México, for continuous research support.

References

Casasola González JA (2006) Phylogenetic relationships of the genera of Epipsocetae (Psocoptera: Psocomorpha). Zootaxa 1194: 1–32.

García Aldrete AN (2006) New genera of Psocoptera (Insecta), from Mexico, Belize and Ecuador (Psoquillidae, Ptiloneuridae, Lachesillidae). Zootaxa 1319: 1–14.

García Aldrete AN, González Obando R, Sarria Sarria FA (2011) Three new species of *Loneura* (Psocodea: 'Psocoptera': Ptiloneuridae) from Gorgona Island, Cauca, Colombia, with a new infrageneric classification. Zootaxa 3050: 55–62.

Goloboff P (1993) Estimating character weights during tree search. Cladistics 9: 83–91. https://doi.org/10.1111/j.1096-0031.1993.tb00209.x

Goloboff P, Farris J, Nixon K (2003) Improvements to resampling measures of group support. Cladistics 19(4): 324–332. https://doi.org/10.1111/j.1096-0031.2003.tb00376.x

Goloboff P, Farris J, Nixon K (2008a) TNT, a free program for phylogenetic analysis. Cladistics 24: 774–786. https://doi.org/10.1111/j.1096-0031.2008.00217.x

Goloboff P, Carpenter JM, Arias JS, Esquivel DRM (2008b) Weighting against homoplasy improves phylogenetic analysis of morphological data sets. Cladistics 24(5): 758–773. https://doi.org/10.1111/j.1096-0031.2008.00209.x

Nixon KC (1999–2002) WinClada, version 1.00.08. Published by the author, Ithaca, NY.

Rangel-Ch JO, Aguilar-P PM (1995) Una aproximación sobre la diversidad climática en las regiones naturales de Colombia. In: Rangel-Ch JO (Ed.) Diversidad Biótica I. Instituto de Ciencias Naturales-Universidad Nacional de Colombia-Inderena, Bogotá, 25–77.

Silva-Neto AM, García Aldrete AN (2012) A new species of *Spurostigma* Eertmoed (Psocodea: 'Psocoptera': Spurostigmatidae) from Brazil. Zootaxa 3501: 83–87.

Silva-Neto AM, García Aldrete AN (2015) A new genus in the family Ptiloneuridae (Psocodea: 'Psocoptera': Psocomorpha: Epipsocetae) from Brazil. Zootaxa 3914(2): 168–174. https://doi.org/10.11646/zootaxa.3914.2.6

Silva-Neto AM, García Aldrete AN, Rafael JA (2016a) A new species of *Brasineura* Silva-Neto & García Aldrete (Psocodea, 'Psocoptera', Ptiloneuridae), with comments on morphological variation in *B. troglophilica* and a revised generic diagnosis. Zootaxa 4085(3): 445–450. https://doi.org/10.11646/zootaxa.4085.3.8

Silva-Neto AM, García Aldrete AN, Rafael JA (2016b) Phylogenetic relationships of the genera of Ptiloneuridae (Psocodea, 'Psocoptera', Epipsocetae) and a test on the monophyly of *Brasineura* Silva-Neto & García Aldrete and *Loneuroides* García Aldrete. Zootaxa 4150(1): 073–084. https://doi.org/10.11646/zootaxa.4150.1.4

Yoshizawa K (2002) Phylogeny and higher classification of suborder Psocomorpha (Insecta: Psocodea: 'Psocoptera'). Zoological Journal of the Linnean Society 136: 371–400. https://doi.org/10.1046/j.1096-3642.2002.00036.x

ZooKeys 780: 35–59 (2018)
doi: 10.3897/zookeys.780.26272
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Review of the ant genus *Technomyrmex* Mayr, 1872 in the Arabian Peninsula (Hymenoptera, Formicidae)

Mostafa R. Sharaf[1], Hathal M. Al Dhafer[1], Abdulrahman S. Aldawood[1]

[1] *Plant Protection Department, College of Food and Agriculture Sciences, King Saud University, Riyadh 11451, PO Box 2460, Kingdom of Saudi Arabia*

Corresponding author: *Mostafa R. Sharaf* (antsharaf@gmail.com; mosharaf@ksu.edu.sa)

Academic editor: *B. Fisher* | Received 28 April 2018 | Accepted 2 July 2018 | Published 8 August 2018

http://zoobank.org/83973C30-EC17-4CFA-A486-FB775F37793A

Citation: Sharaf MR, Al Dhafer HM, Aldawood AS (2018) Review of the ant genus *Technomyrmex* Mayr, 1872 in the Arabian Peninsula (Hymenoptera, Formicidae). ZooKeys 780: 35–59. https://doi.org/10.3897/zookeys.780.26272

Abstract

The taxonomy of the dolichoderine ants of the genus *Technomyrmex* Mayr, 1872 is revised for the Arabian Peninsula. Six species are treated, *T. albipes* (F. Smith, 1861), *T. difficilis* Forel, 1892, *T. briani* Sharaf, 2009, *T. vexatus* (Santschi, 1919), *T. montaseri* Sharaf, Collingwood & Aldawood, 2011, and *T. setosus* Collingwood, 1985. The successful tramp species *T. difficilis* Forel, 1892 is recorded for the first time from the Kingdom of Saudi Arabia (KSA) and Yemen, representing new records for the Palearctic Region. *Technomyrmex vexatus* (Santschi, 1919) is a new species record for Yemen. The queen caste of the rare endemic species, *T. briani* Sharaf, 2009 is described for the first time. A neotype for KSA endemic *T. setosus* Collingwood 1985 is designated based on a specimen collected from the type locality, the Asir Mountains, KSA, including new information on habitats and distribution. A male cast of *Technomyrmex*, possibly of *T. setosus*, is also described. An illustrated key based on the worker caste of the Arabian species of *Technomyrmex* is given. New geographical records and a distribution map for the treated species are presented.

Keywords

Afrotropical Region, Arabian Peninsula, Asir Mountains, Dolichoderinae, male, Middle East, Neotype, new record, Palearctic Region

Introduction

The ant genus *Technomyrmex* Mayr, 1872 is a member of the subfamily Dolichoderinae, with 94 valid species and four fossil species worldwide (Bolton 2017). *Technomyrmex* species are distributed throughout Old World tropical and subtropical zones (Brown 2000), the Oriental-Malesian (Bolton 2007), and Neotropical (Fernández and Guerrero 2008) regions. Most species are arboreal or subarboreal (Collingwood 1985, Bolton 2007), but some species nest directly in the ground (Collingwood 1985, Bolton 2007, Sharaf 2009, Fisher and Bolton 2016). The feeding habits of most species include honeydew produced by a wide range of hemipterans, whereas other species are considered generalized foragers (Brown 2000, Bolton 2007).

Bolton (2007) provided a world revision of the genus in which 90 species were recognized including 37 new species described. Subsequently, a synopsis of the New World species was made available by Fernández and Guerrero (2008) including a key to six species. The males of the Malagasy *Technomyrmex* were diagnosed by Yoshimura and Fisher (2011). Recently, the Taiwanese species were revised, recognizing five species including a description of a new species (Yamane et al. 2018).

Technomyrmex is one of the incompletely studied ant genera of the Arabian Peninsula. The first treatment of the ants of the Kingdom of Saudi Arabia (KSA) (Collingwood 1985) reported two species, *T. albipes* (F. Smith, 1861) from the Eastern Region, and *T. setosus* Collingwood, 1985 from the southwestern Asir Mountains. In addition, this author mentioned two additional putative species designated as sp. A. and sp. B., and indicating that these taxa may represent undescribed species. In their work on the ant fauna of the Arabian Peninsula, Collingwood and Agosti (1996) briefly treated and keyed the Arabian *Technomyrmex* species and recorded *T. albipes* and *T. setosus* from Yemen. Subsequently, two new species were added to the Arabian Peninsula, *T. briani* Sharaf, 2009 and *T. montaseri* Sharaf, Collingwood & Aldawood, 2011 from the KSA and Oman, respectively (Sharaf 2009, Sharaf et al. 2011). A key to the Arabian species was included in in the latter work. The faunal list of Al Bahah Province (El-Hawagry et al. 2013) recorded *T. briani* and *T. setosus* from various localities in the Al Sarawat Mountains of KSA.

Recent collecting efforts, especially in the southwestern Mountains of KSA by the senior author and the entomology team of King Saud University Museum of Arthropods (KSMA) have resulted in new material for study. Also, several years of field surveys (2009-2017) throughout KSA using different collecting methods (*e.g.* hand collecting, pitfall traps, beating sheets, light traps, etc.), have added material for study, and importantly new information on the distribution of this genus. The study of this new material has allowed us to provide this updated synopsis of the genus for the Arabian Peninsula, providing identification, distribution, and habitat information.

Materials and methods

Measurements and indices follow Bolton (2007).

Measurements

TL	Total Length: The total outstretched length of the ant from the mandibular apex to the gastral apex.
EL	Eye Length: The maximum diameter of eyes in profile.
HL	Head Length: The length of the head capsule excluding the mandibles; measured in full-face view in a straight line from the mid-point of the anterior clypeal margin to the mid-point of the posterior margin.
HW	Head Width: The maximum width of the head behind the eyes, measured in full-face view.
SL	Scape Length: The maximum straight-line length of the scape, excluding the basal constriction or neck that occurs just distal of the condylar bulb.
PW	Pronotal Width: The maximum width of the pronotum in dorsal view.
WL	Weber's length of mesosoma: The diagonal length of the mesosoma in profile, from the most anterior point of the pronotum to the posterior basal angle of the metapleuron.

All measurements are expressed in millimetres.

Indices

CI	Cephalic Index: HW divided by HL × 100.
DTI	Dorsal Thoracic Index: In dorsal view the length from the mid-point of the anterior pronotal margin to the midpoint of the metanotal groove, divided by PW × 100.
EPI	Eye Position Index: In full-face view the straight-line length (parallel to the long axis of the head) from the most anterior point of the eye to the anterior clypeal margin, divided by the straight-line length from the most posterior point of the eye to the posterior margin × 100.
OI	Ocular Index: Maximum diameter of eye divided by HW × 100.
SI	Scape Index: SL divided by HW × 100.

Throughout the text, 'w' stands for 'worker' or 'workers', 'q' for 'queen', and 'm' for 'male'.

Abbreviations of museums

CASC	California Academy of Sciences Collection, San Francisco, CA, USA.
KSMA	King Saud University Museum of Arthropods, Riyadh, Kingdom of Saudi Arabia.
MHNG	Muséum d'Histoire Naturelle, Genève, Switzerland.
NHMB	Naturhistorisches Museum, Basel, Switzerland.
OXUM	Hope Entomological Collection, Oxford Museum of Natural History, Oxford, United Kingdom.

UABC	Universitat Autònoma de Barcelona, Bellaterra, Spain.
WMLC	World Museum Liverpool, Liverpool, United Kingdom.

Abbreviations of collecting technique

BS	Beating sheet.
LT	Light trap.
MT	Malaise trap.
PT	Pitfall trap.

During more than 20 field trips to the southwestern mountains of KSA, more than 500 specimens were collected using hand picking, pitfall traps, beating sheets, and sifting trays. Beating sheets and sifting trays are efficient methods for collecting this genus of arboreal and ground dwelling ants. All specimens were preserved in 95% ethanol in the field. Ants were later removed and mounted.

Results

Diagnosis of the genus *Technomyrmex*

Workers of the genus *Technomyrmex* are distinguished by the following characters (Bolton 2007): Masticatory margin of mandibles armed with 12–14 teeth; palp formula 6, 4; anterior clypeal margin transverse or strongly incised; eyes present; ocelli absent; antennae 12-segmented without a terminal club; metanotal groove well-developed; propodeum unarmed; propodeal dorsum and declivity junction rounded or distinctly angled in profile; petiole reduced, completely concealed by the first gastral tergite when seen from dorsal view; gaster with five tergites visible in dorsal view.

Synoptic species list of the Arabian *Technomyrmex*

Technomyrmex albipes (F. Smith, 1861)
  = *Technomyrmex nigrum* Mayr, 1872
  = *Technomyrmex albitarse* Emery, 1893
  = *Technomyrmex albipes* var. *bruneipes* Forel, 1895
  = *Technomyrmex albipes* r. *wedda* Forel, 1913
***Technomyrmex briani* Sharaf, 2009**
***Technomyrmex difficilis* Forel, 1892**
  = *Technomyrmex mayri nitidulans* Santschi, 1930
***Technomyrmex montaseri* Sharaf, Collingwood & Aldawood, 2011**
***Technomyrmex setosus* Collingwood, 1985**
***Technomyrmex vexatus* (Santschi, 1919)**

Key to the Arabian *Technomyrmex* Mayr (modified after Bolton 2007, Sharaf et al. 2011)

1 Head in profile with the dorsal surface of the frontal carina entirely without setae (Fig. 1a); mesosoma without setae (Fig. 1b)........ ***T. gibbosus*-group**...**2**

– Head in profile with the dorsal surface of the frontal carina with setae present (Fig. 1c); at least one seta present, or more usually with a row of 2–4; mesosoma with setae (Fig. 1d) .... ***albipes*-group**...**3**

2 Larger relatively shining brown species (TL 3.0–3.4, HL 0.72–0.78, HW 0.68–0.76, PW 0.44–0.48, WL 0.90–0.96); dorsal outline of mesonotum distinctly convex in profile, with a descending face sloping abruptly back to a deep metanotal groove (Fig. 1e); propodeal dorsum approx. half length of propodeal declivity (Fig. 1e) (Spain, Morocco, and Yemen) .... ***T. vexatus* Santschi**

– Smaller dull yellow species (TL 2.2–2.9, HL 0.60–0.62, HW 0.57–0.60, PW 0.37–0.38, WL 0.65–0.80); dorsal outline of mesonotum feebly convex in profile, with a descending face sloping evenly back to a shallow metanotal groove (Fig. 1f); propodeal dorsum approximately one-third length of propodeal declivity (Fig. 1f) (Oman) .... ***T. montaseri* Sharaf et al.**

3 First gastral tergite usually without setae or rarely with one pair (Fig. 2a) (Saudi Arabia).. ***T. briani* Sharaf**

– First gastral tergite usually with at least seven pairs of setae (Fig. 2b)...........**4**

4 Bicolored species, head and gaster brown, mesosoma yellow-brown lighter than head and gaster; setae on first gastral tergite longer with maximum length 0.18 mm (KSA, Oman, Yemen)....................***T. setosus* Collingwood**

– Uniform black-brown to black species; setae on first gastral tergite distinctly shorter with maximum length less than 0.10 mm **5**

5 Cephalic dorsum behind level of posterior margin of eyes without setae (Fig. 2c); eyes in full-face view fail to break sides of head (Fig. 2d); promesonotum relatively short (DTI 110–124) (Introduced species).....***T. albipes* (F. Smith)**

– Cephalic dorsum behind level of posterior margin of eyes with one or more pairs of setae (Fig. 2e); eyes in full-face view break sides of head (Fig. 2f); promesonotum relatively longer and slender (DTI 127–135) (Introduced species) .... ***T. difficilis* Forel**

Technomyrmex albipes (F. Smith, 1861)

Figure 3A, B, C

Formica (*Tapinoma*) *albipes* Smith, 1861: 38 (w.) Syntype worker, Indonesia: Sulawesi, Tond, (A.R. Wallace), CASENT0102952, Indomalaya, (OXUM), (image examined); Forel 1891: 98 (q.); Forel 1908: 21 (ergatoid m.); Karavaiev 1926: 441 (m.);

Wheeler and Wheeler 1951: 205 (l.); Crozier 1969: 245 (k.). Combination in *Tapinoma*: Mayr, 1863: 455; in *Technomyrmex*: Emery 1888: 392. Senior synonym of *Technomyrmex nigrum*: Mayr 1872: 147; Mayr 1876: 83; of *Technomyrmex albitarse*: Emer 1893: 249; of *Technomyrmex bruneipes*, *Technomyrmex detorquens*, *Technomyrmex forticulus*, *Technomyrmex wedda*: Bolton 2007: 68.

Description. Worker. Measurements: TL: 2.40–2.90; HL: 0.56–0.63; HW: 0.52–0.58; SL: 0.48–0.58; PW: 0.35–0.42; WL: 0.66–0.78. Indices: CI: 87–95; SI: 91–102; OI: 24–27; EPI: 70–88; DTI: 110–124 (n = 50, from Bolton 2007).

Head. Anterior clypeal margin with a feeble, shallow median indentation; head in full-face view with a small shallow indentation medially and strongly convex sides; eyes of moderate size with approximately nine ommatidia in longest row (OI: 24–27), located in front of midlength, with outer margins just fail to break outlines of head sides. **Mesosoma.** In profile the mesonotal outline evenly curved; propodeal dorsum making a distinct obtuse angle with declivity in profile. **Pilosity.** Frontal carina with two pairs of setae; pronotum with 1–3 pairs; mesonotum bare or with one pair (usually none); propodeal dorsum bare; lateral margins of propodeal declivity with one or two pairs, usually with one pair above spiracle, another pair higher up; gastral tergites 1–4 each with abundant scattered long setae (length of setae relatively less than eye diameter or even subequal) on sclerites. **Sculpture.** Body sculpture finely and densely reticulate-punctate, general appearance dull. **Colour.** Head, mesosoma, petiole and gaster black-brown to black; tarsi of mid- and hind legs yellow.

Material examined. KSA, Eastern Province, Hofuf, 25.3142°N, 49.6299°E, 28.v.1978, (W. Büttiker leg.) (1 m) (WMLC).

Previous records. KSA, Eastern Province, Al Qatif, 26.51028°N, 49.96889°E, 30 m, 14.iv.1984, (C. A. Collingwood leg.) (1 m); (Collingwood & van Harten 2001); Yemen: Al Kawd (misspelled AI Kowd), vii.1999, 13.088622°N, 45.364722°E, LT, (Van Harten & Al Haruri leg.); Lahj, iv.1999, 17.1661000°N, 43.3336600°E, MT, (Van Harten & Sallam leg.); Sana'a, 15.3694°N, 44.1910°E, 2250 m, 24.xi.1998, (Van Harten leg.); Ta'iz, V.1998, 13.57952°N, 44.02091°E, LT (Van Harten & Awad leg.) (Collingwood 1985); Al Kadan, vi.2003, 15.248°N, 43.254°E, LT, (Van Harten & T. Abdul Haq leg.) (Collingwood & van Harten 2005).

Ecological and biological notes. *Technomyrmex albipes* nests and forages in and beneath fallen wood and rocks, in tree trunks, in leaf litter, in twigs, on the forest floor, on low vegetation, and into the canopy (Bolton 2007). The species is known to feed on honeydew of a broad range of sap sucking attended hemipterans including the mealybug vectors of pineapple wilt disease (Sulaiman 1997).

Geographic range. A successful introduced species that has spread worldwide including the Australian, the Afrotropical, and the Malagasy regions (Bolton 2007).

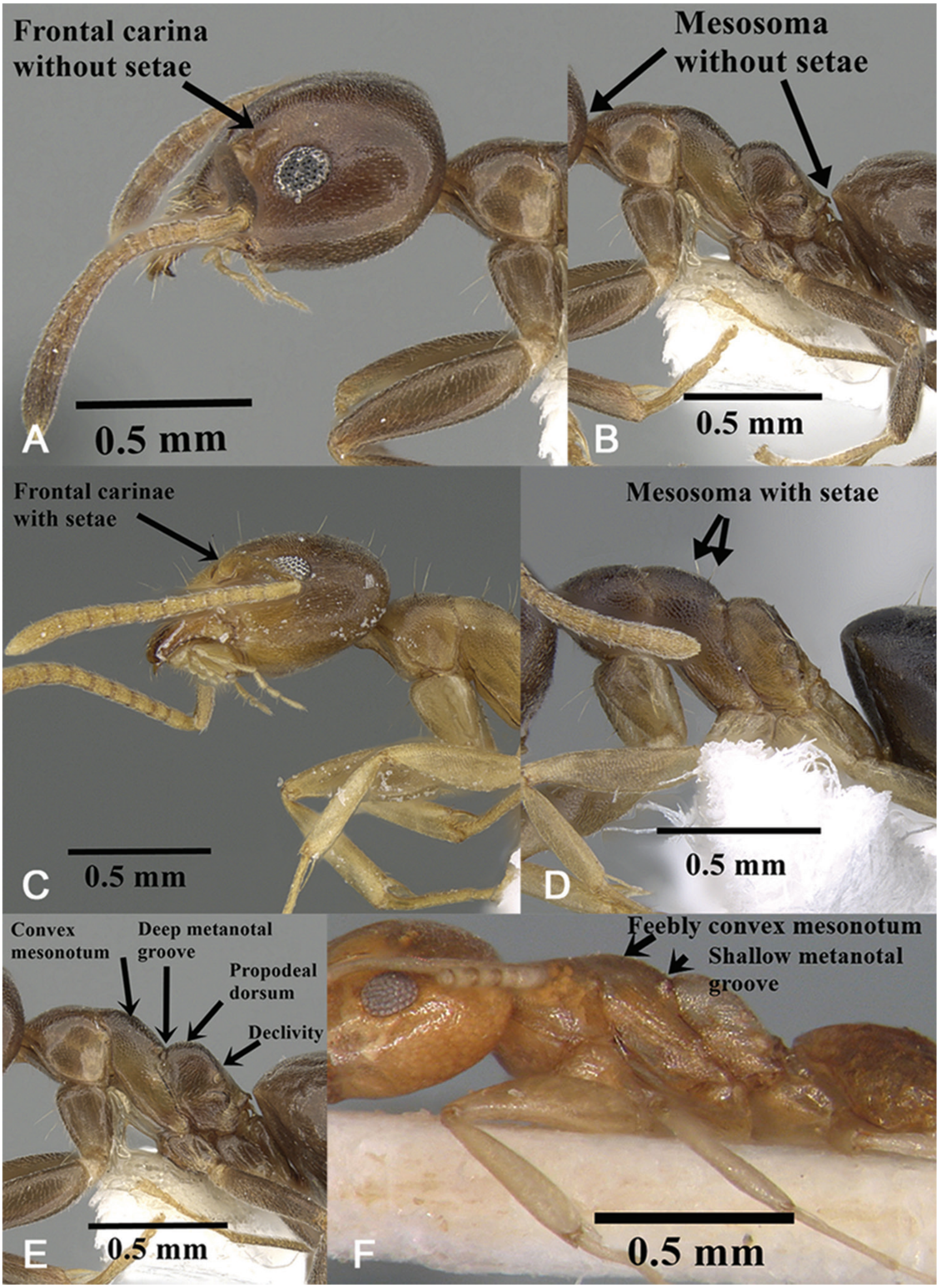


Figure 1. *Technomyrmex* key illustrations: **A** *T. vexatus*, head in profile, CASENT0249804 **B** mesosoma in profile **C** *T. briani*, head in profile, CASENT0919799 **D** *T. setosus*, mesosoma in profile, CASENT0746639 **E** *T. vexatus*, mesosoma in profile, CASENT0249804 **F** *T. montaseri*, mesosoma in profile, images from www.AntWeb.org except **F**.

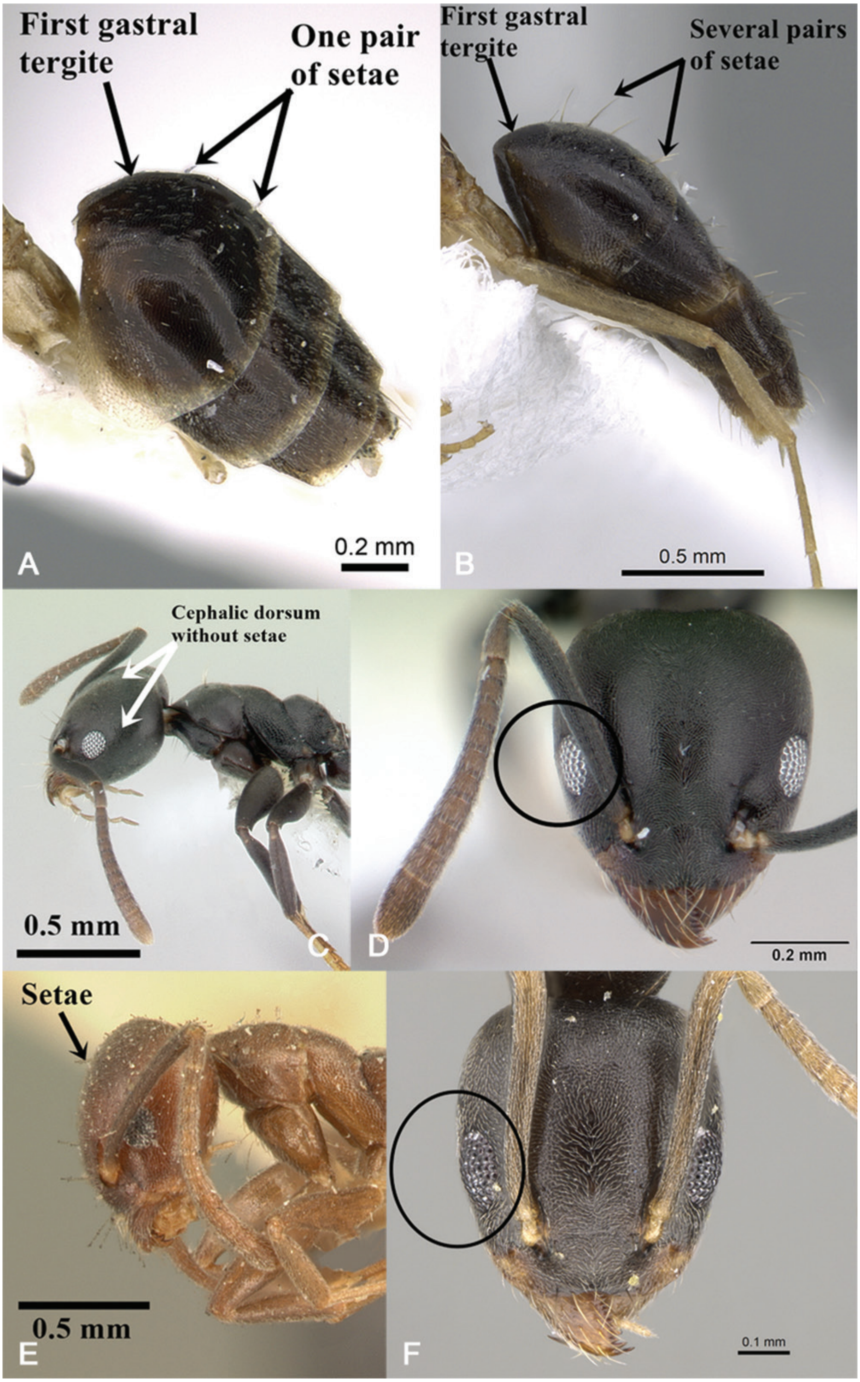


Figure 2. *Technomyrmex* key illustrations: **A** *T. briani*, gaster in profile, CASENT0906400 **B** *T. setosus*, gaster in profile, CASENT0746639 **C** *T. albipes*, head and mesosoma in profile, CASENT0178469 **D** *T. albipes*, head in full-face view, CASENT0178469 **E** *T. difficilis*, head in profile, CASENT0101932 **F** *T. difficilis*, head in full-face view, CASENT0922887, images from www.AntWeb.org.

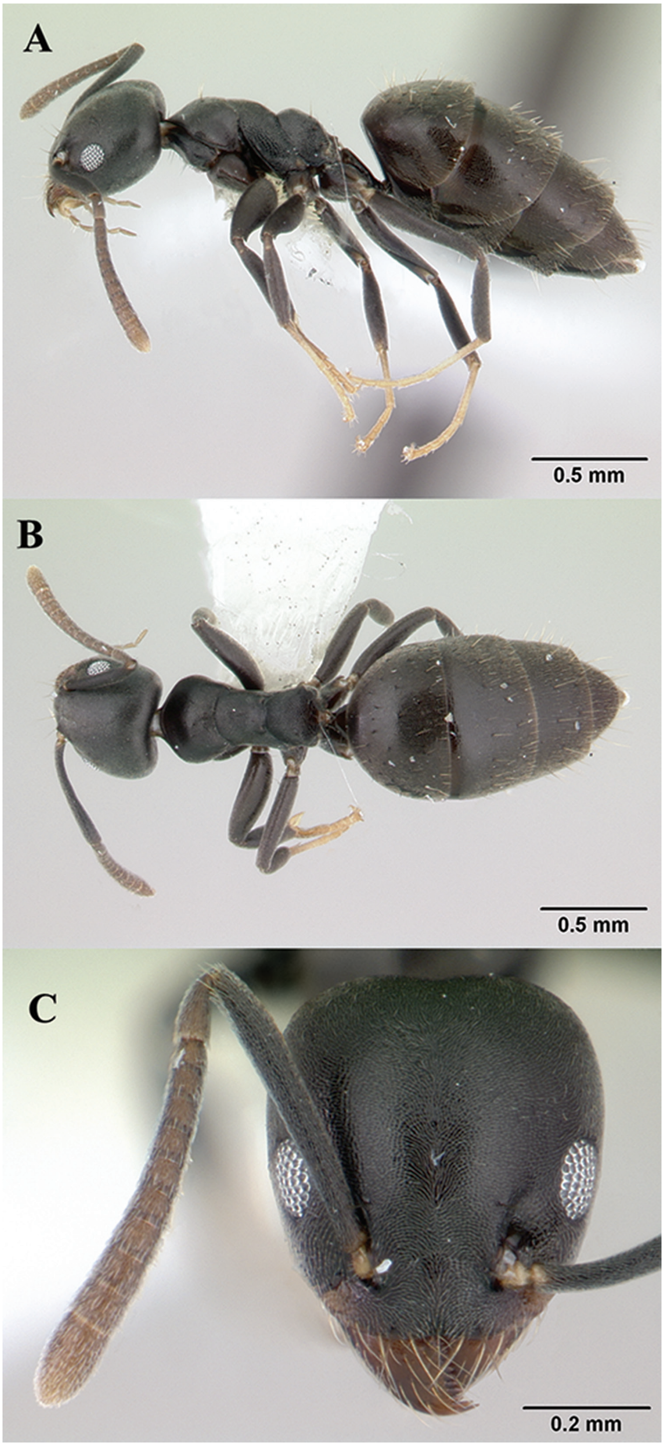


Figure 3. *Technomyrmex albipes*, worker, CASENT0178469. **A**, body in profile **B** body in dorsal view **C** head in full-face view, images from www.AntWeb.org.

Technomyrmex briani Sharaf, 2009

Figure 4A, B, C

Technomyrmex briani Sharaf, 2009: 213, figs 1–3 (w.), Holotype worker, KSA: Wadi Abha, 18.216389°N, 42.505278°E, 2261 m, 18.iii. 2004, (M. R. Sharaf), 2 paratype workers, same data as the holotype, CASENT0906400, (KSMA), CASENT0911583, (NHMB), (examined), Afrotropic.

Description. Worker. Measurements: TL: 2.62–3.0; HL: 0.62–0.72; HW: 0.60–0.67; SL: 0.60–0.72; PW: 0.42–0.47; WL: 0.80–0.92; Indices: CI: 89–100; SI: 92–112; OI: 22–29; EPI: 73–117; DTI: 106–128 (n = 10, from Sharaf 2009).

Head. Head distinctly longer than broad with straight posterior margin and clearly curved sides; anterior clypeal margin transverse or very feebly concave medially; posterior margin of head transverse or slightly concave; eyes with 10 ommatidia in the longest row (OI: 22–29) with outer margins just fail to break the outlines of the sides in full-face view; scapes surpass posterior margin of head by approximately ¼ its length. **Mesosoma.** Promesonotal suture distinct; mesonotum in profile evenly rounded descending abruptly to a well-developed metanotal groove; propodeal dorsum short approximately ¼ × length of propodeal declivity. **Pilosity.** Number of setal pairs; frontal carina with two pairs: in profile one pair above the torulus and another pair at the level of the anterior portion of the eye; pronotum with one or two pairs; mesonotum bare or with one or two pairs; sides of propodeal declivity bare or in some individuals with one to three pairs; first, second, and third gastral tergites mostly bare; entire body covered with appressed pale pubescence. **Sculpture.** Body finely superficially granulate, general appearance relatively dull. **Colour.** Bicolored species, head and gaster dark brown, mesosoma yellow-brown clearly lighter than head and gaster; clypeus, mandibles, legs and antennae dirty yellow.

Worker similar to *T. setosus* but it can be separated by the following characters: eyes located relatively posteriorly on head sides; mesosoma and gastral tergites 1–3 mostly bare, rarely promesonotum with one pair of setae.

Queen. Measurements: TL: 3.67; HL: 0.80; HW: 0.75; SL: 0.75; PW: 0.62; WL: 1.12; Indices: CI: 94; SI: 100; OI: 29; EPI: 78; DTI: 121. (n = 1).

Head. In full-face view with feebly convex sides and nearly straight posterior margin; anterior clypeal margin weak but distinct medially concave; eyes of medium size, with approximately 12 ommatidia in longest row (OI: 29), located on midlength of head, with outer margin of eye touching head sides; scapes when laid back from their insertions surpass the posterior margin of head approximately by the length of first funicular segment. **Mesosoma.** In profile propodeal dorsum and declivity forming a continuous curve; propodeal spiracle located at midlength of declivity. **Pilosity.** Anterior clypeal margin with a single pair of setae; frontal carina with two pairs of black based setae: in profile the first above torulus, the second at about level of anterior margin of eyes, another three setal pairs, behind posterior margin of eyes, in front of small ocelli and on the posterior margin of head. Number of setal pairs on mesosoma:

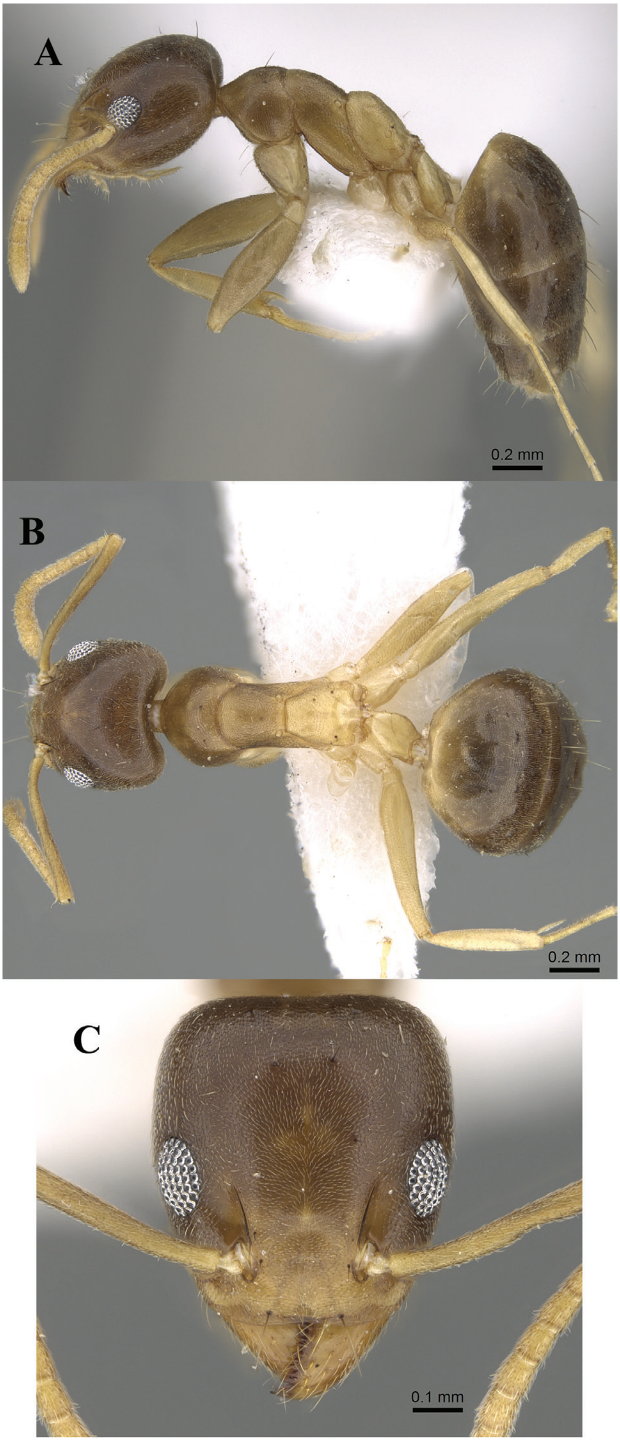


Figure 4. *Technomyrmex briani*, worker, CASENT0919798. **A** body in profile **B** body in dorsal view **C** head in full-face view, images from www.AntWeb.org.

promesonotum and metanotum each with one pair; lateral margins of propodeal declivity with three pairs; first and second gastral tergites each with three pairs on sides, third and fourth tergites each with three pairs scattered on sides. **Sculpture.** Head and mesosoma finely and densely punctate, general appearance dull except gaster feebly shining. **Colour.** Head brown, gaster bark brown, mesosoma yellow-brown, lighter than head, legs and antennae yellow.

Material examined. KSA, Al Bahah Province: Elqamh Park, Belgurashi, 19.913056°N, 41.905°E, 1931 m, 17.v.2010, (M. R. Sharaf) (1 w, CASENT0919798, CASC); Shohba Forest, 20.234167°N, 41.623611°E, 2324 m, 14.v.2011, (M. R. Sharaf) (1 w, CASENT0919799, CASC); Shohba Forest, 20.234167°N, 41.623611°E, 2324 m, 14.v.2011, (M. R. Sharaf) (33 w,); Saudi Arabia, Al Baha, Wadi Elzaraeb, 20.216944°N, 41.436944°E, 2123 m, 15.v.2010, (M. R. Sharaf) (5 w); Shada Al A'la, 19.838817°N, 41.310067°E, 1563 m, 15.xi.2015, (Al Dhafer et al.), PT, (6 w); Shada Al A'la, 19.8627°N, 41.301483°E, 1225 m, 23.viii.2014, (Al Dhafer et al.), PT, (3 w), all in KSMA.

Biological notes. *Technomyrmex briani* nests under rocks often next to *Acacia* and *Juniper* trees in southwestern mountains of the KSA. Workers were descending small shrubs and other native plants.

Geographic range. *Technomyrmex briani* is known only from the KSA and is considered endemic to the southwestern mountains of the Arabian Peninsula.

Technomyrmex difficilis Forel, 1892

Figure 5A, B, C

Technomyrmex mayri r. *difficilis* Forel, 1892: 242 (w. q.) Syntype worker, Madagascar, Nosibe, Village de l'Imerina coll. (Sikora), CASENT0101932, (MHNG), (image examined), Malagasy.

Junior synonym of *Technomyrmex mayri nitidulans* Santschi, 1930; raised to species and senior synonym of *Technomyrmex nitidulans*: Bolton 2007: 47.

Description. Worker. Measurements: TL: 2.40–3.10; HL: 0.57–0.76; HW: 0.52–0.69; SL: 0.52–0.74; PW: 0.36–0.47; WL: 0.74–1.02; Indices: CI: 89–97; SI: 95–107; OI: 25–30; EPI: 72–86; DTI: 127–135 (n = 35, from Bolton 2007).

Head. In full-face view with feebly convex sides and nearly straight posterior margin; anterior clypeal margin weak but distinct medially concave; eyes located in front of midlength of head, with outer margin of eye fail to break head sides. **Mesosoma.** In profile promesonotal and mesonotal outlines forming a continuous curve that descends steeply to a well-defined metanotal groove; propodeal dorsum and declivity meeting in a continuous curve in profile. **Pilosity.** Frontal carina with two pairs of setae: in profile the first above torulus, the second at about level of anterior margin of eyes. Number of setal pairs on mesosoma: pronotum with one or two pairs; mesonotum bare or with one pair; propodeal dorsum bare; lateral margins of propodeal declivity with one or two pairs. Gastral tergites 1–4 each with many pairs of setae, scattered on tergites.

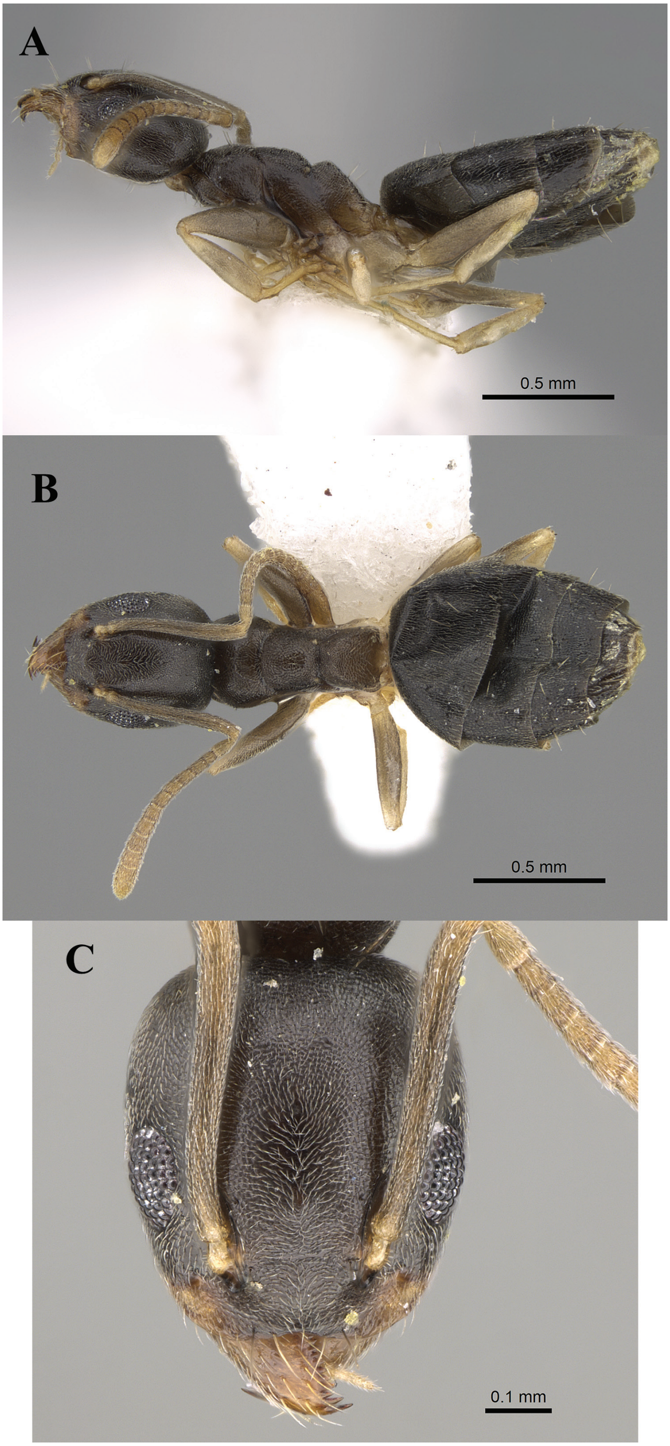


Figure 5. *Technomyrmex difficilis*, worker, CASENT0922887. **A** body in profile **B** body in dorsal view **C** head in full-face view, images from www.AntWeb.org.

Sculpture. Body sculpture finely and densely reticulate-punctate, general appearance dull. **Colour.** Head, mesosoma, petiole and gaster dark brown to black; coxae, femora and tibiae of same colour as mesosoma or slightly lighter. Tarsi of middle and hind legs yellow-white to yellow, lighter than tibiae.

Material examined. KSA, Riyadh Province: Riyadh, Almorouj, 24.75837°N, 46.66409°E, 07.x.2017, (M. R. Sharaf) (1 w), KSMA.

Ecological and biological notes. The nesting habit of *T. difficilis* is diverse (Warner 2003). Nests are found in both urban and undisturbed native habitats and are constructed directly into the ground, in trees holes, under palm fronds and old petiole bases, in leaf-litter and under stones and debris. The feeding habits include plant nectar, honeydew, dead insects, and other protein sources. The wide range of nesting sites and feeding habits make *T. difficilis* one of the most successfully dispersed species of the genus worldwide (Bolton 2007). The single specimen studied here was found hiding inside the persistent stamen cluster of a pomegranate fruit imported from Yemen at "Al Othaim Hypermarket", Riyadh.

Geographic range. *Technomyrmex difficilis* is broadly distributed worldwide and recorded from the Nearctic (Deyrup 1991), the Australian (Shattuck 1999, Andersen 2000), the Malagasy, the Neotropical, and the Oriental (Bolton 2007) Regions. The present record represents the first for the KSA, Yemen, and the Palearctic Region in general.

Technomyrmex montaseri Sharaf, Collingwood & Aldawood, 2011

Figure 6A, B, C

Technomyrmex montaseri Sharaf, Collingwood & Aldawood, 2011: 14, figs 1–3 (w.) Holotype worker, Oman: Bani Sur, 24.659°N, 56.494°E 7.iii.1984, (W. Büttiker), (WMLC) (examined), Palearctic.

Description. Worker. Measurements: TL: 2.80–2.90; HL: 0.60–0.62; HW: 0.57–0.60; SL: 0.58–0.62; PW: 0.37–0.38; WL: 0.65–0.80; EL: 0.15; Indices: CI: 95–97; SI: 97–109; OI: 25–26; EPI: 80–125; DTI: 122–126 (n = 2). **Head.** In full-face view with feebly convex posterior margin and distinctly convex lateral sides; anterior clypeal margin nearly straight; scapes when laid back from their insertions surpass posterior margin of head by approximately length of first funicular segment; eyes of moderate size with approximately ten ommatidia in longest row (OI: 25–26), located in front of the midlength and their outer margins just failing to break outlines of head sides. **Mesosoma.** In profile mesonotal dorsal outline with short, flat to feebly convex anterior section, posterior section broadly and evenly curved and descending to a deep metanotal groove; propodeum in profile with short convex dorsal surface that rounds evenly into declivity which is nearly three times longer than dorsal face, the two surfaces not separating by an angle. **Pilosity.** Body surface entirely without setae except few long pairs on anterior clypeal margin. **Sculpture.** Body sculpture effaced microreticulum, general appearance more or less dull. **Colour.** Uniformly yellow.

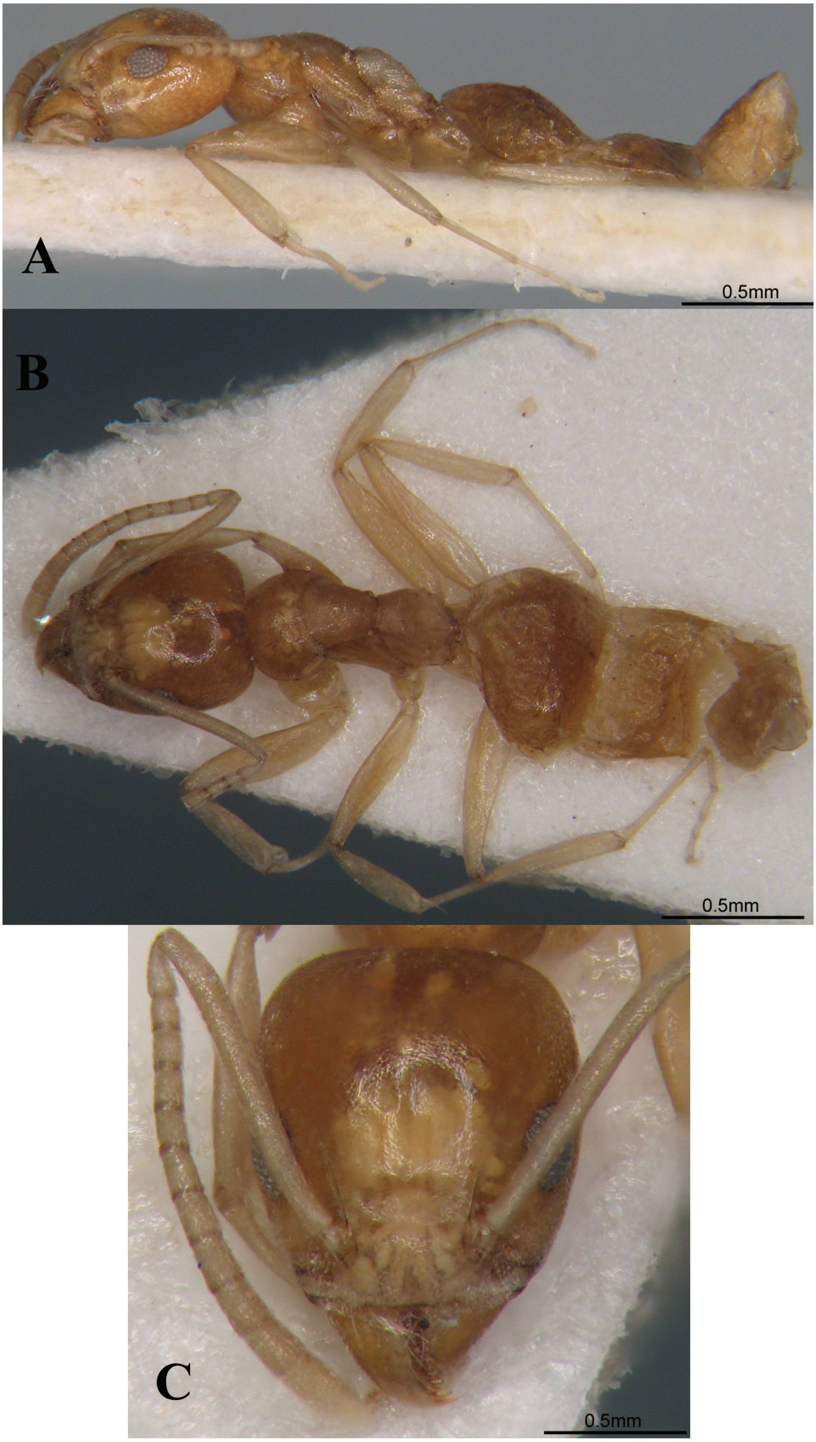


Figure 6. *Technomyrmex montaseri*, holotype worker. **A** body in profile **B** body in dorsal view **C** head in full-face view.

Ecological and biological notes. Nothing is known on ecology or biology of species.

Geographic range. This species is originally described from Oman (Sharaf et al., 2011) and has not been recorded from any other country in the Arabian Peninsula. It is likely endemic to the country.

Technomyrmex setosus Collingwood, 1985

Figure 7A, B, C

Technomyrmex setosus Collingwood, 1985:243, fig. 12. KSA: Wadi Shugub, 7.iv.1983 (C. A. Collingwood) (Holotype worker not in NHMB, presumably lost, Neotype is designated below). Afrotropical.

Neotype worker. KSA, Abha, Alswdah, 18.274167°N, 42.364444°E, 2982 m, 24.iv.2011, (M. R. Sharaf) (CASENT0906357, KSMA) **[here designated].**

Description. Worker. Measurements: TL: 2.40–3.27; HL: 0.62–0.67; HW: 0.55–0.62; SL: 0.62–0.70; PW: 0.37–0.45; WL: 0.70–0.80; Indices: CI: 85–100; SI: 105–123; OI: 19–27; EPI: 74–88; DTI: 104–125 (n=9).

Neotype worker. Similar to *T. briani* but it can be separated by the following characters: eyes located relatively anteriorly on head sides; first, second and third gastral tergites mostly with abundant scattered pairs of setae.

Material examined. KSA, Shaqiq, 17.71987°N, 42.02869°E, 8.iv.1983 (2 w) (WMLC); **Asir Province:** Gebel Balas (incorrectly as Beles), near Bishah, 19.841389°N, 41.865275°E, 1.ix.1984, (3 w, WMLC); Abha, Raydah Protectorate, 23.iv.2011, 13.221667°N, 42.404167°E, 2600 m, (M. R. Sharaf) (12 w); Abha, Raydah Protectorate, 22.ii.2014, 18.19790°N, 42.40951°E, 2443 m, (M. R. Sharaf), MRS0190, (4 w); Abha, Raydah Protectorate, 28.viii.2014, 18.1961°N, 42.40525°E, 2285 m, (Al Dhafer et al.), PT, (1 w); Abha, Raydah Protectorate, 26.viii.2014, 18.194917°N, 42.4396967°E, 1897 m, (Al Dhafer et al.), PT, (1 w); Abha, Raydah Protectorate, 21.ii.2014, 18.204417°N, 42.4124°E, 2820 m, (M. R. Sharaf), MRS0185, PT, (45 w); Alsawdah, 24.iv.2011, 18.274167°N, 42.364444°E, 2982 m, (M. R. Sharaf) (2 w); Alsawdah, 12.iv.2011, 18.274167°N, 42.364444°E, 2982 m, (M. R. Sharaf) (2 w); **Al Baha Province:** Wadi Turabah, Almandaq, 10.v.2011, 20.310278°N, 41.332222°E, 1793 m, (M. R. Sharaf), BS, (6 w); Shohba Forest, 14.v.2010, 20.234167°N, 41.623611°E, 2324 m, (M. R. Sharaf) (6 w); Wadi Elzaraeb, 20.216944°N, 41.436944°E, 2123 m, 15.v.2010, (M. R. Sharaf) (13 w); Shada Al A'la, 19.842917°N, 41.311517°E, 1666 m, 23.iv.2014, (Al Dhafer et al.), PT, (1 w), all in KSMA.

Previous records. KSA: Gebel Balas (incorrectly written as Beles), near Bishah, Asir Province, 19.841389°N, 41.865275°E, 1.iv.1984; Wadi Al-Farah, Medina, 24.0045°N, 38.005°E, 180 m, 09.viii.1983; Gebel Ghar Harith (written as Harithi), near Najran, 17.479839°N, 44.02525°E, 11.iv.1984 (all collected by W. Büttiker); Yemen: Al-Hajjarah, 15.068889°N, 43.716111°E, 14.iii.1992, (A. van Harten); Oman: no locality (Collingwood & Agosti, 1996).

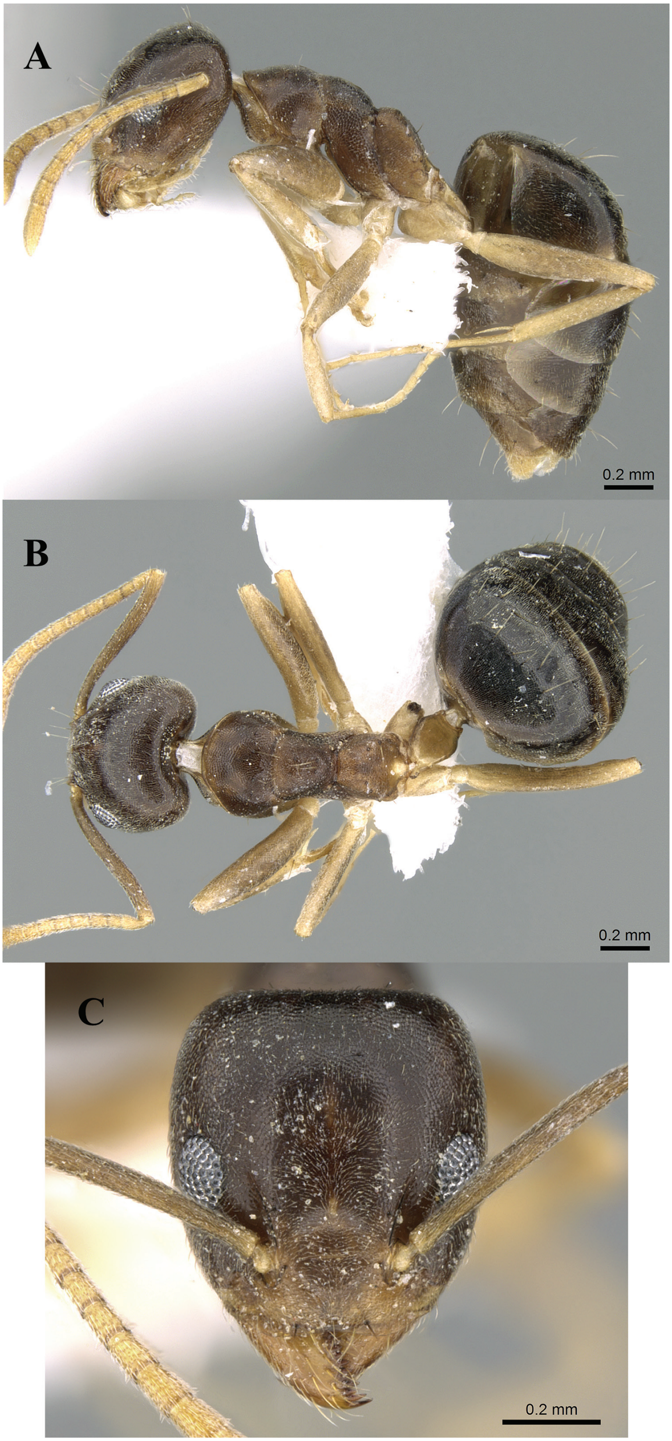


Figure 7. *Technomyrmex setosus*, neotype worker, CASENT0906357. **A** body in profile **B** body in dorsal view **C** head in full-face view, images from www.AntWeb.org.

Remarks. *Technomyrmex setosus* was described from the holotype worker and two paratype workers collected from Wadi Shuqub (incorrectly written by Collingwood (1985) as Shugub because of the pronunciation of "q" to "g" by native KSA citizens), Al Bahah Province. The holotype and the two paratypes are not in NHMB and are considered lost. Two workers from Shaqiq (KSA) and three from Jebel Balas (KSA) are deposited in the WMLC and are *T. setosus*, but are not considered to be types. These specimens are from a locality not indicated in the original publication (Collingwood 1985). A Neotype for the species is herein designated to maintain the nomenclatural stability. Bolton (2007) already indicated that no type material of *T. setosus* could be located in NHMB or WMLC. He mentioned the presence of the two workers from Shaqiq (examined above) labelled as types, but with different locality data than the type material listed in the original description. Bolton (2007) concept of *T. setosus* was based on these two specimens.

Ecological notes. Workers were collected from diverse habitats in the southwestern mountains of the KSA: Wadi Turabah (Al Bahah Province). A nest series was found under a rock next to an old *Acacia* (Fabaceae), where several workers were ascending the trunks and the twigs of these native plants, a foraging behavior mentioned by Bolton (2007). Several workers of Formicinae *Lepisiota obtusa* (Emery 1901) were found foraging in the same area. This site is in a valley that has flowing drainages during the rainy season and supports a remarkable diversity of native vegetation that flourishes after the rains.

In Shohba Forest (Al Bahah Province) this species was found foraging on a trunk of *Acacia* sp. and next to a *Juniperus procera* Hochst. exEndl. tree (Cupressaceae). In Wadi El Zaraeb (Al Bahah Province) workers of *T. setosus* were found under a rock near a *J. procera* tree in an area of scattered trees of *Olea europea* L. subsp. *africana* (Mill.) PS Green (Oleaceae) and *Dodonae aviscosa* Jacq. (Sapindaceae). In Beljorashi Forest (Al Bahah Province), this species was observed under an *Acacia* tree. In Al Sawda Mountains and in the Raydah Nature Preserve (Asir Province), workers of *T. setosus* were foraging on the ground where the soil was dry and rich in decaying organic material.

Technomyrmex setosus was also collected from Wadi Al-Farah (Medina Province) (Collingwood and Agosti 1996), a mountainous rocky region with steep hillsides. The plant cover includes some *Acacia* trees, perennial bushes, and shrubs (Abo-Khatwa et al. 1980). The species was collected from Wadi Shuqub (Collingwood 1985), a site with dense *Balanites aegyptiaca* (L.) Delile (Zygophyllaceae), perennial vegetation and *Acacia* woods (Büttiker 1981).

Geographic range. *Technomyrmex setosus* was originally described from KSA and has been recorded from Oman and Yemen (Collingwood and Agosti 1996) and is apparently an endemic species of the Arabian Peninsula.

Technomyrmex vexatus (Santschi, 1919)

Figure 8A, B, C

Tapinoma vexatum Santschi 1919:220, Syntype male, Morocco: Tanger, 1897 (Vaucher), CASENT0911580, (NHMB), (examined), Palearctic.

Tapinoma (*Tapinoptera*) *vexatum* Santschi, 1925: 348.
Combination in *Technomyrmex* by Cagniant and Espadaler 1993: 92.
Technomyrmex bruneipes: Collingwood and Agosti 1996; Fauna of Arabia 15: 361 [misidentification].

Description. Worker. Measurements: TL: 3.1–3.4; HL: 0.72–0.78; HW: 0.68–0.76; SL: 0.64–0.70; PW: 0.44–0.48; WL: 0.90–0.96; Indices: CI: 94–99; SI: 90–94; OI: 22–25; EPI: 68–76; DTI: 118–130 (n=10, from Bolton 2007).

Head. Head with nearly straight posterior margin and convex sides; anterior clypeal margin feebly concave; eyes of moderate size with 10 ommatidia in the longest row (OI: 22–25), located just in front of the midlength of head, in full-face view outer margins of eyes just fail to protrude beyond sides of head. **Mesosoma.** Mesosonotum in profile with a flat anterior section that is slopping posteriorly and steeply to a well-developed narrow metanotal groove; propodeal dorsum short making a continuous curve with propodeal declivity. **Pilosity.** Head and mesosoma entirely lacking setae, first, second, and third gastral tergites without setae, fourth tergite with two or three pairs. **Sculpture.** Body finely and faintly microreticulate. **Colour.** Uniform dark brown, tarsi and funiculi paler yellow-bown.

Material examined. Yemen, Sana'a, 15.3694°N, 44.1910°E, 2250 m, iii.1993, (Van Harten) (2 w, WMLC); Morocco, Septa, 29.v.1986, (X. Espadaler), det. B. Bolton, 2006, 1 w, CASENT0249804 (image examined).

Remarks. *Technomyrmex vexatus* was originally described from Morocco. This species seems to exist as a series of isolated populations in rather restricted and specialized habitats throughout North Africa and eastward into the Arabian Peninsula, and perhaps Iran (B. Bolton, pers. comm.). Two species of the *T. gibbosus*-group are known from the Arabian Peninsula, the above record of *T. vexatus* from Yemen and *T. montaseri* from Oman. *Technomyrmex vexatus* was recorded for the first time from Palearctic (Gibraltar) by Guillem and Bensusan (2008).

Ecological and biological notes. Nothing is known on ecology or biology of this species.

Geographic range. Morocco (Santschi 1919, Cagniant and Espadaler 1993), Gibraltar (Guillem and Bensusan 2008). This species is newly recorded from Yemen and the Arabian Peninsula.

Material of unknown male of *Technomyrmex* sa01

Figure 9A, B, C, D

Measurements. TL 3.25–3.75; HL 0.55–0.65; HW 0.50–0.67; SL 0.22–0.32; WL 1.25–1.40. Indices: SI 35–58; CI 81–112; EI 37–52 (n = 9).

Description. Head. Head distinctly broader than long; mandible triangular, basal and masticatory margins with serrate denticles; apical tooth on masticatory margin longer than subapical one; scapes when laid back from their insertions just reach posterior mar-

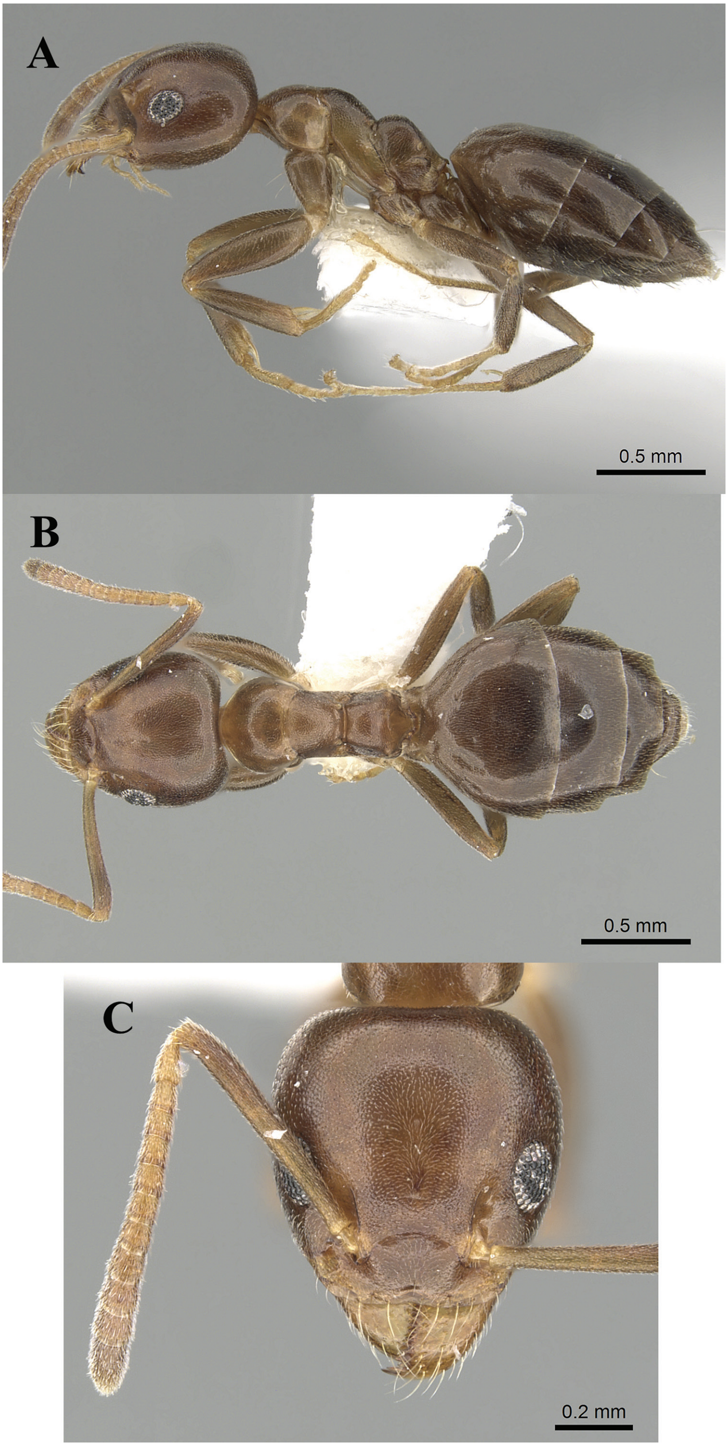


Figure 8. *Technomyrmex vexatus*, worker, CASENT0249804. **A** body in profile **B** body in dorsal view **C** head in full-face view, images from www.AntWeb.org.

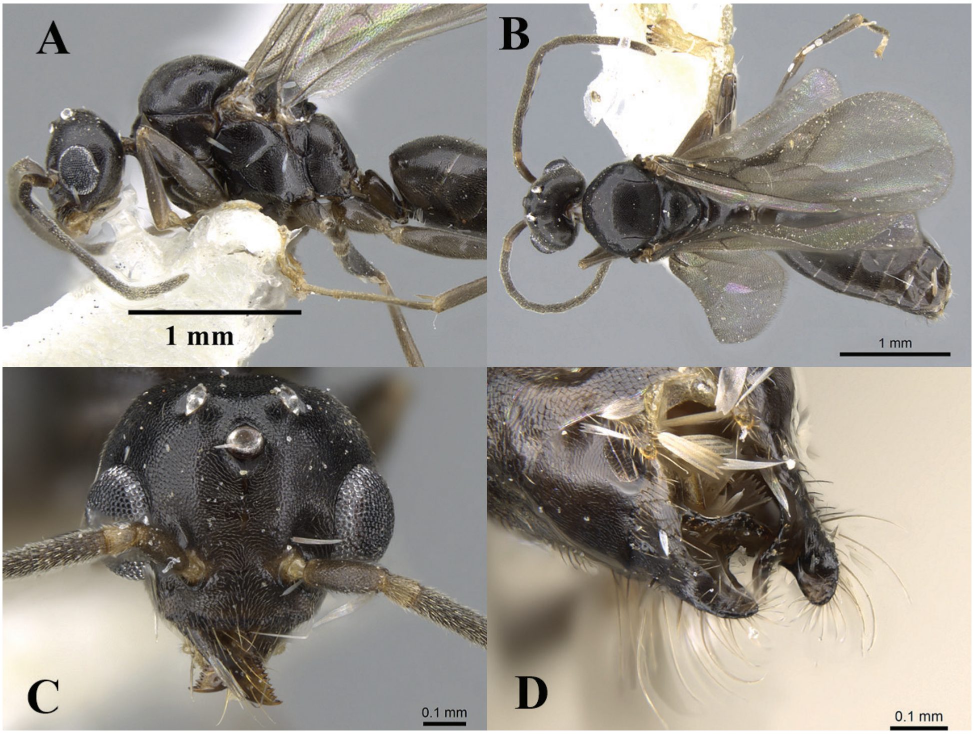


Figure 9. *Technomyrmex* sa01 male, CASENT0746638. **A** body in profile **B** body in dorsal view **C** head in full-face view **D** genitalia, images from www.AntWeb.org.

gin of eyes; scape excluding its basal condyle shorter than length of funicular segments 1+2; first and second funicular segments cylindrical and straight; first funicular segment approximately one-third length of second; second and third funicular segments approximately twice as long as broad; third and fourth funicular segments straight; inner margin of eye entire, flat; anterior clypeal margin broad, convex, without a central notch or concavity of any type with five yellow setae, approximately as long as the maximum diameter of the scape; median portion of clypeus with a raised area which has curved anterior and posterior margins; anterior tentorial pit nearer antennal socket than mandibular insertion; anterolateral hypostoma reduced to a thin sclerite; medial hypostoma entire; palp formula 6, 4; third maxillary palp segment subequal in length to segment 4; third and fourth maxillary palp segments subequal; fifth approximately 2/3 × length of sixth. **Mesosoma.** Axillae medially compressed, anterior and posterior margins not parallel; anterior axillar suture concave; declivitous and dorsal faces of propodeum convex; dorsal face shorter than the declivitous face; propodeal angle indistinct. **Petiole.** Petiolar node strongly inclined anteriorly, its anterior margin much shorter than posterior margin in lateral view, not much expanded laterally; attachment to gaster narrow. **Genitalia**. Pygostyles present; apicoventral portion of basimere without projection. **Pilosity.** Whole body covered with pale appressed pubescence; mandibles with long yellow hairs. **Sculpture.** Body more or less shining with fine superficial microreticulation. **Colour.** Dull dark brown or black-brown.

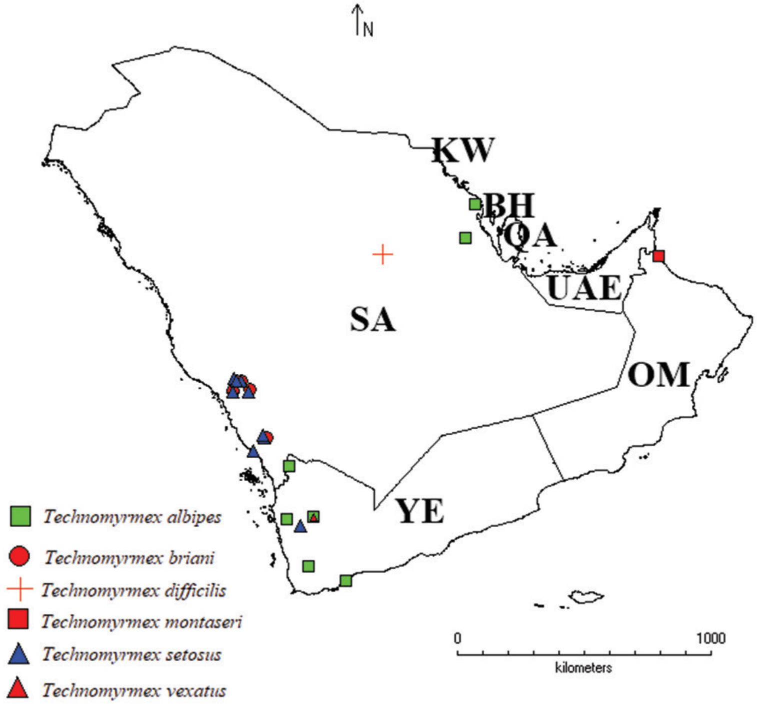


Figure 10. Distribution maps showing the known distribution ranges of *Technomyrmex* species on the Arabian Peninsula, BA (Bahrain), KW (Kuwait), OM (Oman), QA (Qatar), SA (Saudi Arabia), UAE (United Arab Emirates), and YE (Yemen).

Material examined. KSA, **Asir Province:** Abha, Raydah Protectorate, 18.201583°N, 42.408933°E, 2600 m, 20.x.2014, (Al Dhafer et al.) (1 m); Saudi Arabia, Abha, Raydah Protectorate, 18.198067°N, 42.40725°E, 2600 m, 20.x.2014, (Al Dhafer et al.) (2 m); Saudi Arabia, Abha, Raydah Protectorate, 18.193633°N, 42.390333°E, 2600 m, 20.x.2014, (Al Dhafer et al.) (3 m); Abha, Raydah Protectorate, 18.198067°N, 42.40725°E, 2387 m, 20.x.2014, (Al Dhafer et al.) (1 m); Abha, Raydah Protectorate, 18.198067°N, 42.40725°E, 2387 m, 26.iv.2014, (Al Dhafer et al.) (1 m, CASENT0746638, CASC). **Al Baha Province:** Al Baha, Shada Al Ala, 19.8627°N, 41.301483°E, 1225 m, 3.vi.2014, (Al Dhafer et al.) (1 m); Saudi Arabia, Al Baha, Shada Al Ala, 19.842917°N, 41.311517°E, 1666 m, 3.vi.2014, (Al Dhafer et al.) (1 m); Saudi Arabia, Al Baha, Shada Al Ala, 19.842917°N, 41.311517°E, 1666 m, 27. i.2015, (Al Dhafer et al.) (1 m); all previous material was collected by e light trap and is deposited in KSMA.

Remarks. Although there is no direct association between the male specimens studied here and the worker castes of *T. setosus*, it is highly likely that these male specimens are *T. setosus*. This supposition is supported by the relatively broad distribution of *T. setosus* in the southwestern mountains of the Arabian Peninsula and also with the scarcity and limited distribution of the closely related species, *T. briani*. This association may be confirmed with the use of the molecular techniques in the future.

Discussion

The diversity of the genus *Technomyrmex* in the Arabian Peninsula is noticeably lower than in other ant genera. Bolton (2007) previous noted the lower abundance and species richness of the genus relative to the total ant fauna.

In terms of species endemism, *T. briani* and *T. setosus* apparently are restricted to the Arabian Peninsula. The genus is known to exhibit endemism in the Old World tropics (Fisher and Bolton 2016) and also in the Neotropics (Fernández and Guerrero 2008). The confined distribution of the Arabian *Technomyrmex* species in the southwestern region and the limited distribution in the eastern region may be due to the geographical separation by vast areas of deserts and the existence of the preferred habitats in the former region.

It is worth mentioning that relatively few specimens of *T. briani* are available as compared to *T. setosus*. Both species apparently have similar habitat preferences and geographical occurrence, despite equal efforts of collecting. It is apparent that both species prefers inhabiting grasslands of southwestern mountains of the KSA where *Acacia* and *J. procera* trees occur, and both prefer nesting under rocks at the elevated sites on both sides of valleys away from drainages.

Acknowledgments

This work was supported by the Deanship of Scientific Research at King Saud University [RG-1438-010]. We are much indebted to Barry Bolton for useful discussions on the genus *Technomyrmex* and Boris Kondratieff (Colorado State University) for useful suggestions. We thank Francisco Hita Garcia, Roberto Keller, and Alexander Wild for valuable comments. We are grateful to Antonius van Harten for permission to study materials from Yemen. Special thanks to the following colleagues: Brian Fisher (CAS, Entomology curator) for permission to use some species on AntWeb.org, and Michele Esposito and Estella Ortega for photographing species, and Ahmed Shams Al'Ola for technical support. Mostafa Sharaf is grateful to Stephen Judd (WML, Director), shirley Judd, and Tony Hunter (WML, Entomology curator) for invaluable support during his visit to Liverpool, U.K. We thank Boris Kondratieff, James Trager, and Beth Conrey, English Professor at Colorado State University for language editing.

References

Abo-Khatwa N, Banaja A, Büttiker W, Wittmer W (1980) Fauna of Saudi Arabia, Zoological Expedition to the Northern Hedjaz region. Fauna of Saudi Arabia 2: 5–14.

Andersen AN (2000) The Ants of Northern Australia. A guide to the monsoonal fauna, CSIRO publishing, 106 pp.

Bolton B (2007) Taxonomy of the Dolichoderine ant genus *Technomyrmex* Mayr (Hymenoptera: Formicidae) based on the worker caste. Contributions of the American Entomological Institute 35(1): 1–149.

Bolton B (2017) An online catalog of the ants of the world. Available at http://antcat.org/ [accessed 10 April 2018].

Brown Jr WL (2000) Diversity of ants. In: Agosti D, Majer J, Alonso E, Schultz TR (Eds) Ants: standard methods for measuring and monitoring biodiversity. Biological diversity hand book series. Smithsonian Institution Press, Washington and London, 280 pp.

Büttiker W (1981) Fauna of Saudi Arabia, Further notes on the Zoological Survey of Saudi Arabia. Fauna of Saudi Arabia 3: 5–24.

Cagniant H, Espadaler X (1993) Liste des espèces de fourmis du Maroc. Actes des Colloques Insectes Sociaux 8: 89–93.

Collingwood CA, Agosti D (1996) Formicidae (Insecta: Hymenoptera) of Saudi Arabia (part 2). Fauna of Saudi Arabia 15: 300–385.

Collingwood CA (1985) Hymenoptera: Family Formicidae of Saudi Arabia. Fauna of Saudi Arabia 7: 230–301.

Collingwood CA, van Harten A (2001) Additions to the ant fauna of Yemen. In: Hacker H, Peks H (Eds) Esperiana. Buchreihe zur Entomologie 8: 1–942.

Collingwood CA, van Harten A (2005) Further additions to the ant fauna (Hymenoptera: Formicidae) of Yemen. Zoology in the Middle East 35: 73–78. https://doi.org/10.1080/09397140.2005.10638105

Crozier RH (1969) Cytotaxonomic studies on some Australian dolichoderine ants (Hymenoptera: Formicidae). Caryologia 21: 241–259. https://doi.org/10.1080/00087114.1968.10796302

Deyrup M (1991) *Technomyrmex albipes,* a new exotic ant in Florida. Florida Entomologist 74: 147–148. https://doi.org/10.2307/3495251

El-Hawagryi MS, Khalil MW, Sharaf MR, Fadl HH, Aldawood AS (2013) A preliminary study on the insect fauna of Al-Baha Province, Saudi Arabia, with descriptions of two new species. ZooKeys 274: 1–88. https://doi.org/10.3897/zookeys.274.4529

Emery C (1888) Über den sogenannten Kaumagen einiger Ameisen. Zeitschrift für Wissenschaftliche Zoologie 46: 378–412.

Emery C (1893) Voyage de M. E. Simon à l'île de Ceylan (janvier-février 1892). Formicides. Annales de la Société Entomologique de France 62: 239–258.

Fernández F, Guerrero RJ (2008) *Technomyrmex* (Formicidae: Dolichoderinae) in the New World: synopsis and description of a new species. Revista Colombiana de Entomologia 34: 110–115.

Fisher BL, Bolton B (2016) Ants of Africa and Madagascar, A Guide to the Genera. University of California Press, Berkeley, 503 pp.

Forel A (1891) Les Formicides. [part]. In: Grandidier A (Ed.) Histoire physique, naturelle, et politique de Madagascar. Volume XX. Histoire naturelle des Hyménoptères. Deuxième partie (28e fascicule). Hachette et Cie, Paris, 237 pp.

Forel A (1895) Les Formicides de l'Empire des Indes et de Ceylan. Part V. Journal of the Bombay Natural History Society 9: 453–472.

Forel A (1908) Fourmis de Ceylan et d'Égypte récoltées par le Prof. E. Bugnion. *Lasius carniolicus*. Fourmis de Kerguelen. Pseudandrie? *Strongylognathus testaceus*. Bulletin de la Société Vaudoise des Sciences Naturelles 44: 1–22.

Forel A (1913) Quelques fourmis des Indes, du Japon et d'Afrique. Revue Suisse de Zoologie 21: 659–673. https://doi.org/10.5962/bhl.part.37159

Guillem R, Bensusan, K (2008) *Technomyrmex vexatus* (Santschi, 1919) from Gibraltar (Hymenoptera: Formicidae) a new ant species for Europe and genus for Iberia. Myrmecological News 11: 21–23.

Karavaiev V (1926) Ameisen aus dem Indo-Australischen Gebiet. Treubia 8: 413–445.

Mayr G (1863) Formicidarum index synonymicus. Verhandlungen der Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien 13: 385–460.

Mayr G (1872) Formicidae Borneenses collectae a J. Doria et O. Beccari in territorio Sarawak annis 1865–1867. Annali del Museo Civico di Storia Naturale 2: 133–155.

Mayr G (1876) Die australischen Formiciden. Journal des Museum Godeffroy 12: 56–115.

Santschi F (1919) Fourmis du genre *Bothriomyrmex* Emery. (Systématique et moeurs.). Revue Zoologique Africaine (Brussels) 7: 201–224. https://doi.org/10.5962/bhl.part.15117

Santschi F (1925) Fourmis d'Espagne et autres especes palearctiques. Eos. Revista Espanola de Entomologia 1: 339–360.

Santschi F (1930) Description de Formicides éthiopiens nouveaux ou peu connus. V. Bulletin et Annales de la Société Entomologique de Belgique 70: 49–77.

Sharaf MR (2009) A new ant species of the *Technomyrmex albipes*-group from Saudi Arabia. (Hymenoptera: Formicidae). Fauna of Arabia 24: 211–216.

Sharaf MR, Collingwood CA, Aldawood AS (2011) *Technomyrmex montaseri* n. sp., a new ant species of the *T. gibbosus*-group from Oman (Hymenoptera: Formicidae). ZooKeys 108: 11–19. https://doi.org/10.3897/zookeys.108.930

Shattuck SO (1999) Australian ants. Their biology and identification. Monographs on Invertebrate Taxonomy 3: 1–226.

Smith F (1861) Catalogue of hymenopterous insects collected by Mr. A. R. Wallace in the islands of Ceram, Celebes, Ternate, and Gilolo. [part]. Journal and Proceedings of the Linnean Society of London. Zoology 6: 36–48.

Sulaiman SFM (1997) Impact of weed management on ant density and fruit yield in the control of pineapple wilt disease. Acta Horticulturae 425: 475–484. https://doi.org/10.17660/ActaHortic.1997.425.51

Warner JR (2003) Bait preferences and toxicity of insecticides to white-footed ants, *Technomyrmex albipes.* University of Florida, 59 pp.

Wheeler GC, Wheeler J (1951) The ant larvae of the subfamily Dolichoderinae. Proceedings of the Entomological Society of Washington 53: 169–210.

Yamane S, Leong CM, Lin CC (2018) Taiwanese species of the ant genus *Technomyrmex* (Formicidae: Dolichoderinae). Zootaxa 4410: 35–56. https://doi.org/10.11646/zootaxa.4410.1.2

Yoshimura M, Fisher BL (2011) A revision of male ants of the Malagasy region (Hymenoptera: Formicidae): key to genera of the subfamily Dolichoderinae. Zootaxa 2794: 1–34. https://doi.org/10.5281/zenodo.276993

ZooKeys 780: 61–70 (2018)
doi: 10.3897/zookeys.780.26264
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

The genera *Areopraon* Mackauer, 1959 and *Pseudopraon* Starý, 1975 (Hymenoptera, Braconidae, Aphidiinae) from China, with keys to species

Hong-Wei Tian[1], Cornelis van Achterberg[2], Xue-Xin Chen[1]

1 *State Key Laboratory of Rice Biology and Ministry of Agriculture Key Lab of Molecular Biology of Crop Pathogens and Insect Pests, Institute of Insect Sciences, Zhejiang University, Hangzhou 310058, China* **2** *Key Laboratory of Resource Biology and Biotechnology in Western China (Northwest University) and Ministry of Education, College of Life Sciences, Northwest University, 229 North Taibai Road, Xi'an, Shaanxi 710069, China*

Corresponding author: *Xue-Xin Chen* (xxchen@zju.edu.cn)

Academic editor: *J. Fernandez-Triana* | Received 29 April 2018 | Accepted 11 June 2018 | Published 8 August 2018

http://zoobank.org/872D1F56-6F8C-4A36-AE3D-36FB3DAD1981

Citation: Tian H-W, van Achterberg C, Chen X-X (2018) The genera *Areopraon* Mackauer, 1959 and *Pseudopraon* Starý, 1975 (Hymenoptera, Braconidae, Aphidiinae) from China, with keys to species. ZooKeys 780: 61–70. https://doi.org/10.3897/zookeys.780.26264

Abstract

Two genera, *Areopraon* Mackauer, 1959 and *Pseudopraon* Starý, 1975, are newly recorded from China in this paper. Two new species, namely *A. chui* Tian & Chen, **sp. n.** and *P. hei* Tian & Chen, **sp. n.**, are described and illustrated. Keys to the known species of these two genera are provided.

Keywords

parasitoid wasp, Aphidiinae, *Areopraon*, China, key, new species, Oriental, Praini, *Pseudopraon*, Yunnan, Zhejiang

Introduction

The genus *Areopraon* was erected by Mackauer in 1959 with eight known species at present (Davidian and Gavrilyuk 2011). The species of *Areopraon* have two types of pupation behavior simultaneously: internal (within the host aphid) and external (under the host aphid) (Starý 1976; Tobias and Kyriac 1971). They usually attack aphids of the families Aphididae (mainly the subfamilies Pterocommatinae, Pemphiginae, and Chaitophorinae) and Eriosomatidae that usually produce a waxy cover and galls on their host plants (Mackauer 1959; Starý 1976).

The genus *Pseudopraon* was erected by Starý in 1975 based on specimens reared from *Mindarus abietinus* Koch, 1857 (Homoptera: Mindaridae) on *Abies alba* in the Czech Republic (Starý 1975), and used to be treated as a monotypic genus (Tobias and Kyriac 1971; Starý 1975; Tomanović et al. 2006; Tomanović et al. 2009). The type species, *P. mindariphagum* Starý, 1975, also has two types of pupation behavior simultaneously (Starý 1975).

Pseudopraon is a sister group to *Areopraon* (Tomanović et al. 2006), and can be clearly separated by having an entirely smooth propodeum (usually having areola or carina in *Areopraon*), and the absence of vein 1-SR+M of fore wing (at least partly present in *Areopraon*).

Both *Areopraon* and *Pseudopraon* are here newly recorded from China, and two new species, *A. chui* Tian & Chen, sp. n. and *P. hei* Tian & Chen, sp. n. are described and illustrated. Identification keys to the known species of these two genera are also provided.

Materials and methods

Specimens studied are deposited in the Parasitic Hymenoptera Collection of Zhejiang University, Hangzhou, China (**ZJUH**). Descriptions and measurements were made under a stereomicroscope (Zeiss Stemi 2000). All photographs were made by a digital camera (KEYENCE VHX-2000C) with a KEYENCE VH-Z20R lens and processed with Adobe Photoshop CS5.0, mostly to adjust the size and background. Terminology follows van Achterberg (1988), veins follow the modified Comstock-Needham system (van Achterberg, 1979).

Abbreviations used in this paper are as follows:

POL	distance between hind ocelli
Od	maximum diameter of hind ocellus
T1	first tergite of the metasoma
F1	first flagellomere of the antenna (or third antennal segment)
F2	second flagellomere of antenna

Taxonomy

Areopraon Mackauer, 1959

Areopraon Mackauer, 1959: 810. Type-species: *Praon lepelleyi* Waterston, 1926.
Mesopraon Starý, 1981: 175. (Syn. by Tomanović, Ž.). Type-species: *Mesopraon helleni* Starý, 1981.

Diagnosis. Head transverse, with occipital carina. Maxillary palpi with four segments, labial palpi with three segments. Female antenna filiform, with 12–22 segments. Notauli deep and distinct throughout. Propodeum usually with areola or with carinae. Fore wing with pterostigma longer than vein 1-R1 (= metacarp), radial vein (= r+3-SR) not reach the wing apex, vein 1-SR+M usually faintly indicated, and vein 2-M always distinct. Hind wing with cross vein cu-a absent. Apex of ovipositor sheaths usually densely pubescent. Larva pupates either inside or outside of mummified aphid.

Key to world species of the genus *Areopraon* Mackauer, 1959

1 Fore wings without vein m-cu (= recurrent vein), or faintly indicated; carinae or areola of propodeum not always present **2**

– Vein m-cu of fore wing distinctly present (Figure 2A); propodeum with distinct carinae or areola (Figure 2J) **4**

2 Propodeum with distinct carinae posteriorly; mesoscutum almost hairless; antenna of female with 12 segments .... ***A. thailandicum* Starý, 2008**

– Propodeum without any carinae; mesoscutum densely pubescent; antenna with more than 12 segments **3**

3 Antenna of ♂ with 19–20 segments; pterostigma less slender, no more than 3.0× as long as wide .... ***A. antiquum* Mackauer, 1967**

– Antenna of ♀ with 15 segments; pterostigma slender, 5.0× as long as wide..... .... ***A. rasnitsyni* Davidian, 2011**

4 Propodeum with complete areola (Figure 2J) **5**

– Propodeum without complete areola, only with distinct carinae posteriorly **8**

5 T1 slender, at least 1.6× as long as wide at spiracle level; antenna of ♀ with 17–18 segments **6**

– T1 less slender or nearly subquadrate; Antenna of ♀ with 19–20 segments.... 7

6 Mesoscutum glabrous, with medial and lateral lobes nearly glabrous, with any setae (Fig. 2C, D); T1 2.3× as long as wide at spiracle level (Figure 2F); Pterostigma triangular, 3.4× as long as wide (Figure 2A); Antenna of ♀ with 18 segments (Figure 2I) .... ***A. chui* Tian & Chen, sp. n.**

– Mesoscutum densely pubescent, only with small hairless area; T1 1.6× as long as wide at spiracle level; Pterostigma triangular, 4.0× as long as wide; Antenna of ♀ with 17 segments .... ***A. helleni* (Starý, 1981)**

7 Antenna of ♀ with 19–20 segments; T1 1.2–1.5× as long as wide at spiracle level .... ***A. silvestre* (Starý, 1971)**

– Antenna of ♀ with 22 segments; T1 subquadrate, nearly as long as wide at spiracle level .... ***A. pilosum* Mackauer, 1959**

8 Antenna of ♀ with 13–14 segments; T1 subquadrate, nearly as long as wide at spiracle level .... ***A. lepelleyi* (Waterston, 1926)**

– Antenna of ♀ with 16–17 segments; T1 1.25–1.33× as long as wide at spiracle level .... ***A. chaitophori* Tomanović & Petrović, 2009**

Areopraon chui **Tian & Chen, sp. n.**

http://zoobank.org/EF57B900-B6C6-4D41-A6B1-F78BA9055A46
Figures 1, 2

Description. Female. Body length 2.6 mm, fore wing length 2.2 mm.

Head. Head transverse in dorsal view, slightly wider than mesoscutum, smooth and shiny, with sparse long setae (Fig. 2H). Eyes medium-sized (Figure 2G), oval, sparsely setose. Temple in dorsal view 1.4 times as long as eye. Malar space equal to 0.15× longitudinal diameter of eye. POL 1.0× Od. Width of face 1.4× its height and 0.4× width of head. Face with several setae. Clypeus oval, raised with several long setae, tentoriocular line equal to 0.3 of inter-tentorial line. Antenna filiform, with 18 segments. F1 approx. 1.3 times longer than F2. F1 4.3× as long as wide, F2 2.5× as long as wide (Figure 2I).

Mesosoma. Mesonotum with central and lateral lobes glabrous, covered with several long setae. Notauli deep and distinct throughout (Figure 2D). Propodeum with complete areola (Figure 2J).

Wings. Apical margin of fore wing with long setae, which are longer than setae on wing membrane. Pterostigma triangular, 3.4× as long as wide. Distal abscissa of 1-R1 (= metacarp) 0.7× as long as pterostigma. Radial vein (= r+3-SR) 1.5× as long as 1-R1, do not reach the wing apex. Basal half of SR+M vein distinctly pigmented (Figure 2A).

Metasoma. T1 with medial and lateral carinae, 2.3× as long as wide at spiracle level, with two long setae each side close to spiracle (Figure 2F). Ovipositor sheaths glabrous, except the apex (Figure 2K).

Colour. Head dark brown, face somewhat paler, clypeus and mandibles yellowish to light brown. Maxillary and labial palpi white to yellowish. Antennal scape, pedicel and F1 yellowish to brown. The ventral view of mesosoma and propodeum brown. Wings hyaline with brown venation. Legs yellowish to light brown, apices of tarsi dark. Remainder of antenna and mesosoma dark brown. Metasoma and ovipositor sheath brown.

Male. Unknown.

Host. Unknown.

Material examined. Holotype: ♀, S China, Zhejiang, Mt. Qingliang, 16.V.2012, Tang Pu, No.201205480.

Distribution. China (Zhejiang).

Taxonomic remarks. This species is similar to *Areopraon helleni* Starý, 1981, by having T1 very long, but can be separated by the differences listed in the above key. It is also similar to *A. thailandicum* Starý, 2008, by having the mesoscutum nearly hairless, but can be distinguished by having the vein m-cu of fore wing distinctly present (the latter completely absent) and the antenna 18-segmented (the latter 12-segmented).

Etymology. The species is named in honour of Prof. Chu Joo-tso (ZJUH), the well-known Chinese hymenopterist.

Figure 1. *Areopraon chui* Tian & Chen, sp. n. Habitus, lateral aspect. Scale bar: 0.2 mm.

Pseudopraon Starý, 1975

Pseudopraon Starý, 1975: 249. Type species: *Pseudopraon mindariphagum* Starý, 1975.

Diagnosis. Head transverse. Eyes small. Maxillary palpi 4-segmented, labial palpi 2-segmented. Antenna filiform, with the number of segments different in both sexes. Mesoscutum with the notauli completely developed. Propodeum smooth. Fore wing with vein 1-R1 (= metacarp) intermediate in length; vein r+3-SR (= radial vein) partially distinct, feebly indicated up to the wing apex; vein 1-SR+M absent; and vein m-cu+2-M feebly pigmented but distinctly present. Hind wing with basal cell complete. Metasoma lanceolate in the female, robust at apex in the male. T1 quadrate. Ovipositor lanceolate at the apex. Ovipositor sheaths narrowed to the apex, slightly arcuate, shortly pubescent.

Figure 2. *Areopraon chui* Tian & Chen, sp. n. **A** fore wing **B** hind wing **C** mesosoma, lateral aspect **D** mesoscutum, dorsal aspect **E** metasoma, lateral aspect **F** T1, dorsal aspect **G** head, anterior aspect **H** head, dorsal view **I** antenna **J** propodeum, dorsal aspect **K** ovipositor sheaths, dorsal aspect.

Key to world species of the genus *Pseudopraon* Starý, 1975

1 Ovipositor sheaths densely pubescent; Vein 1-R1 (= metacarp) half the length of pterostigma; T1 subquadrate, slightly longer than wide at spiracle level (10:9); antenna of female with 12–13 segments .... ***P. mindariphagum* Starý, 1975**

– Ovipositor sheaths less pubescent (Figure 3J); Vein 1-R1 0.7× the length of pterostigma (Figure 3G); T1 1.2–1.3× as long as wide at spiracle level (Figure 3E); antenna of female with 18 segments (Figure 3H) .... ***P. hei* Tian & Chen, sp. n.**

Pseudopraon hei Tian & Chen, sp. n.

http://zoobank.org/9715BD3E-C3AA-445A-B478-0A1B36CAEBEF
Figure 3

Description. Female. Body length 2.0 mm, fore wing length 1.8 mm.

Head. Head transverse in dorsal view, slightly wider than mesoscutum, smooth and shiny, with sparsely long setae (Figure 3B). Eyes medium-sized, oval, sparsely setose (Figure 3A). Temple in dorsal view 0.85 times as long as eye. Malar space equal to 0.2× longitudinal diameter of eye. POL 1.4× Od. Width of face 1.25× its height and 0.4× width of head. Face with dense setae. Clypeus oval, raised with several long setae, tentoriocular line equal to 0.25 of intertentorial line. Maxillary palp 4-segmented, labial palp 2-segmented (Figure 3A). Antenna filiform, with 18 segments. F1 approx. 1.2 times longer than F2. F1 4.0× as long as wide, F2 3.1× as long as wide (Figure 3H).

Mesosoma. Mesonotum with central and lateral lobes densely pubescent. Notauli deep and distinct throughout (Figure 3C). Propodeum glabrous, with dense long setae (Figure 3D).

Wings. Fore wing: apical margin with long setae, which are longer than setae on wing membrane. Pterostigma triangular, 3.4× as long as wide. Distal abscissa of 1-R1 (= metacarp) 0.7× as long as the length of pterostigma. Vein r+3-SR (= radial vein) slightly longer than the width of pterostigma, shorter than 1-R1 (5:7), do not reach the wing apex. 1-SR+M totally absent. Vein m-cu+2-M feebly pigmented, but distinctly present (Figure 3G). Hind wing with a complete cell, apical margin with long setae, which are longer than setae on wing membrane.

Metasoma. T1 nearly smooth, 1.2× longer than width at spiracle level, with long setae close to lateral corners. Ovipositor sheath with some long setae and its apex obtuse (Figure 3J).

Colour. Head dark brown, face somewhat paler, clypeus and mandibles yellowish to light brown. Maxillary and labial palpi white to yellowish. Antennal scape, pedicel and F1 yellowish. Remainder of antenna and mesoscutum dark brown. Wings hyaline with brown venation. Legs yellowish to light brown, apices of tarsi dark. Metasoma and ovipositor sheath dark brown to brown.

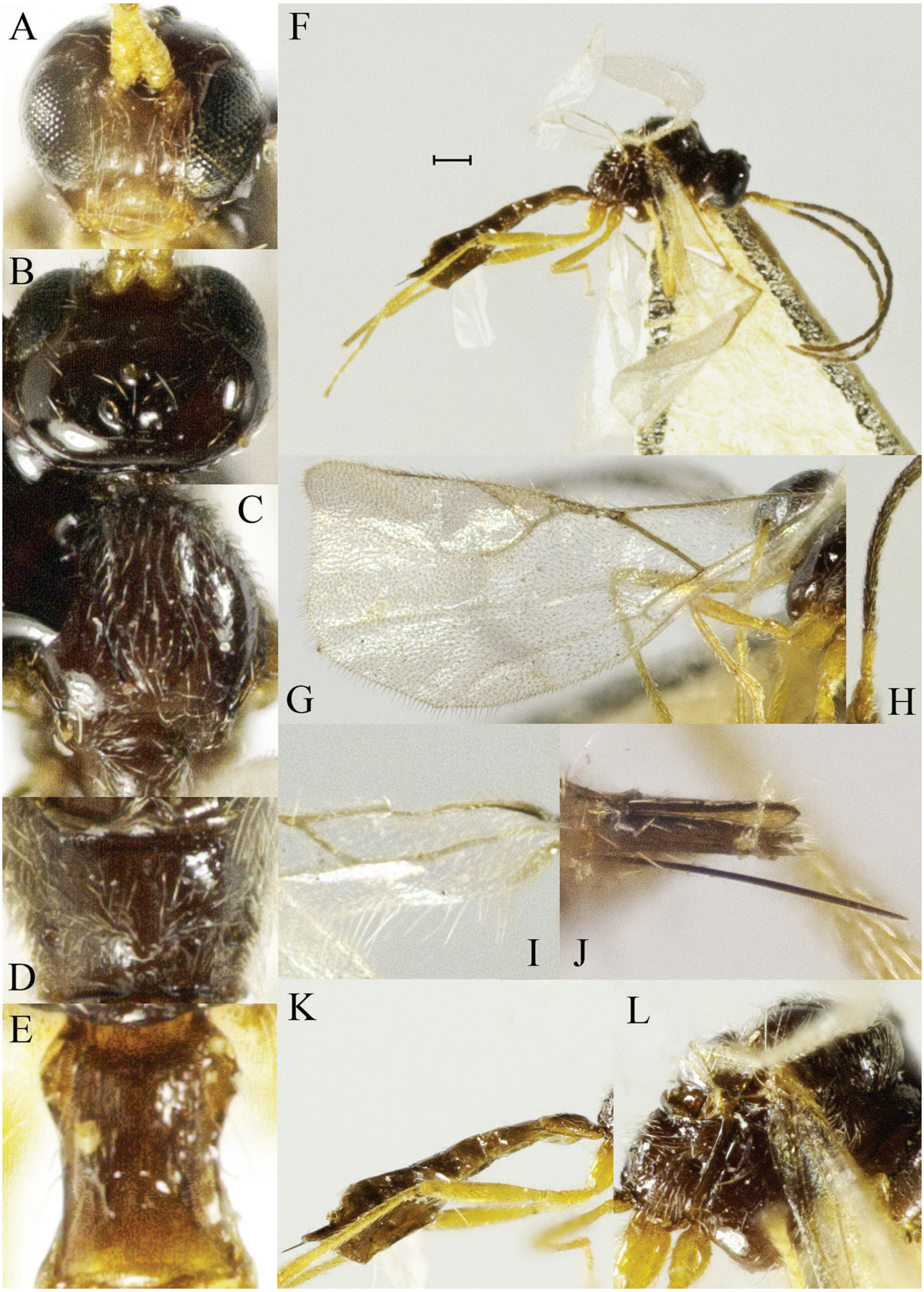


Figure 3. *Pseudopraon hei* Tian & Chen, sp. n. **A** head, anterior aspect **B** head, dorsal aspect **C** mesonotum, dorsal aspect **D** propodeum, dorsal aspect **E** T1, dorsal aspect **F** habitus, lateral aspect **G** fore wing **H** antennae **I** hind wing **J** ovipositor & ovipositor sheath, lateral aspect **K** metasoma, lateral aspect **L** mesosoma, lateral aspect. Scale bars: 0.2 mm.

Male. Unknown.

Host. Unknown.

Material examined. Holotype: ♀, S China, Yunnan, Kunming, 30.III.1981, He Jun-Hua, No.811140.

Distribution. China (Yunnan).

Taxonomic remarks. This species is the second known species of this genus and can be easily differentiated from the type species, *P. mindariphagum* Starý, 1975 by having the flagellomere of antenna with more segments and the apex of ovipositor sheath sparsely setose (versus densely pubescent).

Etymology. The new species is named in honour of Prof. Jun-Hua He (ZJUH), who also collected the holotype, for his valuable contribution to the taxonomy of parasitoid wasps in China.

Acknowledgements

We are grateful to Dr. D.S. Yu (Ottawa, Canada) for his kind help during the research. Funding for this study was provided by the National Natural Science Foundation of China (31702035), the State Key Program of National Natural Science Foundation of China (31230068) and the National Key Research and Development Plan (2017YFD0201000).

References

Davidian EM (2007) Aphidiidae. In: Lelej AS (Ed.) Key to the insects of Russian Far East. Vol.4. Neuropteroidea, Mecoptera, Hymenoptera. Pt.5. Dal'nauka, Vladivostok, 192–254. [in Russian]

Davidian EM, Gavrilyuk AV (2011) A new species of the genus *Areopraon* Mackauer, 1959 (Hymenoptera: Aphidiidae) from Western Siberia. Russian Entomological Journal 20(3): 247–249.

Kambhampati S, Voelkl W, Mackauer M (2000) Phylogenetic relationships among genera of Aphidiinae (Hymenoptera: Braconidae) based on DNA sequence of the mitochondrial 16S rRNA gene. Systematic Entomology 25: 437–445. https://doi.org/10.1046/j.1365-3113.2000.00129.x

Mackauer M (1959) Die europäischen Arten der Gattungen *Praon* und *Areopraon* (Hymenoptera: Braconidae: Aphidiinae). Beitraege zur Entomologie 9: 810–865.

Mackauer M (1967) A new genus and several new species of aphid parasites (Hymenoptera: Aphidiidae). Entomophaga 12: 139–147. https://doi.org/10.1007/BF02370610

Smith P, Kambhampati S, Völkl W, Mackauer M (1999) A phylogeny of aphid parasitoids (Hymenoptera: Braconidae: Aphidiinae) inferred from mitochondrial NADH 1 dehydrogenase gene sequence. Molecular Phylogenetics and Evolution 11: 236–245. https://doi.org/10.1006/mpev.1998.0575

Starý P (1975) *Pseudopraon mindariphagum* gen. n., sp. n. (Hymenoptera: Aphidiidae) description and life history of a parasite of *Mindarus abietinus* (Homoptera: Mindaridae) in Central Europe. Acta Entomolica Bohemoslovaca 72: 249–258.

Starý P (1976) Biology of *Areopraon lepelleyi* Waterston, a parasite of some Eriosomatid aphids (Hymenoptera: Aphidiidae). Acta Entomologica Bohemoslovaca 73: 312–317.

Starý P, Sharkey M, Hutacharern C (2008) Aphid parasitoid sampled by Malaise traps in the national parks of Thailand (Hymenoptera, Braconidae, Aphidiinae). Thai Journal of Agricultural Science 41(1–2): 37–43.

Takada H (1968) Aphidiidae of Japan (Hymenoptera). Insecta Matsumurana 30(2): 67–124.

Tobias VI, Kyriac IG (1971) *Areopraon pilosum* Mackauer, 1959, and problems concerning phylogeny and evolution of the family Aphidiidae (Hymenoptera). Entomologicheskoe Obozrenie 5: 11–16.

Tomanović Ž, Petrović A, Kavallieratos NG, Starý P, Toševski I, Bogdanović AM (2009) *Areopraon chaitophori* sp. n. (Hymenoptera: Braconidae: Aphidiinae) associated with *Chaitophorus leucomelas* Koch on poplars, with a key for European *Areopraon* Mackauer species. Annals of the Entomological Society of America 45(2): 187–192. https://doi.org/10.1080/00379271.2009.10697601

Tomanović Ž, Kavallieratos NG, Starý P, Stanisavljević LŽ, Petrović-Obradović O, Tomanović S, Milutinović M (2006) Phylogenetic relationships among Praini (Hymenoptera: Braconidae: Aphidiinae) aphid parasitoids, with redescription of two species. Insect Systematic & Evolution 37(2): 213–226. https://doi.org/10.1163/187631206788831128

van Achterberg C (1988) Revision of the subfamily Blacinae Foerster (Hymenoptera, Braconidae). Zoologische Verhandelingen Leiden 249: 1–324.

van Achterberg C (1997) Subfamily Aphidiinae. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of The New World Genera of the Family Braconidae (Hymenoptera), Allen Press, Lawrence, 117–125.

Yu DS, van Achterberg C, Horstmann K (2017) Taxapad 2017, Ichneumonoidea 2015. Nepean, Ontario. http://www.taxapad.com

ZooKeys 780: 71–88 (2018)
doi: 10.3897/zookeys.780.23280
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

Description of immature stages and biological notes of *Cassidispa relicta* Medvedev, 1957, a newly recorded species from China (Coleoptera, Chrysomelidae, Cassidinae, Hispini)

Chengqing Liao[1], Zhilin Zhang[2], Jiasheng Xu[1], Charles L. Staines[3], Xiaohua Dai[1,4]

1 *Leafminer Group, School of Life and Environmental Sciences, Gannan Normal University, Ganzhou, Jiangxi 341000, China* **2** *Ulanqab Municipal Forestry Pest Control and Quarantine Station, Ulanqab, Inner Mongolia 012000, China* **3** *Department of Entomology, National Museum of Natural History, Smithsonian Institution, P. O. Box 37012, Washington, DC 20013-7012, USA* **4** *National Navel-Orange Engineering Research Center, Ganzhou, Jiangxi 341000, China*

Corresponding author: *Xiaohua Dai* (ecoinformatics@gmail.com; leafminer@vip.qq.com)

Academic editor: *A. Eben* | Received 27 December 2017 | Accepted 21 June 2018 | Published 8 August 2018

http://zoobank.org/E14728C9-70A5-45CD-945D-520E1AEEEEF9

Citation: Liao C, Zhang Z, Xu J, Staines CL, Dai X (2018) Description of immature stages and biological notes of *Cassidispa relicta* Medvedev, 1957, a newly recorded species from China (Coleoptera, Chrysomelidae, Cassidinae, Hispini). ZooKeys 780: 71–88. https://doi.org/10.3897/zookeys.780.23280

Abstract

The first instar and mature larva and pupa of *Cassidispa relicta* Medvedev, 1957, a newly recorded species from China, are described and figured. The chaetotaxy of the head, mouthparts, legs, and dorsal and ventral surfaces of the body is described. This is the first detailed description of immatures in the genus *Cassidispa*. Diagnostic characters of this species are compared with other described immatures of some Hispini genera. Biological notes on *C. relicta*, such as host plants, feeding patterns of adults, structure of larval mines and life history, are also presented.

Keywords

Cassidinae, *Cassidispa*, chaetotaxy, Hispini, immature stages, leaf-mining insects, morphology

Introduction

Cassidispa Gestro, 1899 is a leaf beetle genus belonging to the tribe Hispini Gyllenhal, 1813 (Chrysomelidae: Cassidinae), with eight species occurring in China, Russia, Angola, Democratic Republic of Congo and Zimbabwe (Staines 2015). Four species are previously recorded from China: *C. bipuncticollis* Chen, 1941, *C. femoralis* Chen & Yu, 1976, *C. maderi* Uhmann, 1938 and *C. mirabilis* Gestro, 1899 (Chen et al. 1986; T'an 1993; Hua 2002; Staines 2015). Adults of the genus *Cassidispa* can be distinguished from all other genera of Hispini by the anterior margin of the pronotum without spines, by the pronotum and elytra with broadly expanded margins, and by the antennae having nine antennomeres (Chen et al. 1986). The main diagnostic characters between *Cassidispa* and the similar genus *Platypria* Guérin-Méneville, 1840 are the lateral margins of pronotum expanded from base to anterior angle with irregular translucent patches, the continuous expanded margins of the elytra, the elytra with very low and obtuse tubercles, never with spines, and the lateral margins of elytra with numerous small spines not with long ones (Chen et al. 1986).

There is little published biological information on *Cassidispa* species. Hua (2002) listed the host of *C. bipuncticollis* as *Betula* spp. (Betulaceae) from China. Recently, we discovered that the larvae of *C. relicta* mine in the leaves of *Betula platyphylla* Suk. (Betulaceae) and *Ulmus pumila* Linn. (Ulmaceae) in Inner Mongolia, China. The species reached outbreak levels in 2016–2017 and became a potential pest of the dominant trees in the area. As Dr. Lukáš Sekerka pointed out, the species is *Cassidispa relicta* Medvedev, 1957 not *C. mirabilis*. Both species are superficially similar by predominantly black coloration but they are distinct: *C. relicta* has generally strongly shiny dorsum (but not as shiny in *C. mirabilis*); *C. relicta* has shorter and thicker antennae, explanate margin of pronotum largely black (but yellow in *C. mirabilis*); *C. relicta* has anterior spots on explanate margin of elytra almost reaching to humeri (but widely separated from humeri in *C. mirabilis*); elytra of *C. relicta* is very distinctly constricted in 3/4 length (but weakly in *C. mirabilis*) (Lukáš Sekerka, Personal Communications). *C. relicta* is previously reported in Russia (Medvedev 1957; Staines 2015). Therefore, it is a newly recorded species from China and China hosts all five Asian *Cassidispa* species now.

In this publication, we describe the larvae and pupa of *C. relicta* and provide the first detailed report on immature morphology and biological information for the genus *Cassidispa*.

Materials and methods

All immatures and adults were observed and collected at Shanggaotai Forest Farm (Zhuozi County, Inner Mongolia) from March 2016 to October 2017. Immatures and adults of *C. relicta* were collected on wild plants and some of them were preserved in anhydrous ethanol. Some adults were pinned in the laboratory (Figs 1–3) and determined using the keys in Chen et al. (1986). Four first-instar larvae, three mature larvae

Figures 1–3. *Cassidispa relicta*. **1** Dorsal view **2** Ventral view **3** Lateral view.

and three pupae were examined morphologically. For microscopic study, the heads of the larvae were separated from the rest of the body, boiled in 10% NaOH solution and cleaned in water before dissecting the mouthparts.

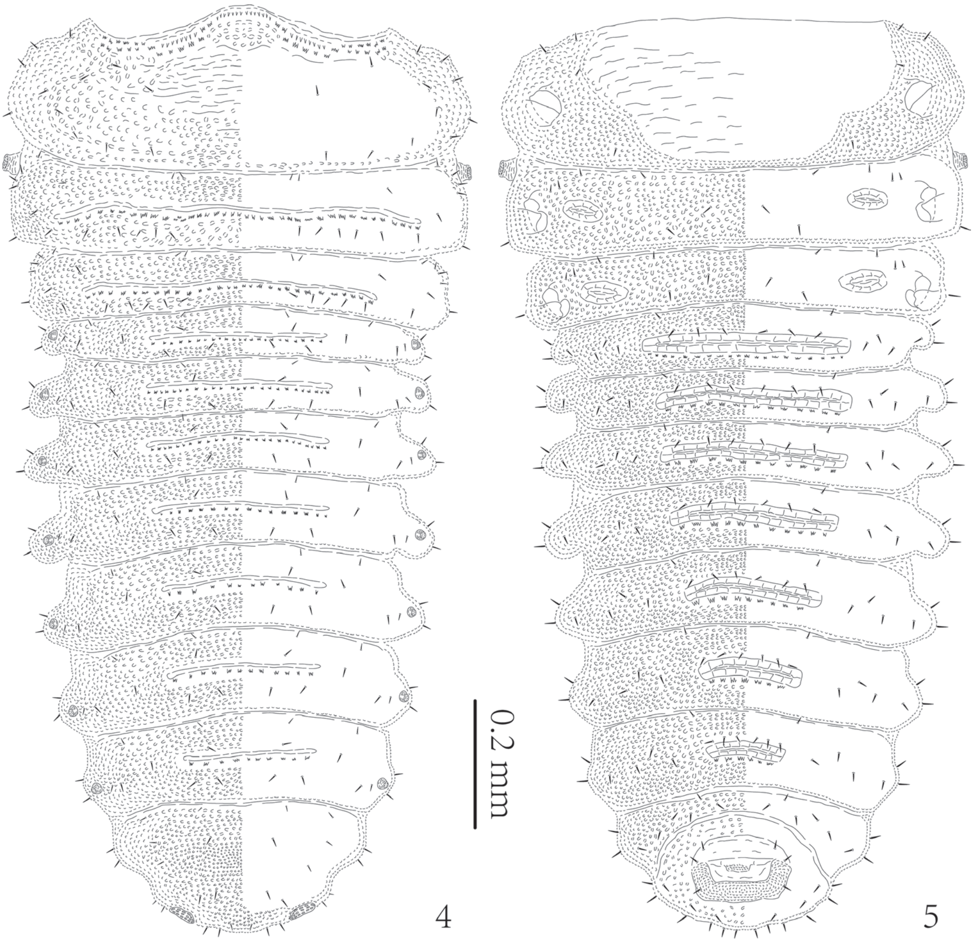
The photos of adults were taken using a Cannon EOS 7D camera with macro lenses; the dissection of heads and mouthparts was made with a Motic SMZ-140 and Olympus SZX2-ILLT stereomicroscope; figures and examination were performed using an Optika B-292 microscope and Cannon EOS 70D camera. Our descriptions of immature stages follow Świętojańska et al. (2006). The terminology of the chaetotaxy of the head follows Borowiec and Świętojańska (2003). All studied material (first-instar larvae, mature larvae, and pupae) and adults were deposited at the Leafminer Group, School of Life and Environmental Sciences, Gannan Normal University (Ganzhou, China).

Results

Cassidispa relicta Medvedev, 1957

Larva (Figs 4–17). Length of mature larva 6.1–6.2 mm without head, width 1.6–1.7 mm across pronotum. Length of first instar larva 1.4–1.8 mm without head, width of body 0.7–0.8 mm across pronotum.

Body distinctly flattened dorso-ventrally. Pronotum of first instar larvae slightly wider than abdominal segments; mature larvae widest across abdominal segments



Figures 4–5. *Cassidispa relicta*, first instar larva. **4** Dorsal view **5** Ventral view.

IV–V (Figs 6–7, 16–17). Body color of alcohol-preserved larvae yellowish-white with two irregular brown patches on pronotum (paler and without dark markings in first instar larvae), black anterior margin of abdominal segment IX, dark brown spiracles, yellowish-brown triangular patch on prosternum, brown head and legs. Abdomen of live larvae dark brown or black (Figs 31–32).

Body with eight pairs of lateral scoli on abdominal segments (Figs 6–7, 16–17). Lateral scoli short and round, approximately of same length; scoli of segments VI–VII with two small simple lateral branches (first instar larvae without lateral branches as in Figs 4–5). All lateral scoli with two setae apically and one seta ventrally.

Granulation of body distinct in all examined specimens including both first instar and mature larvae. Each tergite and sternite (except for sternite VIII) with minute setae on anterior margin; tergites and sternites covered with short pointed setae. Tergites of meso- and metathorax, abdominal segments I–VI and sternites I–VII of

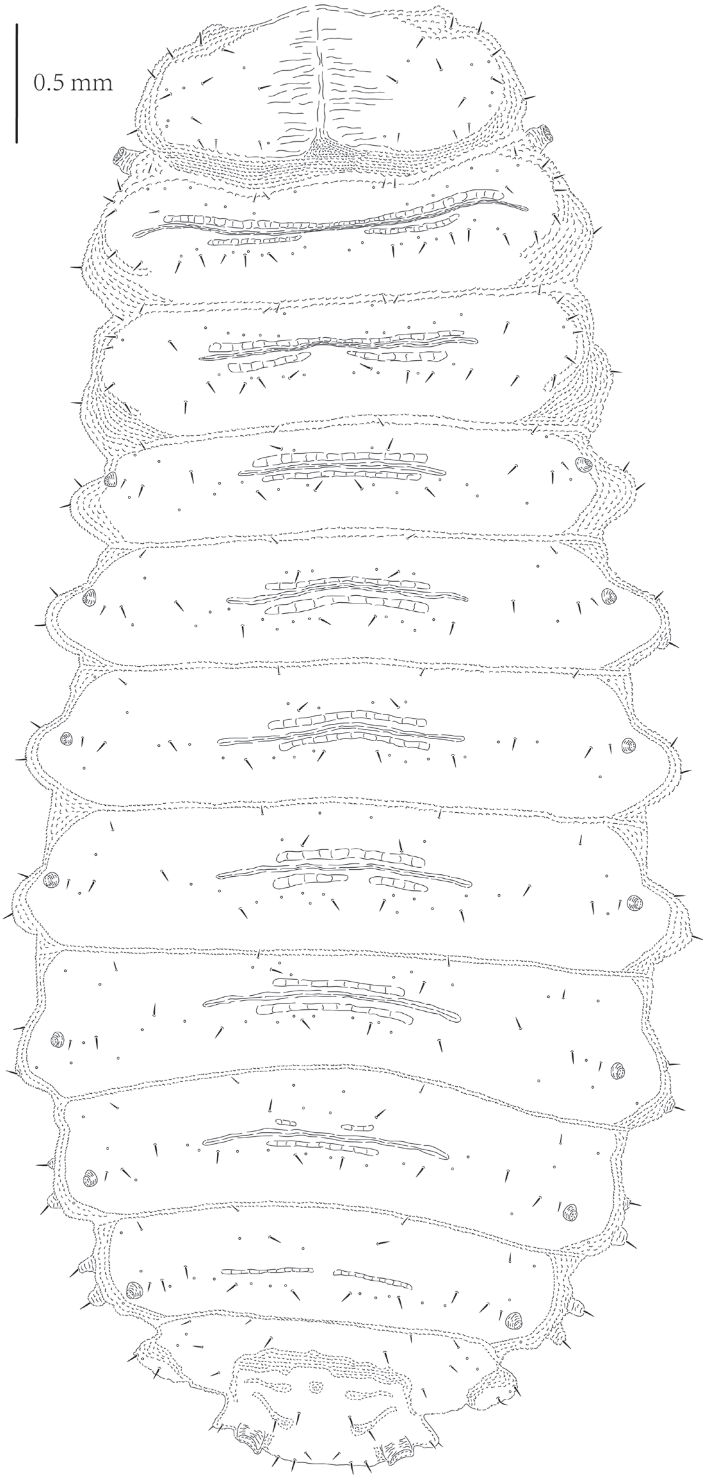


Figure 6. *Cassidispa relicta*, last instar larva, dorsal view.

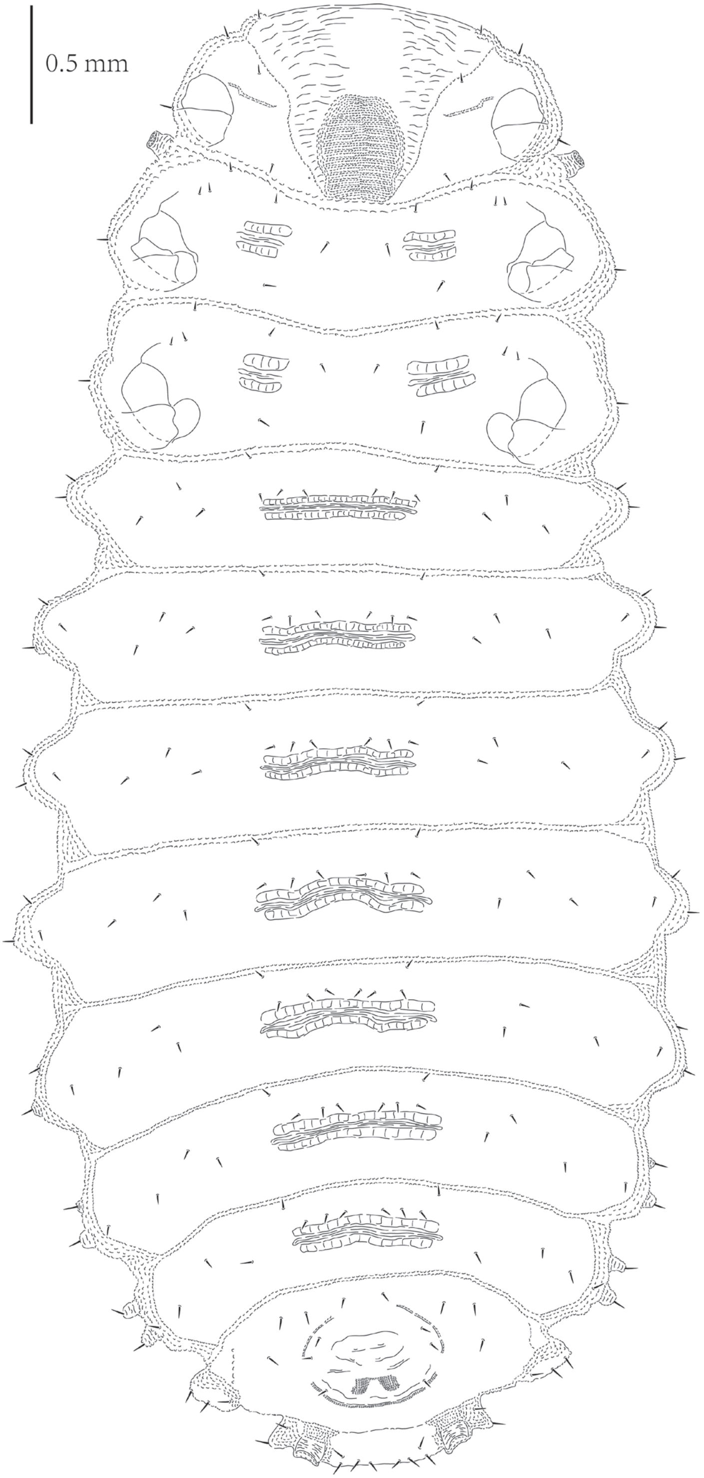


Figure 7. *Cassidispa relicta*, last instar larva, ventral view.

abdomen with transverse grooves (Figs 4–7). Sternites of meso- and metathorax with two short transverse grooves medially, very similar in shape to other tergites and sternites. Posterior margin of each transverse groove and anterior margin of pronotum with distinct asperites.

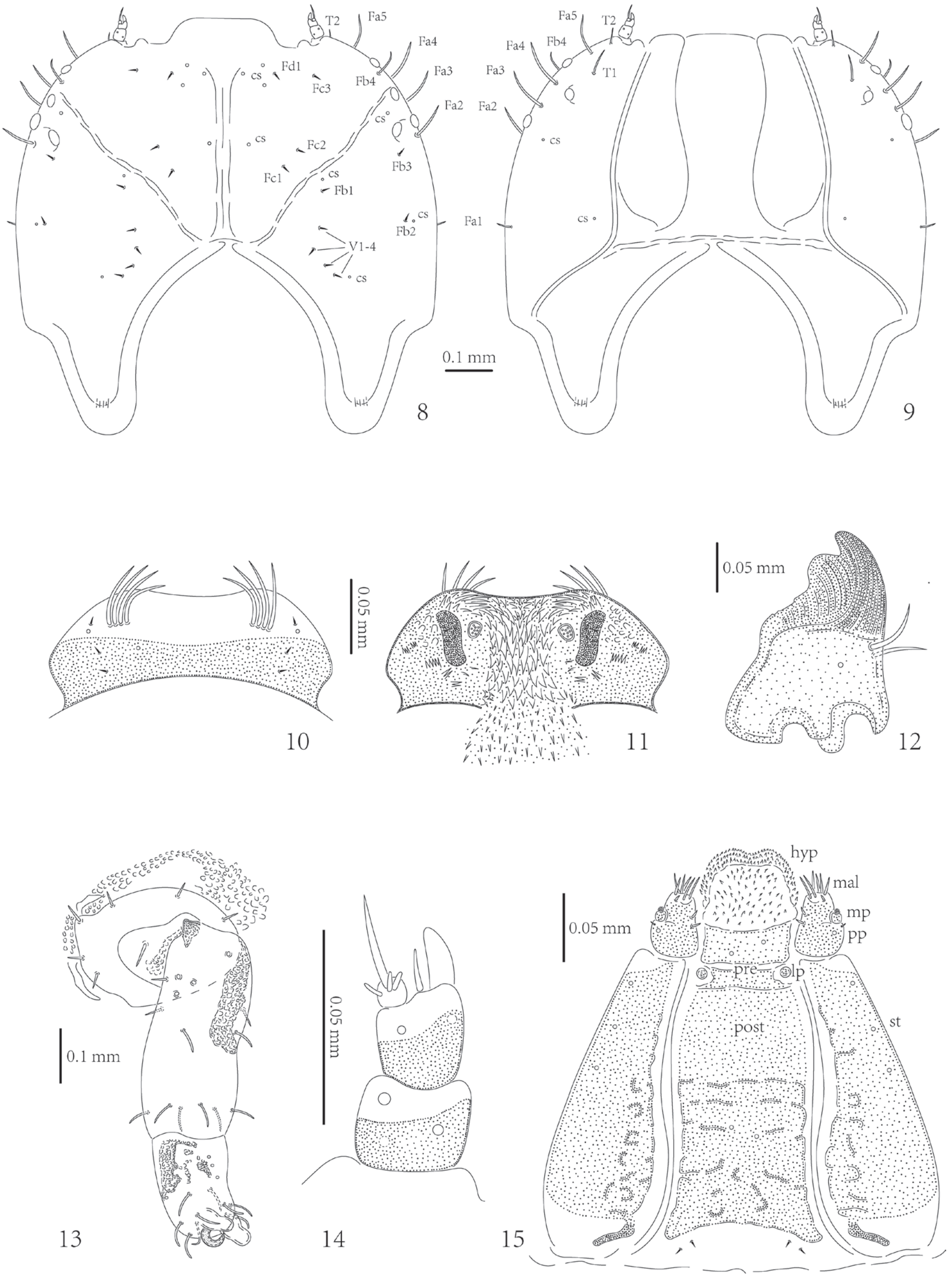
Pronotum with four setae on each lateral margin, five setae on each lateral side, and three setae close to posterior margin (Figs 4, 6). Meso- and metanotum with six minute setae on anterior margin: two pairs at middle and one pair laterally; row of ten setae running across segment; group of six setae laterally. Meso- and metanotum with one seta on slightly visible protuberance laterally. Abdominal tergites I–VII with four setae on anterior margin; two rows of setae running across segment: anterior with two setae, posterior with four setae; three setae close to each spiracle (seta closest to spiracle minute). Abdominal tergite VIII with four minute setae on anterior margin; three rows of setae running across segment: anterior with four setae, median with two setae, and posterior with four setae (between spiracles). Posterior margin of abdominal segment VIII with ten setae: two pairs close to spiracles laterally, three pairs between spiracles medially.

Prosternum with one seta in each anterior angle; one seta laterally at base of leg; and two setae close to posterior margin (Figs 5, 7). Meso- and metasternum with four setae on anterior margin; two rows of setae running across segment medially, both with two setae; and two setae laterally at base of leg. Abdominal sternites I–VII with pair of minute setae on anterior margin medially; with row of six setae running across segment medially; and three setae laterally. Abdominal sternite VIII with row of eight setae across segment anteriorly and two setae posteriorly; with two setae close to each spiracle; four setae along anterior base of anus.

Nine pairs of distinct spiracles (Figs 4, 6, 16): one on thorax and eight on abdomen. Thoracic spiracles distinctly more elevated than abdominal spiracles, diameter of spiracles of abdominal segments I–VII approximately equal, but spiracles of abdominal segment VIII distinctly larger, flattened, slightly elevated.

Head well sclerotized, prognathous, partially retracted into pronotum (Figs 8–9). Epicranial stem absent; median endocarina wide, extending between frontal arms; frontal arms V-shaped, fronto-clypeal suture absent. Clypeus wider than long, without setae and campaniform sensilla. Frons with two short setae (Fd1 and Fc3) and three campaniform sensilla laterally, two setae (Fc1 and Fc2) and one campaniform sensillum between median endocarina and frontal arm, one long seta (Fb4) laterally close to frontal arm; vertex with seven short setae (Fb1, Fb2, Fb3, and V1-4) and four campaniform sensilla (three respectively close to Fb1, Fb2 and V4, one between Fb4 and dorsal stemmata). One long seta (Fa1) on lateral margin close to pronotum, four long pointed setae (Fa2, Fa3, Fa4, and Fa5) close to stemmata. Temporal side with two long setae (T2 close to antenna, and T1 between T2 and ventral stemmata) and two campaniform sensilla.

Five stemmata laterally: four dorsal-laterally, one ventrally (Figs 8–9). Antenna with three antennomeres, set in membranous ring (Figure 14). First antennomere stout, approximately as wide as long, with three campaniform sensilla; second antennomere stout, slightly longer than wide, with two campaniform sensilla, one promi-



Figures 8–15. *Cassidispa relicta*, larva. **8** Dorsal view of head: cs – campaniform sensilla **9** Ventral view of head **10** Dorsal view of labrum **11** Ventral view of labrum **12** Mandible **13** Leg **14** Antenna **15** Maxillae and labium, ventral. Abbreviations: hyp – hypopharynx; mal – mala; mp – maxillary palp; pp – palpifer; lp – labial palp; pre – prementum; post – postmentum; st – stipes.

nent sensory appendix apically, and one stout seta close to third antennomere; third antennomere very short, with long, pointed seta and three peg-like sensilla.

Labrum approximately three times wider than long, anterior margin slightly emarginate (Figs 10–11), dorsal surface with: three setae and one campaniform sensillum laterally; one pair of campaniform sensilla medially; and four stout setae laterally close to anterior margin. Mid- and anterior areas of ventral surface with numerous stout spines; lateral and posterior areas with tiny spines; two irregular groups of few small sensilla medially.

Mandibles heavily sclerotized, with two prominent teeth (Figure 12): anterior distinct and conical, posterior blunt; followed by some tiny teeth. Two long setae very close to each other and one campaniform sensillum.

Maxillae and labium connate (Figure 15). Each stipes (st) with three campaniform sensilla anteriorly. Palpifer (pp) with one small seta apically and one campaniform sensillum laterally. Maxillary palp (mp) with two palpomeres: first palpomere stout, second palpomere with group of small peg-like sensilla at apex. Mala (mal) with six long pointed setae and one short seta apically, and two setae subapically. Hypopharynx (hyp) covered with numerous small spines. Labial palp (lp) with one palpomere, with group of small peg-like sensilla at apex. Prementum (pre) with two campaniform sensilla anteriorly. Postmentum (post) with two pairs of short setae at base and two campaniform sensilla medially.

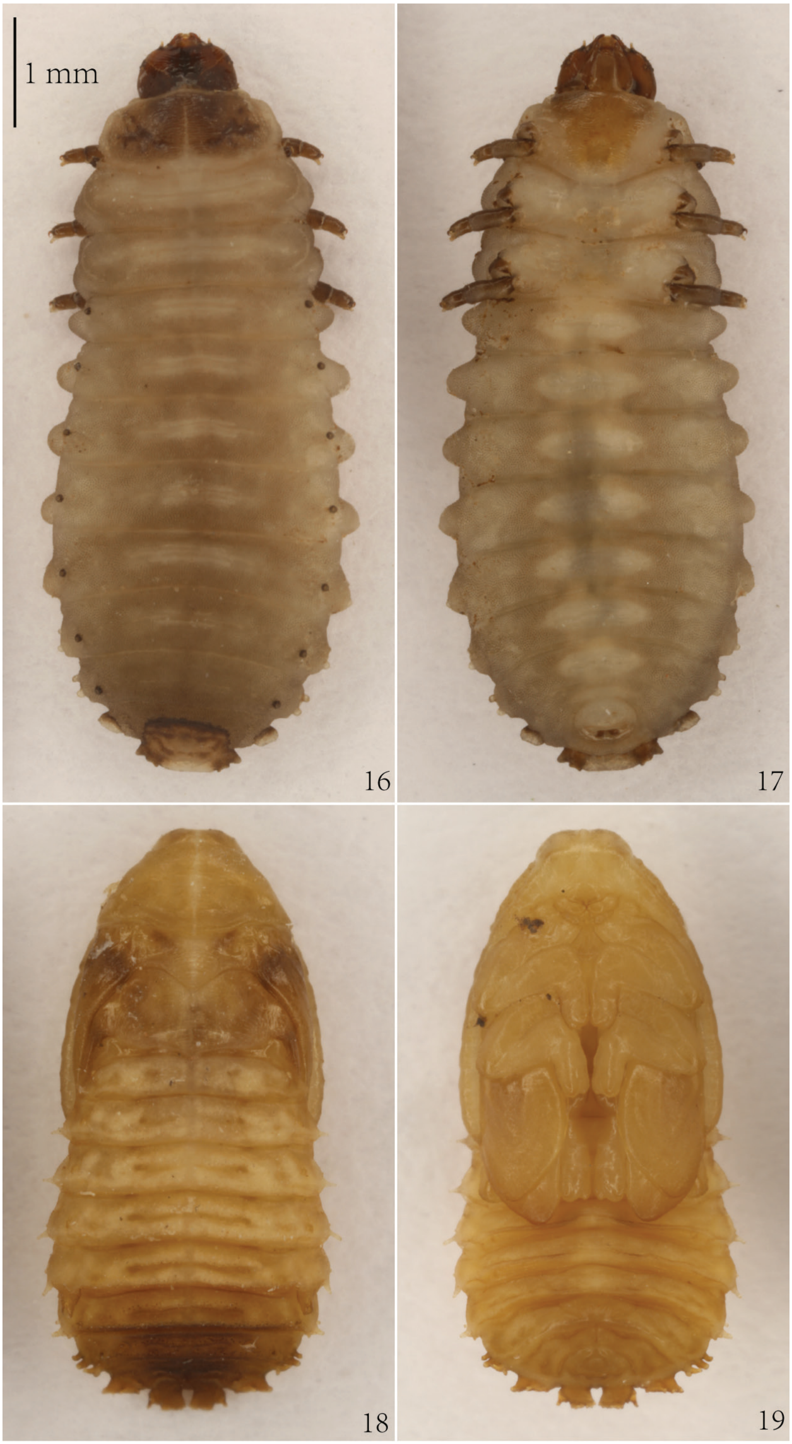
Legs oblong, consisting of three segments: coxa, femur, and tibiotarsus (Figure 13). Tibiotarsus armed apically with claw. Coxa with four setae along base on internal surface, and one seta dorsally and two setae on external surface. Femur with five setae and four campaniform sensilla on basal half, and six long setae on apical half. Tibiotarsus with nine long pointed setae and two campaniform sensilla: two setae at middle laterally, six setae around claw apically, one seta and two sensilla above claw. Base of claw with distinct pulvilli.

Pupa (Figs 18–21). Length of pupa 5.2 mm, width 1.7 mm across base of pronotum and 2.5 mm across abdominal segment IV without lateral scoli.

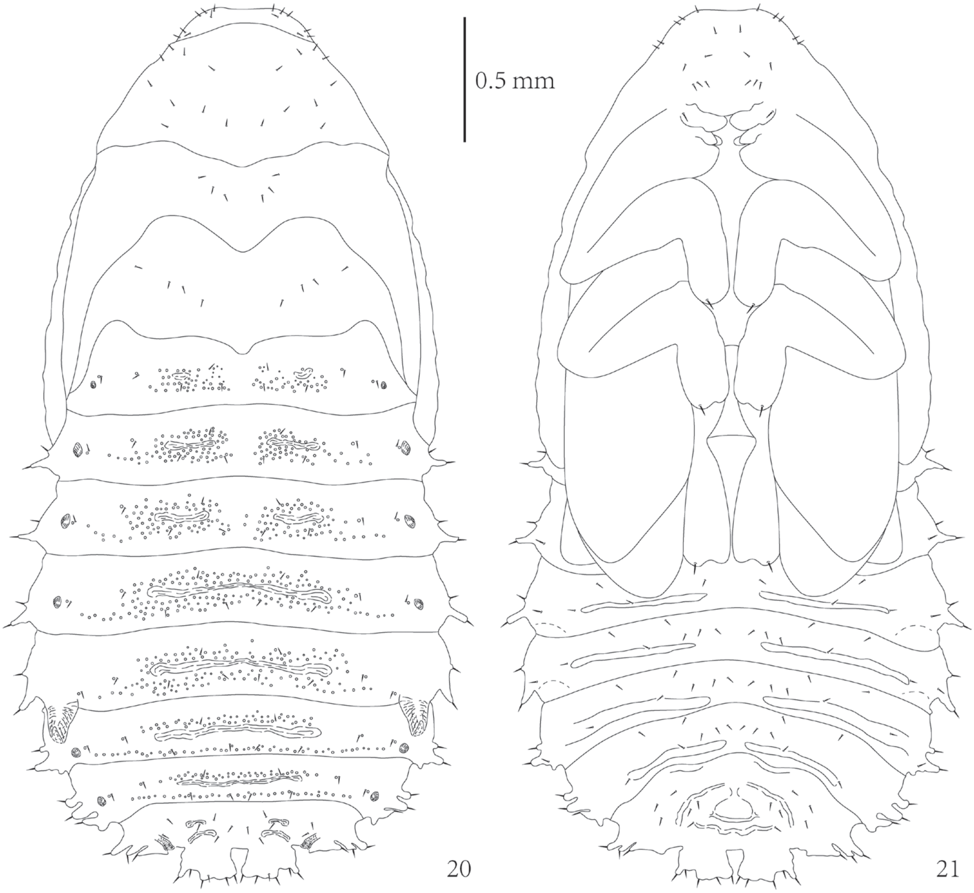
Body flattened dorso-ventrally, elongate-oval. Color of live as well as alcohol-preserved pupa brownish yellow, mesothorax with two dark markings at base of wings, apex of abdomen dark brown (Figs 18–19).

Body, especially abdomen, distinctly granulate (Figs 18–21). Abdominal tergites I–III with two short transverse grooves medially. Abdominal tergites IV–VII each with long transverse groove. Tergites of abdominal segments I–VII with several small tubercles around grooves. Tubercles of tergites VI–VII arranged as row close to posterior margin. Sternites of abdominal segments IV–VII each with two transverse ridges close to posterior margin.

Head visible in dorsal view (Figs 18, 20). Prothorax trapezoidal in shape. Thorax without lateral scoli. First abdominal segment without lateral scoli. Segments II–V with single simple scolus laterally and small low tubercle anteriorly armed with pointed



Figures 16–19. *Cassidispa relicta*. **16** Larva, dorsal view **17** Larva, ventral view **18** Pupa, dorsal view **19** Pupa, ventral view.

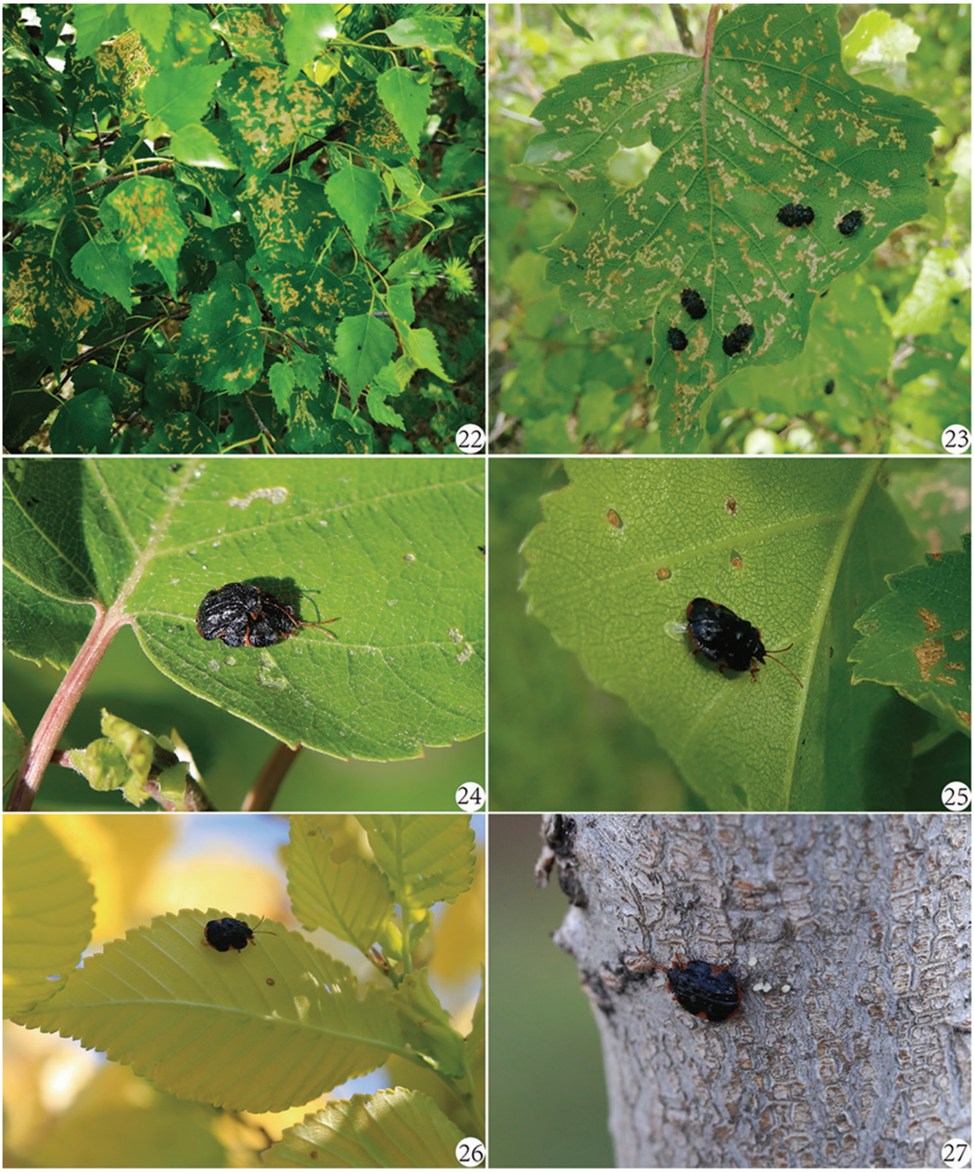


Figures 20–21. *Cassidispa relicta*, pupa. **20** Dorsal view **21** Ventral view.

seta. Abdominal segment VI with two lateral scoli. Segments VII–VIII each with three lateral scoli. Each scolus apically armed with one seta. Posterior lateral scolus of segments VI–VIII with one lateral branch directed posteriorly without setae. Segment VIII additionally with two broad, flattened processes on posterior margin; each with six setae apically.

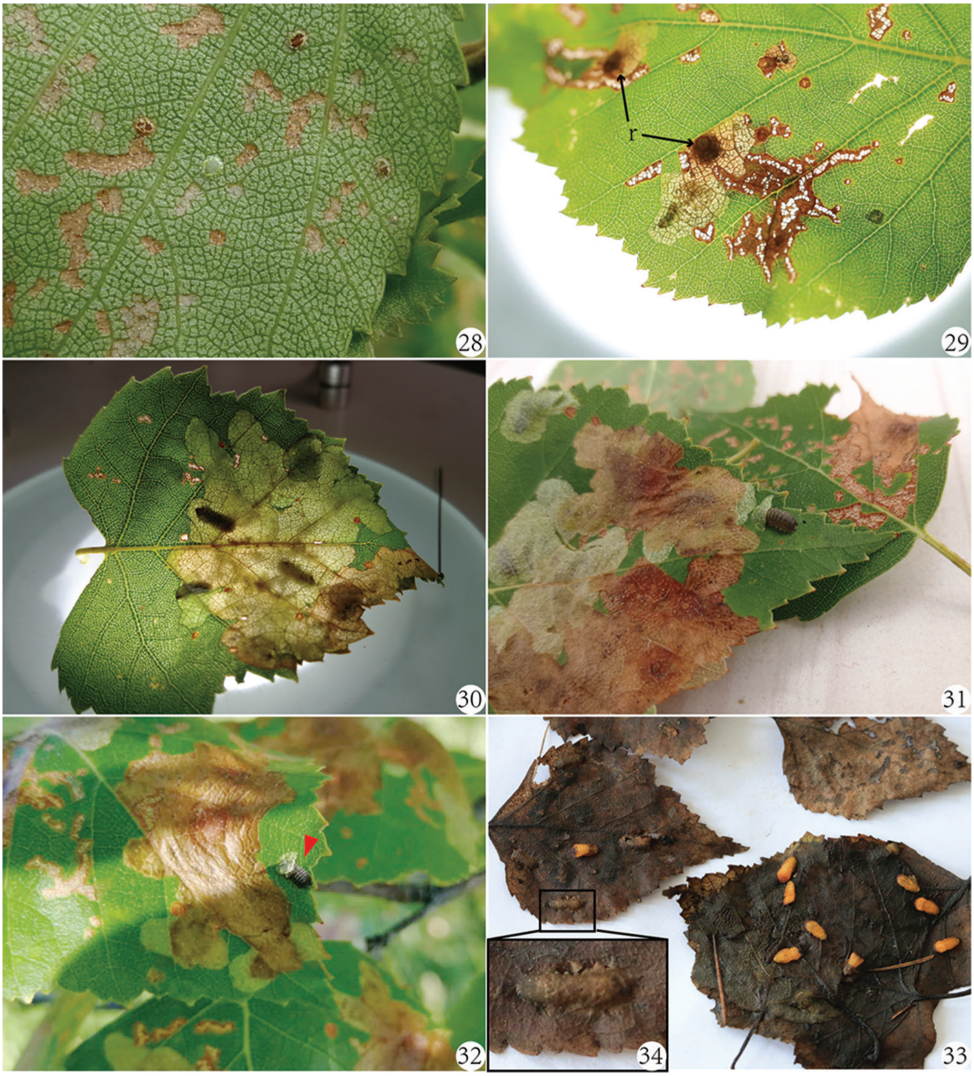
Head with three pairs of setae laterally and four setae anteriorly (Figure 20). Pronotum with group of nine setae laterally. Mesonotum with three pairs of setae medially. Metanotum with oblique row of four setae on each side medially. Abdominal tergites I–VII with two rows of setae running across segment: anterior with two setae, posterior with four setae; two setae close to each spiracle. Abdominal tergite VIII with three rows of setae running across segment: anterior with four setae, median with four setae, and posterior with two setae medially; one seta very close to each spiracle.

In ventral view (Figure 21), head with group of 14 setae: two setae anteriorly, four setae medially, six setae posteriorly at base of labrum, and two setae at base of mandibles. Tarsus of leg apically armed with one pointed seta. Visible abdominal sternites



Figures 22–27. Life stages of *Cassidispa relicta* on host plants (all on *Betula platyphylla* except Fig. 26 on *Ulmus pumila*). **22–23** Adults and their feeding pattern **24** Adults copulate on upper surface of host leaf **25–26** Females laying eggs on lower surface of host leaves **27** Female laying eggs on the tree trunk.

IV–VII with four setae on anterior margin, row of six setae medially, two setae laterally, and one seta at base of lateral scoli ventrally. Abdominal sternite VIII with rows of six setae anteriorly and six setae along anterior base of anus.



Figures 28–34. Life stages of *Cassidispa relicta* on host plants *Betula platyphylla*. **28** Eggs **29** A leaf with new mines of hatching larvae and larval resting places focusing on their egg points: r – resting place of larva **30** Shared large mine of three older larvae in a same leaf **31–32** Mature larva leaves its original mine and builds a new one for overwintering and pupation, in Fig. 32 the red arrow indicates the location of mature larva **33** Pupae in the leaf litter in spring **34** A pupal mine in the fallen leaf.

Abdominal segments each with one pair of spiracles (Figure 21). Spiracles of segment I smaller than others, spiracles of segments II–IV and VI–VII similar in shape but approximately twice as large as spiracles of segment I. Spiracles of segment VIII not elevated, oblong. Spiracles of segment V prominent, elongated into cylindrical appendage (respiratory horns), directed posteriorly.

Biological notes. The biology of the genus *Cassidispa* is poorly known. There is only one species having confirmed host plant record. Hua (2002) reported *C. bipuncticollis* to be associated with *Betula* (Betulaceae), but it is just a list even without some evidences. Our rearing of *C. relicta* on *Betula* and some other trees indicates that there might be more larval host associations for the genus. Additionally, the immature stages of the genus *Cassidispa* were completely unknown and this paper was the first study about it.

The larvae of *C. relicta* were found mainly mining in the leaves of *Betula platyphylla* (Figs 22–25, 27–34) and occasionally mining the leaves of some other trees, such as *Ulmus pumila* Linn. (Ulmaceae) (Figure 26), *Populus davidiana* Dode, *P. cathayana* Rehd. (Salicaceae) and *Armeniaca sibirica* (L.) Lam. (Rosaceae).

The life cycle of *C. relicta* is univoltine based on our field observations throughout 2016–2017. *C. relicta* overwinters as a mature larva until the temperature rises and the soil thaws in the spring. The mature larvae break dormancy and pupate in the fallen leaves in early April (Figs 33–34). The pupal stage lasts about one month. Adults emerge in late May (the freshly emerged adults are mostly white, with antenna and legs brown, and disc of pronotum black) and feed on the mesophyllic tissue of the upper surface of host leaves (Figs 22–24). The feeding pattern of the adults is usually irregular and may densely cover the leaves (Figs 22–25, 28–32). In early June, the adults start to copulate (Figs 23–24), and fertilized females lay an egg within a shallow hole which was chewed on the lower leaf surface, and then covered with feces (Figs 25–26). Adults have no apparent feeding preferences for young or old leaves, but females generally do not oviposit on new leaves. Females oviposit eggs scatteredly in a one-by-one way (Figs 24–26, 28). The newly deposited eggs are usually milk-white and translucent and its covered feces turn brown over time (Figs 25–26, 28). Sometimes, females will lay some eggs on the tree trunk, perhaps when they could not find any suitable leaves (Figure 27). The egg stage lasts about 20 days. A freshly hatched larva bores into the mesophyllic tissue and forms a large irregular mine with a resting place (dark color) surrounding the oviposition point (Figure 29). The larvae deposit their feces in their own mine (Figs 29–32). Each younger larva has its own absolute mine at the early stage which will combine with other mines on the same leaf over time (Figs 29–32). One leaf usually has three larvae or, in an outbreak, up to seven larvae. If one leaf does not likely provide enough food for these larvae to complete their development, they leave their original mine, migrate to a new leaf, and construct a new mine (Figs 31–32). The final larval mine is a large irregular blotch type, almost without any mesophyllic tissue left (Figs 30–32). The mined leaves gradually become yellow and may dry-up or abscise early. In early October the mature larvae leave their mine to enter a fresh uneaten area of the same leaf to construct a pupal mine (Figs 33–34). The mature larvae of *C. relicta* does not directly go into pupation like other leaf-mining hispines (Świętojańska and Kovac 2007; Lee et al. 2009; Liao et al. 2014; Liao et al. 2018) but into a long dormant period for overwintering. However, it is a shortcoming we did not perform the larval instar observations.

Discussion

General morphology of the larva and pupa of *C. relicta* is typical for species of leaf-mining Hispini. The immature stages of Hispini beetles have been reported on some species, such as *Acmenychus inermis* (Zubkoff, 1833) (Medvedev 1968), *Dactylispa setifera* (Chapuis, 1877) (Chen et al. 1986), *D. xanthopus* (Gestro, 1898) (as *D. chinensis* Weise, 1905), *D. doriae* Gestro, 1890, *D. chaturanga* Maulik, 1919, *D. xanthospila* Gestro, 1890 (Zaitsev 2012), *D. ignorata* Uhmann, 1953 (as *D. chapuisi* (Gestro, 1890)), *D. rufiventris* (Kraatz, 1895) (Maulik 1932), *D. feae* (Gestro, 1888) (as *D. flavomaculata* Uhmann, 1930), *D. issiki* Chûjô, 1938 (Fukuda and Kurosa 1959), *D. higoniae* (Lewis, 1896), *D. subquadrata* (Baly, 1874) (Yano 1965), D. hystrix (Duvivier, 1891) (Paulian 1949), *D. cladophora* (Guérin-Méneville, 1841), *D. nemoralis* (Gestro, 1897), *D. vethi* (Gestro, 1906) (Uhmann 1956), *D. callosa* Uhmann, 1935 (Uhmann 1962), *Dicladispa armigera* (Olivier, 1808) (Chen et al. 1986; Kimoto and Takizawa 1994; Lee and Cheng 2010), *Dicladispa testacea* (Linnaeus, 1767) (Świętojańska et al. 2014), *Hispa atra* Linnaeus, 1767 (Grandi 1935), and *Platypria erinaceus* (Fabricius, 1801) (as *P. andrewesi* Weise, 1904) (Uhmann 1957), *P. kapauku* Gressitt, 1957 (as *P. linnei* Weise, 1905) (Gressitt 1963), *P. melli* Uhmann, 1954 (Kimoto et al. 1997; Liao et al. 2014) and so on. However, some early literatures had no detailed information or illustrations on their immature stages. In this paper, some diagnostic characters of the immature stages among several representative species in the genera of *Cassidispa*, *Dactylispa*, *Dicladispa* and *Platypria* are compared and summarized in Table 1.

The larva of *C. relicta* is very similar to that of some *Dactylispa* species and can be distinguished by the lateral branches of abdominal scoli on segments VI–VII (very small and with a rounded apex), although this character also presented on *D. haturanga* but distinctly slender and with a pointed apex (Zaitsev 2012). Additionally, the abdominal processes are distinctly round in shape (Figs 6–7, 16–17), with a pair of spiracles whose opening directed backward (in genus *Dactylispa* the spiracles usually formed very pointed or triangular respiratory horns). The pupa of *C. relicta* is most similar to that of *Di. testacea*. These two species each have a pair of lateral scoli on abdominal segments I–V and have 2–3 pairs of lateral scoli on segments VI–VIII, the abdominal apex has two flattened processes; and the spiracles of the fifth abdominal segment look very similar. The differences are that the body shape of *C. relicta* is broadly ovate and the anterior margin of the head is slightly straight, but the head of *Di. testacea* is distinctly emarginate.

The larvae, especially younger larvae, usually returned to the resting place (Figure 29). Such an interesting and specific behavior was also found in some species of the genus *Dactylispa*, such as *D. subquadrata* (Baly, 1874) and *D. higoniae* (Lewis, 1896) (Yano 1965), but not in *D. angulosa* (Solsky, 1871) (Yano 1965) and *D. approximata* Gressitt, 1939 (Dai et al. 2012). The leaf areas with obviously deeper color smeared with larval feces which may help the larvae to avoid predators and parasitoids (Hering 1951; Yano 1965).

Table 1. Comparisons of diagnostic characters of immature stages among *C. relicta* and some species in the genera of *Dactylispa*, *Dicladispa,* and *Platypria*.

Diagnostic characters	Larva			Pupa			References
	Lateral scoli on meso- and metathorax	Shape of abdominal scoli	Lateral branches of abdominal scoli	Processes on pronotum	Processes on abdominal apex	Spiracles of fifth abdominal segment	
C. relicta	absent	rounded	segments VI–VII	absent	2 flattened	short, thick	This paper
D. setifera	absent	triangular	absent	absent	2 flattened	short, pointed	Chen et al. 1986
D. rufiventris	absent	diminutive	absent	absent	2 spinulose	short, pointed	Maulik 1932
D. chapuisi	absent	rounded	absent	absent	2 spinulose	spiniform	Maulik 1932
D. javaensis	present	triangular	absent	absent	2 small	long conical	Maulik 1931
D. higoniae	present	triangular	absent	absent	2 small triangular	long conical	Yano 1965; Kimoto et al. 1997 (larva); Lee and Cheng 2007
D. insulicola	present	triangular	absent	absent	2 flattened	long conical	Lee and Cheng 2007
D. latipennis	present	triangular	absent	absent	2 flattened	long conical	Lee and Cheng 2010
D. doriae	present	triangular	absent	absent	2 pointed	upward-hooked	Zaitsev 2012
D. xanthopus	present	triangular	absent	absent	2 short	upward-hooked	Zaitsev 2012
D. haturanga	present	triangular	segments VI–VII	absent	2 branched	long conical	Zaitsev 2012
Di. armigera	absent	triangular	absent	present	6 small spinous	long pointed	Chen et al. 1986; Kimoto et al. 1997 (larva); Lee and Cheng 2010
Di. testacea	absent	short, fine	absent	absent	2 flattened	elongate-horned	Świętojańska et al. 2014
P. andrewesi	present	triangular	absent	present	2 flattened	long conical	Uhmann 1957 (pupa); Kimoto et al. 1997 (larva)
P. melli	present	triangular	absent	present	2 flattened	long conical	Kimoto et al. 1997 (larva); Liao et al. 2014

Acknowledgements

We thank every member of Leafminer Group of Gannan Normal University and Ulanqab Forestry Pest Control and Quarantine Station for collection, laboratorial rearing, observations, and recording of leaf-mining hispines. We also acknowledge the great comments from the three reviewers (Drs. Jolanta Świętojańska, Jesus Gomez-Zurita and Lukáš Sekerka), which soundly improve our first manuscript. Special thanks to Dr. Lukáš Sekerka for correct identification of the species. This study was funded by the National Natural Science Foundation of China (31760173, 41361009, 31260116), Natural Science Foundation of Jiangxi, China (20171BAB204023) and Innovation Team Project of Gannan Normal University.

References

Borowiec L, Świętojańska J (2003) The first instar larva of *Cassida nebulosa* L. (Coleoptera: Chrysomelidae: Cassidinae) – a model description. Annales Zoologici 53: 189–200.

Chen SH, Yu PY, Sun CH, T'an CH, Zia Y (1986) Fauna Sinica (Insecta: Coleoptera: Hispidae). Science Press, Beijing, 653 pp. [In Chinese]

Dai X, Xu J, Jiang Z (2012) Bionomics of *Dactylispa approximata* on *Lophatherum gracile*. Northern Horticulture 22: 125–127. [In Chinese]

Gressitt JL (1963) Hispine beetles (Chrysomelidae) from New Guinea. Pacific Insects 5(3): 591–714.

Hering EM (1951) Biology of leaf miners. Springer-Science + Business Media, Berlin, 420 pp. https://doi.org/10.1007/978-94-015-7196-8

Hua LZ (2002) List of Chinese Insects Vol. 2. Sun Yat-sen University Press, Guangzhou, 612 pp.

Kimoto S, Takizawa H (1994) Leaf beetles (Chrysomelidae) of Japan. Tokai University Press, Tokyo, 539 pp.

Lee CF, Cheng HT (2010) The Chrysomelidae of Taiwan 2. Sishow–Hills, Taipei, 191 pp. [In Chinese]

Lee CF, Świętojańska J, Staines CL (2009) *Prionispa houjayi* (Coleoptera: Chrysomelidae: Cassidinae: Oncocephalini), a newly recorded genus and new species from Taiwan, with a description of its immature stages and notes on its bionomy. Zoological Studies 51: 832–861.

Liao C, Xu J, Dai X, Zhao X (2014) Study on the biological characteristics of *Platypria melli*. Northern Horticulture 3: 118–120. [In Chinese]

Liao C, Liu P, Xu J, Staines CL, Dai X (2018) Description of the last-instar larva and pupa of a leaf-mining hispine – *Prionispa champaka* Maulik, 1919 (Coleoptera, Chrysomelidae, Cassidinae, Oncocephalini). ZooKeys 726: 47–60. https://doi.org/10.3897/zookeys.726.21041

Maulik S (1932) On the structure of larvae of hispine beetles-II. Proceedings of the Zoological Society of London 192: 293–322.

Medvedev LN (1957) Hispid beetles (Coleoptera, Chrysomelidae, Hispinae) of the fauna of the USSR. Zoologischesky Zhurnal 36: 293–296. [In Russian]

Medvedev LN (1968) On larvae of Hispinae (Coleoptera, Chrysomelidae) of the fauna of the USSR. Zoologischesky Zhurnal 47: 79–84. [In Russian]

Paulian R (1949) Recherches sur les insectes d'importance biologique de Madagascar I. Mémoires de l'Institut Scientifique de Madagascar 3(A): 348–391.

Staines CL (2015) Tribe Hispini. Catalog of the hispines of the World (Coleoptera: Chrysomelidae: Cassidinae). http://entomology.si.edu/Collections_Coleoptera-Hispines.html [Accessed 14 September 2017]

Świętojańska J, Chorzępa M, Ghate H (2006) Description of last instar larva and pupa of *Chaeridiona picea* Baly, 1869 and *Oncocephala quadrilobata* (Guérin, 1844) (Coleoptera: Chrysomelidae: Cassidinae: Oncocephalini) from India. Zootaxa 1341: 49–68. http://dx.doi.org/10.11646/zootaxa.1341.1.3

Świętojańska J, Kovac D (2007) Description of immatures and the bionomy of the Oriental leaf beetle *Chaeridiona thailandica* Kimoto, 1998 (Coleoptera: Chrysomelidae: Cassidinae: Oncocephalini), a leaf-mining hispine beetle. Zootaxa 1637: 21–36. http://dx.doi.org/10.11646/zootaxa.1637.1.2

Świętojańska J, Borowiec L, Stach M (2014) Redescription of immatures and bionomy of the Palaearctic species *Dicladispa testacea* (Linnaeus, 1767) (Coleoptera: Chrysomelidae: Cassidinae: Hispini), a leaf-mining hispine beetle. Zootaxa 3811(1): 1–33. Https://doi.org/10.11646/zootaxa.3811.1.1

T'an J (1993) Coleoptera: Hispidae– Hispinae. In: Huang C-M (Ed.) Animals of Longqi Mountain. The series of the bioresources expedition of the Longqi Mountain Nature Reserve, 380–383. [In Chinese]

Uhmann E (1956) Hispinae aus Indonesia. 170. Beitrag zur Kenntnis der Hispinae (Coleoptera, Chrysomelidae). Beaufortia, Series of Miscellaneous Publications 5(50): 61–72.

Uhmann E (1957) Hispinae aus dem Britischen Museum. IX. Teil. 184. Beitrag zur Kenntnis der Hispinae (Coleopt. Chrysomelidae). The Annals and Magazine of Natural History (12)10: 364–368. https://doi.org/10.1080/00222935708655969

Uhmann E (1962) *Dactylispa capicola* (Péringuey) und Verwandte. (203. Beitrag zur Kenntnis der Hispinae (Coleoptera, Chrysomelidae)). Annals of the South African Museum 46(8): 223–230.

Yano T (1965) Larval stages of the leaf-miners found in Shikoku (Coleopterous leaf-miners of Japan, VII). Transactions of the Shikoju Entomological Society, Marsuyama, 8(4): 115–132.

Zaitsev YM (2012) The immature stages of the leaf-beetle genus *Dactylispa* (Coleoptera, Chrysomelidae) from Vietnam. Entomological Review 92(3): 305–314. http://dx.doi.org/10.1134/S0013873812030074

ZooKeys 780: 89–108 (2018)
doi: 10.3897/zookeys.780.26977
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

New species and a new genus of Philopotamidae from the Andes of Bolivia and Ecuador (Insecta, Trichoptera)

Ralph W. Holzenthal[1], Roger J. Blahnik[1], Blanca Ríos-Touma[2,3]

[1] Department of Entomology, University of Minnesota, 1980 Folwell Avenue, 219 Hodson Hall, St. Paul, Minnesota 55108 USA **2** *Facultad de Ingenierías y Ciencias Aplicadas, Ingeniería Ambiental, Grupo de Investigación en Biodiversidad Medio Ambiente y Salud – BIOMAS – Universidad de Las Américas, Campus Queri, Quito, Ecuador* **3** *Instituto Nacional de Biodiversidad, Quito, Pichincha, Ecuador*

Corresponding author: *Ralph Holzenthal* (holze001@umn.edu)

Academic editor: *S. Vitecek* | Received 25 May 2018 | Accepted 19 July 2018 | Published 8 August 2018

http://zoobank.org/04DB004E-E4F9-4B94-8EC8-37656481D190

Citation: Holzenthal RW, Blahnik RJ, Ríos-Touma B (2018) New species and a new genus of Philopotamidae from the Andes of Bolivia and Ecuador (Insecta, Trichoptera). ZooKeys 780: 89–108. https://doi.org/10.3897/zookeys.780.26977

Abstract

A new genus and species of Philopotamidae (Philopotaminae), *Aymaradella boliviana*, is described from the Bolivian Andes of South America. The new genus differs from other Philopotaminae by the loss of 2A vein in the hind wing and, in the male genitalia, the synscleritous tergum and sternum of segment VIII, and the elongate sclerotized dorsal processes of segment VIII. The first record of *Hydrobiosella* (Philopotaminae) in the New World is also provided with a new species from the Andes of Ecuador, *Hydrobiosella andina*. In addition, a new species of the Neotropical genus *Chimarrhodella* (Chimarrinae), *Chimarrhodella choco*, is described from the Choco-Andean region of Ecuador, and *Chimarrhodella peruviana* (Ross) is recorded from Ecuador for the first time. Lastly, *Wormaldia imbrialis* (Philopotaminae), new species, is described, also from the Ecuadorian Choco.

Keywords

Andes, Bolivia, Choco, Ecuador, South America

Introduction

The cosmopolitan family Philopotamidae, with approximately 1300 species, is especially species rich in the tropics, where many new species have been described recently (e.g., Blahnik et al 2009, Johanson and Oláh 2012, Dumas and Nessimian 2013). Currently, there are 22 genera in three subfamilies: Chimarrinae (three genera), Philopotaminae (18 genera), and Rossodinae (one genus) (Blahnik 2005, Holzenthal et al. 2007, Morse 2017) (Table 1). The subfamily Philopotaminae was the subject of a revision by Ross (1956). He treated many of what are now recognized as genera, as subgenera of a nearly cosmopolitan genus, *Sortosa*, subsequently emended to *Dolophilodes* by Ulmer (1957) due to name priority. *Dolophilodes*, as formulated by Ross, was based mainly on plesiomorphic characters. The subgenera were largely restricted and endemic to different continental areas: South America, South Africa, Australia, Asia, and North America. Subsequently, some of these were raised to generic status (e.g., Neboiss 1977) and the process was completed by Blahnik (2005), who raised all of the remaining subgenera to genera, based on the criteria initially used by Ross to establish them. However, a great many species have been described in the interim since Ross's revision, both to those originally placed in *Dolophilodes*, or to other genera recognized by Ross or described subsequently (Blahnik 2005, Gibon 2014). The characters used by Ross no longer easily diagnose some genera. This is especially true of the genera *Sortosa* and *Hydrobiosella*, in which the generic assignment of new species has been mostly based on their geographic location. Clearly, what is needed is a revision of the entire subfamily. Pending this, generic assignments are at best provisional for some taxa, made in accordance with existing taxonomic criteria. Ideally, however, their placement should facilitate an eventual generic and subfamily reassessment.

Neotropical areas, especially the Tropical Andes, harbor an incredible and unexplored Trichoptera diversity (Ríos-Touma et al. 2017). More than 3000 species of Trichoptera have been recorded from the region, including 377 extant species in five genera of Philopotamidae: *Alterosa* (39 species), *Chimarra* (256 species), *Chimarrhodella* (12 species), *Sortosa* (20 species), and *Wormaldia* (50 species) (Holzenthal and Calor 2017). Here, we describe a new genus of Philopotaminae, *Aymaradella*, from Bolivia and we provide the first continental record for *Hydrobiosella*, previously known only from the Australasian region (Holzenthal et al. 2007; Cartwright 2010), with a new species from the Andes of Ecuador. Also, we describe a new species of *Chimarrhodella* from the Choco-Andean region of Ecuador and provide new country records of *Chimarrhodella peruviana* (Ross). Finally, *Wormaldia imbrialis*, new species, a member of a group of species related to *W. prolixa* Flint, is also described from the Choco of Ecuador. Larvae have not been described for any of the Neotropical species in the genera treated in this paper, except *Wormaldia*.

Materials and methods

Adult specimens of *Aymaradella boliviana,* new genus, new species, *Chimarrhodella choco*, new species, and *Wormaldia imbrialis*, new species, were collected at UV fluorescent lights placed adjacent to streams. Lights were hung in front of a white bed sheet and powered from a small 12 volt, sealed, lead-acid battery. Additional specimens of *A.*

Table 1. Genera of Philopotamidae, distribution, and approximate number of species. Available synonyms in italics. *=new continental record). Adapted from Holzenthal et al. (2007), Morse (2017).

- CHIMARRINAE Rambur, 1842
  - ***Chimarra*** Stephens, 1829
    - Cosmopolitan
    - ca. 750 species
  - ***Chimarrhodella*** Lestage, 1925
    - Neotropical
    - 13 species
  - ***Edidiehlia*** Malicky, 1993
    - Oriental (Sumatra)
    - 1 species
- PHILOPOTAMINAE Stephens, 1829
  - ***Alterosa*** Blahnik, 2005
    - Neotropical (southeast Brazil)
    - 39 species
  - ***Aymaradella* gen. n.**
    - Neotropical (Bolivia)
    - 1 species
  - ***Cryptobiosella*** Henderson, 1983
    - Australasian (New Zealand)
    - 4 species
  - ***Dolophilodes*** Ulmer, 1909
    - *Hisaura* Kobayashi, 1980
    - *Trentonius* Betten & Mosely, 1940
    - Nearctic, Palearctic, Oriental
    - ca. 60 species
  - ***Dolomyia*** Schmid, 1991
    - Oriental (India)
    - 1 species
  - ***Dolopsyche*** Schmid, 1991
    - Oriental (India)
    - 1 species
  - ***Fumonta*** Ross, 1956
    - Nearctic (eastern USA)
    - 1 species
  - ***Gunungiella*** Ulmer, 1913
    - Oriental
    - ca. 100 species
  - ***Hydrobiosella*** Tillyard, 1924
    - *Zelobiosella* Mosely, 1953
    - Australasian, Neotropical* (Ecuador)
    - ca. 30 species
  - ***Kisaura*** Ross, 1956
    - Oriental
    - ca. 50 species
  - ***Neobiosella*** Wise, 1958
    - Australasian (New Zealand)
    - 1 species
  - ***Philopotamus*** Stephens, 1829
    - Palearctic (Europe)
    - 10 species
  - ***Ranarijaodes*** Gibon, 2014
    - Afrotropical (Madagascar)
    - 3 species
  - ***Sisko*** Ross, 1956
    - Nearctic
    - 2 species
  - ***Sortosa*** Navas, 1918
    - Neotropical (Patagonia)
    - 20 species
  - ***Thylakion*** Barnard, 1934
    - Afrotropical
    - 4 species
  - ***Wormaldia*** McLachlan, 1865
    - *Cabreraia* Enderlein, 1929
    - *Doloclanes* Banks, 1937
    - *Dolophiliella* Banks, 1930
    - *Dolophilus* McLachlan, 1868
    - *Gatlinia* Ross, 1948
    - *Nanagapetus* Tsuda, 1942
    - *Paragapetus* Banks, 1914
    - Cosmopolitan
    - ca. 200 species
  - ***Xenobiosella*** Henderson, 1983
    - Australasian (New Zealand)
    - 1 species
- ROSSODINAE Oezdikmen & Darilmaz, 2008
  - ***Rossodes*** Oezdikmen & Darilmaz, 2008
    - Afrotropical (Madagascar)
    - 16 species

boliviana and of *Hydrobiosella andina*, new species, were borrowed from the National Museum of Natural History, Smithsonian Institution; no information on habitat or collecting method is available. Males and females were associated indirectly by common occurrence and overall similarity in body size and color.

Adult specimens were prepared and examined following standard methods for pinned and alcohol preserved material (Blahnik and Holzenthal 2004; Blahnik et al. 2007). Length of forewing was measured from base to apex, and is presented as the range followed by the number of specimens measured. For specimens collected by us, male genitalia were soaked in 85% lactic acid heated to 125 °C for 20 min to dissolve internal soft tissues. An Olympus BX41 compound microscope outfitted with a drawing tube was used to examine specimens and to aid the rendering of detailed pencil drawings of genitalic structures. Pencil sketches were scanned and placed in Adobe Illustrator (Creative Cloud version) to serve as a template for vector illustrations. Morphological terminology follows that of Blahnik (2005) for genitalia and Holzenthal et al. (2007) for wing venation. Each specimen was affixed with a barcode label (4-mil polyester, 8 × 14 mm, code 49) bearing a unique alphanumeric sequence beginning with the prefix UMSP to serve as a specimen identifier for upload of collection and specimen data to the University of Minnesota Insect Collection (UMSP) database.

Types of the new species and other material examined are deposited in the University of Minnesota Insect Collection, St. Paul, Minnesota, USA (**UMSP**), the Museo Ecuatoriano de Ciencias Naturales, Insituto Nacional de Biodiversidad, Quito, Ecuador (**MECN**), the Museo de Historia Natural Noel Kempff Mercado, Santa Cruz de la Sierra, Bolivia (**UASC**), and the National Museum of Natural History, Smithsonian Institution, Washington, DC (**NMNH**).

Systematics

Aymaradella gen. n.

http://zoobank.org/57368721-91ED-44F0-BA96-151D7A2C4335
Figs 1, 2, 3

Type species. *Aymaradella boliviana*, new species

Diagnosis. *Aymaradella*, new genus, can be distinguished from any other genus of Philopotaminae by the loss of 2A vein in the hind wing, the synscleritous tergum and sternum of segment VIII, and the elongate sclerotized dorsal processes of segment VIII.

This species has the general venational attribute of lacking the second anal vein in the hind wing, a character used to define the genera *Wormaldia* and *Gunungiella*. However, it is very distinctly different from either of those genera in overall form, and completely unlike any described species of *Wormaldia* from either North or South America. In particular, the completely fused segment VIII, with elongate dorsal processes, is unique among species in Philopotaminae.

Description. Adult. Head relatively short and rounded, postparietal sclerite short (ca. ½ diameter of eye). Spur formula 2:4:4. Maxillary palps 5-segmented, segment II with apicomesal bristles, labial palps 3-segmented. Venation complete for Philopotamidae (forewings with forks I-V, hind wing lacking fork IV); forewing with discoidal cell relatively short, forks I and II approximately sessile, crossveins *s*, *r-m*, and *m* hyaline and nearly linear, 3A looped to 2A, 2A to 1A, intersecting in proximal half of vein. Fork I of hind wing with short stem, fork II sessile, 1A and 3A intersecting wing margin, 2A missing.

Male. Sternum VII with short, rounded mesoventral process (rather than flattened, spatulate process typical of *Wormaldia*). Segment VIII synscleritous, expanded anterodorsally, dorsal margin with pair of elongate processes. Segment IX synscleritous, narrowing dorsally. Tergum X simple in structure and entire, wide basally, narrowing apicaly, with numerous sensilla and/or short setae. Preanal appendages elongate, narrow, digitiform, emerging near base of tergum X. Inferior appendages bi-segmented, linear, apical segment with mesal pad of short stiff setae. Phallic apparatus simple in structure, without spines or inclusions.

Female. Genitalia elongate and tapering from segment VII; segment VII longer than preceding segment, with small ventral process at midlength; segment VIII nearly as long as segment VII, tapering, not synscleritous, sternite with lateral pair of very elongate, narrow apodemes. Segment IX very short, anterolateral margin with pair of elongate, narrow apodemes, extending anterad. Segment X composed of pair of elongate, narrow sensillate lobes, each with short apical cercus. Vaginal apparatus membranous, without evident sclerites.

Etymology. The name Aymara is considered feminine and refers to the people and language of Bolivia; the suffix is considered to be a diminutive and makes the name euphonious with *Chimarrhodella* and *Hydrobiosella*, other philopotamids previously and newly known from the Neotropics.

***Aymaradella boliviana* sp. n.**

http://zoobank.org/48C88BD8-662F-47B9-8585-BA1BE0DB2F79
Figs 1, 2, 3

Diagnosis. Diagnosed by the characteristics of the genus as discussed above.

Description. Adult. Forewing length (male) 5.5–5.8 mm (n = 2); (female) 5.8–6.3 mm (n = 2). Spur formula 2:4:4. Overall color, including wings and antennae, light brown, legs yellowish brown. Head short and rounded, eyes with short setae between facets, postparietal sclerite short (ca. ½ diameter of eye). Palps short; maxillary palp with segment I very short, segments II and IV short, II with apicomesal bristles, III only moderately elongate, V longer than III. Forewing with forks I-V, hind wing with forks I-III and V (IV absent). Forewing with discoidal cell relatively short, forks I and II approximately sessile, crossveins *s*, *r-m*, and *m* hyaline and nearly linear, 3A looped to 2A, 2A to 1A, intersecting in proximal half of vein. Fork I of hind wing with short stem, fork II sessile, 1A and 3A intersecting wing margin, 2A missing.

Male. Abdomen with segments through VII with sternites generally setose, tergites V-VII with setae confined to (more or less) linear row on posterior margin, each seta with more or less evident, desclerotized area at base. Sternum VII with short rounded mesoventral process from posterior margin, directed posterad and positioned posterior to sclerotized line that extends near the posterior margin from the mesoventral process to midlateral margin of sternite. Segment VIII synscleritous, ventrally ca. ½ length of sternite VII, widening anterodorsally to width subequal to tergum VII; as viewed dorsally, with anterior margin concavely invaginated, mesally with pair of elongate, narrow, sclerotized processes, with apices acutely narrowed and somewhat laterally projecting, extending from near anterior margin of segment beyond posterior margin of segment IX; dorsomesal part of segment, from lateral margin of posteromesal invagination to posterior of segment, only weakly sclerotized or submembranous. Segment IX synscleritous, ventral margin subequal in length to sternum VIII, evenly narrowed from posterior margin to narrow, sclerotized, invaginated, dorsomesal strap; posterior of segment weakly sclerotized or submembranous. Tergum X simple in structure, elongate, narrow, slightly widened near base and uniformly narrowed apically; apex rounded, basally with pair of small rounded protuberances, each with 2-3 short stiff setae; dorsal surface with short setae or seta-like sensilla, declining in size apically, extreme apex with cluster of small sensilla. Preanal appendages elongate, narrow, emerging near base of tergum X; as viewed dorsally, somewhat mesally curved, emerging near base of tergum X. Inferior appendages elongate and relatively narrow, widest near base of basal segment; apex of apical segment slightly widened, with cluster of short, stiff setae on apicomesal surface. Phallic apparatus with phallobase more or less tubular, with usual basodorsal projection, relatively short, simple, tapering from base to apex; phallotremal sclerite small, indistinct, endotheca simple, without associated spines or ornamentation.

Female. Genitalia very elongate, tapering from segment VII; segment VII much longer than preceding segment (ca. 1½ x length), ventral margin with very small, acute, mesoventral process at midlength; segment VIII nearly as long as segment VII, tapering, not synscleritous, sternite with lateral pair of very elongate, narrow apodemes, extending from anterdorsal margin, apodemes nearly 1½ x length of segment VII. Segment IX very short, (apparently comprised of tergum only), anterolateral margin with pair of very elongate, narrow apodemes, extending anterad, length ca. 1½ x length of segment VIII; posterior margin with pair of elongate, narrow sensillate lobes (segment X), each with short apical cercus. Vaginal apparatus membranous, only indistinctly evident.

Holotype. Male. BOLIVIA: La Paz: quebrada del Río Zongo, 1400 m, 24–30.x.1984, L.E. Peña G. (UMSP000136162) (NMNH). **Paratypes:** same data as holotype, 1 male, 2 females (NMNH); **BOLIVIA: La Paz:** PN-ANMI [Parque Nacional y Área Natural de Manejo Integrado] Cotapata, Estacíon Biológica Tunquini, Quebrada El Padrini, 16°12.193'S, 67°50.692'W, el. 1343 m, 06-07.xii.2004, Robertson, Valdivia, 9 males, 2 females (UMSP, UASC).

Etymology. Named for the country where the species was discovered.

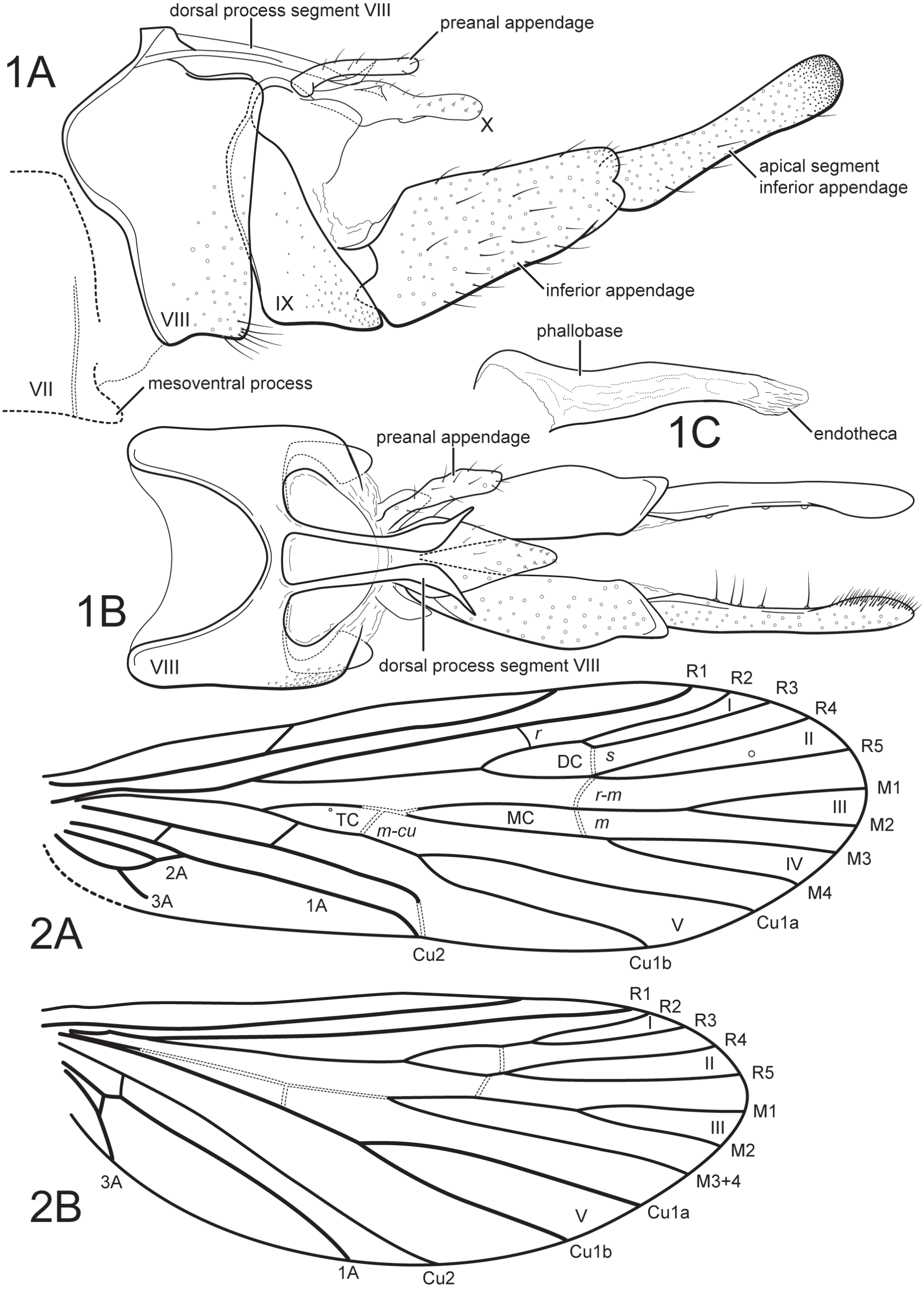


Figure 1–2. 1 *Aymaradella boliviana* gen. n., sp. n. Male genitalia **A** segments VII-X, lateral **B** segments VIII-X, dorsal **C** phallus, lateral. **2** *Aymaradella boliviana*, gen. n., sp. n. Male wings **A** forewing **B** hind wing.

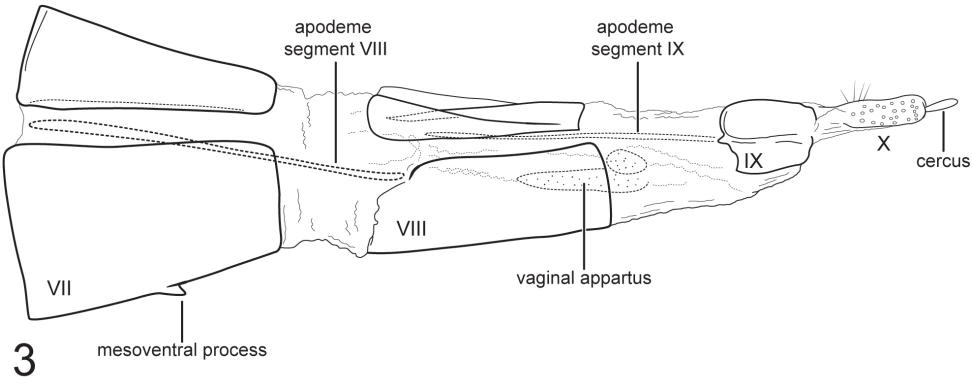


Figure 3. *Aymaradella boliviana*, gen. n., sp. n. Female genitalia, lateral.

Remarks. The generic placement of this new species from Bolivia, which is unlike other Neotropical species of Philopotaminae, requires a discussion of the world fauna, particularly of the genus *Wormaldia*.

Wormaldia, in general, has a cosmopolitan distribution, excluding the Australian region. The Central and South American species of the genus agree in general form with other species in the genus (Muñoz-Quesada and Holzenthal 2015). *Wormaldia* was treated comprehensively by Ross (1956), who recognized two subgenera, *Wormaldia* and *Doloclanes* and a single isolated species from the Philippines, *W. recta* Ulmer. Ross also treated the genus *Gunungiella*, which is characterized by apomorphic and often bizarre modifications of the inferior appendages and a reduced venation, namely with forks III and IV of the forewing absent and also with distinctive reductions and modifications of the hind wing. Only a very few species of *Gunungiella* were known at the time Ross did his revision, but this has changed, especially with a revision of the genus by Schmid (1968), who added 34 new species, mostly from India. Many additional species have been added since then, from India and Southeast Asia to Indonesia (e.g., Huisman 1993, Melnitsky and Ivanov 2010). Ross considered the possibility that *W. recta* might be related to *Gunungiella*, primarily because of its loss of fork IV in the forewing. However, Schmid questioned this placement and decided that the unusual species was probably correctly allied with *Wormaldia*, and thus independently lost fork IV in the forewing. Schmid agreed with Ross that it was a unique and isolated species with many primitive attributes.

The generic name *Doloclanes* has been variably treated by different authors. The genus was established by Banks (1937) for two species from the Philippines. It was reduced to a subgenus of *Wormaldia* by Ross (1956), who provided a rather informal diagnosis and recognized nine species in the subgenus, four of them new. He also reduced the generic names of *Nanagapetus* Tsuda and *Gatlinia* Ross to synonyms. The latter were based on the species *Nanagapetus kisoensis* Tsuda and *Gatlinia mohri* Ross, monotypic genera from Japan and Eastern North America, respectively. *Doloclanes* was subsequently raised to full generic status by Schmid (1991), who provided a more formal diagnosis and described eleven new species from India. The genus was subsequently reduced to synonymy with *Wormaldia* by Sun and Malicky (2002), based on the variability they observed concerning Ross's venational characters in some species (e.g., *W. quadriphylla*). They stated that even a subgeneric status was doubtful. However, no mention was made of Schmid's work and the more extensive list of diagnostic characters he provided. At present, *Doloclanes* is considered a synonym of *Wormaldia*, but its status should probably be considered provisional until a more formal assessment is made. The single North American species placed in *Doloclanes*, *W. mohri*, was subsequently treated by Muñoz-Quesada and Holzenthal (2008), who considered it a member of the *thryia* species group of *Wormaldia*. However, the species rather clearly demonstrates all of the diagnostic criteria used by Schmid to recognize species of *Doloclanes*. Since none of these characters apply to the new species from Bolivia treated here, it cannot be considered a member of the genus *Doloclanes*, regardless of its formal status.

Placement of the new species from Bolivia also requires a consideration of the species of *Wormaldia* from Africa. Ross (1956) placed two African species in what he called the *kyana* group (in the subgenus *Wormaldia*), commenting that they had a peculiar morphology and that they were probably an isolated lineage close to the ancestor of *Wormaldia*. Additional species from Madagascar and the African mainland have been discovered since then, most with elongate and filamentous preanal appendages. Gibon (2014), in describing a number of new species from Madagascar, subsequently divided the African species into the *kyana* group, including four mainland African species, and the *pauliani* group, including eleven species from Madagascar. The Madagascar species seem to consistently lack fork IV in the forewing (as in *W. recta* from the Philippines), as indicated in illustrations of new species from Madagascar by Johanson (2010). However, at least some mainland species have complete and primitive venation for Philopotamidae.

Given the unusual morphology of *W. recta* and the African species of *Wormaldia*, their inclusion in the genus should possibly be reconsidered, especially since the genus is otherwise morphologically uniform and well characterized. It should be noted also that the genus *Thylakion*, from South Africa, while not having the 2A vein of the forewing obsolete, does have it reduced to a stub, much as in the unrelated genus *Chimarrhodella*. *Thylakion* also has processes lateral to tergum X. Its possible relationship to African species of *Wormaldia* should probably be considered. However, these are questions independent of the placement of our new species from Bolivia. Given the fact that it possesses none of the apomorphic characters of the unusual species of *Wormaldia* from either the Philippines or Africa, and has an unusual set of characters of its own, we believe that the most reasonable way to treat the taxon is to assign it to a new genus. The designation also points out the need to include the species in subsequent studies of relationships among and within genera of Philopotaminae, which is sorely needed.

Chimarrhodella choco sp. n.

http://zoobank.org/294225D2-880D-497D-944C-5082317FFFE4
Figs 4, 5

Diagnosis. This new species is distinctive. Especially diagnostic is the coloration, with yellowish head and thorax and brown wings; also diagnostic are the relatively short curved inferior appendages and the characteristic shape of tergum X. The general structure of the inferior appendages, with acute apices, is like that of *C. costaricensis* and species of the *peruviana* group. The linear row of bristle-like setae on the inferior appendage found in the new species, generally characterizes species in both the *galeata* and *peruviana* groups, but apparently not *C. ornata* Blahnik. However, like *C. ornata*, *C. choco* has short preanal appendages and a pale testaceous or yellowish head and thorax. Also it has a relatively simple phallic structure, without the highly pleated endotheca and pleated dorsal expansion that characterizes other species. The short female genitalia resemble those of species in the *galeata* group.

Description. Adult. Forewing length (male) 5.7–6.7 mm (n = 9); (female) 6.1–7.0 (n = 4). Spur formula 2:4:4. Head, thorax, legs, and palps yellowish, setae of head and thorax golden (yellowish orange), postparietal sclerite and mesal suture of head slightly infuscated; basal antennal segments and basal half of subsequent segments brownish, apices yellowish; abdomen grayish brown; setae of wings, tibial spurs (and scant setae of legs) light to medium brown. Maxillary palps relatively short, segment I very short, globular, segments II and IV relatively short, subequal, segment II with apicomesal bristles, segments III and V subequal, moderate in length. Head very elongate (as in *C. galeata* Blahnik & Holzenthal, 1992, fig 1A), distinctly flattened, posparietal sclerite elongate (ca. as long as diameter of eye). Wings held flattened over dorsum of body, nearly horizontal. Wing venation typical for genus, forewing fork IV absent; hind wing 2A reduced to short stub (Blahnik and Holzenthal 1992).

Male. Abdominal segments through VII with relatively sparse, fine setae on sterna and terga, denser posteriorly. Segment VIII relatively short, ca. ½ length of preceding segments, sternum with granulate surface sculpture (posterior margin with fringe of setae, plus premarginal setae mesally); setation of tergum like preceding segments. Segment IX relatively simple in structure, longer than segment VIII, anterior margin nearly linear (slightly concave), ventral margin weakly produced; posterior margin sinuously invaginated at level of inferior appendages, dorsal part setose, broadly rounded and somewhat produced; as viewed dorsally, with dorsal margin narrow, concavely narrowed from both anterior and posterior margins. Tergum X relatively short, bilobed, separated by short, narrow, submembranous mesal lobe; apices of lobes capitate, each with short, acute lateral projection; base of each lobe with prominent lateral conical sensillum; apices of lobes with numerous small sensilla. Preanal appendages short, rounded, fused with posterodorsal margin of tergum IX. Inferior appendages moderately elongate, more or less linear, but distinctly curved dorsad, tapering from base to apex, apex with short, acute projection, lateral margins

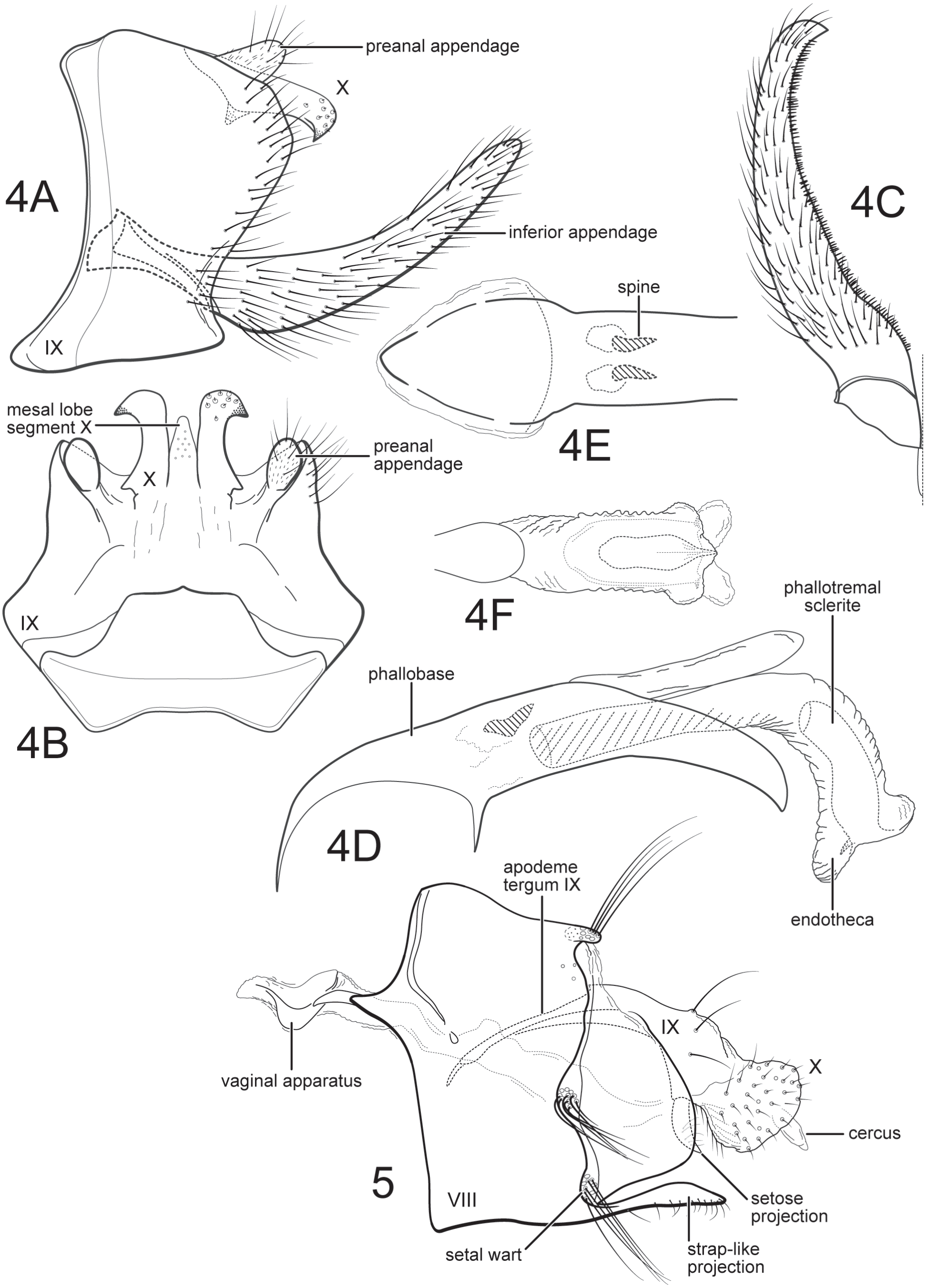


Figure 4–5. 4 *Chimarrhodella choco* sp. n. Male genitalia **A** segments IX–X, lateral **B** segments IX–X, dorsal **C** inferior appendages, ventral **D** phallus, lateral **E** base of phallus, dorsal **F** apex of phallus, dorsal **5** *Chimarrhodella choco*, sp. n. Female genitalia, lateral.

densely setose, mesal margin with linear row of short, stiff setae, extending nearly length of appendage. Phallobase relatively short, with basodorsal expansion, ventral apex projecting, weakly sclerotized, broadly rounded as viewed dorsally or ventrally, internally with 2 short conical sclerotized spines, bases often slightly enlarged; endotheca emerging from tubular structure, distinctly sclerotized basally, membranous and down-curved apically, with short, tubular, weakly sclerotized phallotremal sclerite apically; dorsally with additional hood-like membranous lobe, simple in structure and not at all pleated.

Female. Segment VIII relatively short, with short, but distinct apodemes on anterolateral margin, posterior margin with 3 pairs of setal warts, posteroventral margin with mesal, setose, strap-like projection, fused basally to sternum IX. Tergum IX relatively short, with pair of elongate, narrow apodemes from anterior margin (shorter than length of segment VIII), posterior margin with ca. 3 elongate setae, clustered laterally on either side of segment IX, apically with pair of bulbous, setose projections (tergum X), each with short apical cercus and short setose projection from basoventral margin. Sternum IX short, rounded, lightly sclerotized, not extending beyond ventral strap of segment VIII. Vaginal apparatus membranous, indistinct, apically with small cup-like sclerite.

Holotype. Male. ECUADOR: Imbabura: Reserva Los Cedros, tributary to Rio Los Cedros, 00.30374°N, 78.78229°W, 1312 m, 18-19.x.2011, Holzenthal, Ríos, Encalada, Acosta [UMSP000098416] (UMSP). **Paratypes: ECUADOR: Imbabura:** Reserva Los Cedros, small stream near station, 00.31127°N, 78.78150°W, 1460 m, 17.x.2011, Holzenthal, Ríos, Encalada, Acosta, 5 males (UMSP, MECN); Reserva Los Cedros; Rio de la Plata, 00.32495°N, 78.78084°W, 1587 m, 15.iii.2012, Ríos-Touma, Bragado, Policha, 1 male (UMSP); Reserva Los Cedros, Rio Los Cedros, 00.30359°N, 78.78233°W, 1312 m, 18-19.x.2011, Holzenthal, Ríos, Encalada, Acosta, 1 female (UMSP); **Pichincha:** Amagusa Reserve (private), Río Mashpi Chico "alto", 00.15487°N, 78.85316°W, 1180 m, 17.i.2015, Holzenthal, Huisman, Ríos-Touma, 2 males, 2 females (NMNH, MECN); Río Malimpia in Mashpi Lodge, 00.17063°N, 78.88804°W, 700 m, 18.i.2015, Holzenthal, Huisman, Ríos-Touma, 1 female (UMSP).

Etymology. Named for the Choco-Darién ecoregion, which occurs along the Pacific slope of the Andes from Panama to northwestern Ecuador and is known for its high level endemic biodiversity.

Hydrobiosella andina sp. n.

http://zoobank.org/DB9887DE-E55B-4E9D-B4A2-1881A20FEE34
Figs 6, 7

Diagnosis. This new species is best diagnosed by its venation, elongate and relatively undifferentiated inferior appendages, simple structure of tergum X, and (especially) by the absence of preanal appendages.

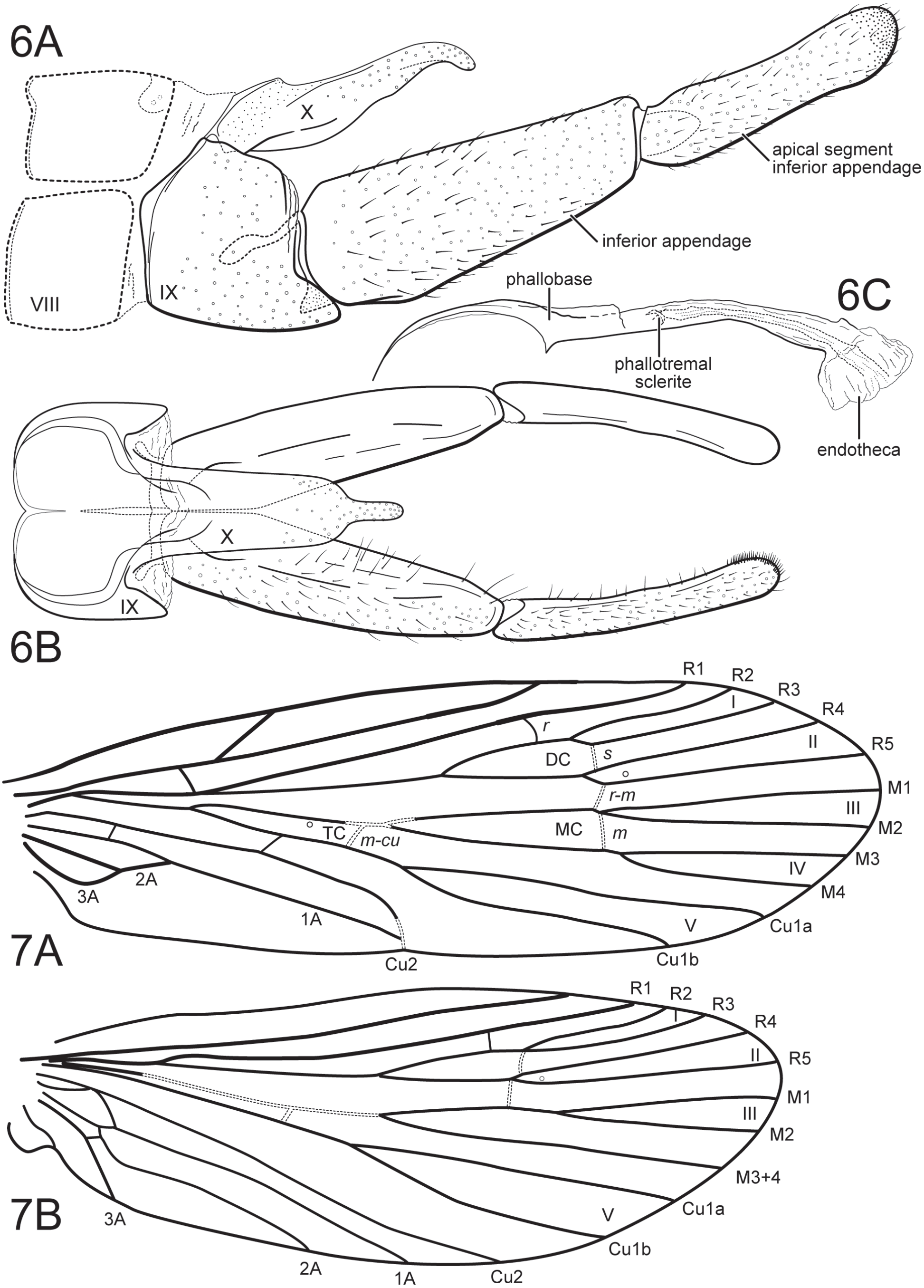


Figure 6–7. 6 *Hydrobiosella andina* sp. n. Male genitalia **A** segments VIII-X, lateral **B** segments IX-X, dorsal **C** phallus, lateral **7** *Hydrobiosella andina*, sp. n. Male wings **A** forewing **B** hind wing

Description. Male. Forewing length 7.8 mm. Spur formula 2:4:4. Overall color fuscous (brownish black), antennae missing (except for scape). Head relatively small, postparietal sclerite moderate in length (shorter than diameter of eye), with 4 dark, stiff bristles subtending eye, eyes without apparent setae between facets. Palps relatively short, segment I very short, globular, segments II and IV short, subequal, II with stout apicomesal bristles, III and V moderate in length, subequal. Hind tibiae distinctly thickened and elongate. Forewing with forks I-V, hind wing with forks I-III and V (IV absent). Forewing with forks I and II slightly subsessile, crossveins *s*, *r-m*, and *m* hyaline and nearly linear, 3A looped to 2A, 2A to 1A, intersecting in proximal half of vein. Hind wing with forks I and II sessile, all 3 anal veins intersecting wing margin.

Genitalia. Sternites (through sternite V) only sparsely setose, V with conspicuous reticulate area surrounding opening of glands, which are well-developed, sternites VI-IX densely setose, with short setae; tergites subquadrate, distinctly narrower than sternites, with paired, desclerotized regions near posterior margins, each with ca. 3 prominent setae (2-5, variation), and also with sparse, minute setae surrounding the desclerotized areas, mostly confined to posterolateral margins. Segment VIII unmodified, only slightly shorter than preceding segments. Segment IX very simple in structure, subquadrate, as viewed laterally, ventral margin ca. twice length of dorsal margin, posteroventral margin slightly projecting; anterior margin nearly linear, with only slightly produced, broadly subtriangular apodemes near middle of segment; venter of segment IX with short suture from anterior margin, dorsum of segment absent (or strap-like and fused to base of tergum X). Tergum X very simple in structure, relatively elongate, narrow, and parallel-sided, apical ¼ abruptly narrowed and similarly parallel-sided, apex rounded, slightly down turned; tergum with numerous minute sensilla, most dense apically and laterally. Preanal appendages absent. Inferior appendages bi-segmented, very elongate, linear, densely setose; basal segment widest near base, narrowing apically; apical segment ca. ¾ length of basal segment, parallel-sided, apex rounded, with dense pad of short, thickened setae on mesal surface. Phallic apparatus very narrow, tubular, much shorter than inferior appendages; phallobase with usual basodorsal expansion, exposed part of endotheca distinctly expanded, apparently elongate (as judged by position of phallotremal sclerite), without spines or ornamentation. Phallotremal sclerite minute, weakly sclerotized.

Female. Unknown.

Holotype. Male. ECUADOR: Tungurahua: Río Verde, 1600 m, 26.xii.1992, VO Becker (UMSP000136163) (NMNH).

Etymology. Named for the Andes Mountains, where the first specimen of this genus in the New World was discovered.

Remarks. The placement of this species in *Hydrobiosella* is somewhat speculative and is based on what was considered by Ross (1956) a diagnostic feature of the genus: absence of preanal appendages (or the appendages very small or fused basally). Neboiss (1977, 1986) also used the absence or reduction of preanal appendages as a character to diagnose the Australian members of *Hydrobiosella*. In general, the genus is not very well defined and the individual species are extremely variable. We consider the placement of this new Ecuadorian species to be provisional, pending a revision of the genus. Most of the characters it possesses could be considered ancestral for Philopotaminae, including its general venation: *s*, *r-m*, and *m* crossveins of forewing hyaline and nearly linear; forks I and II of the forewing sessile or slightly subsessile; 3A of the forewing looped to 2A and 2A looped to 1A (intersecting the vein in the basal ½ of the vein, and without any cross veins); hind wing with all three anal veins reaching the wing margin. If the generic placement is correct, this represents the first record of the genus in the Americas.

***Wormaldia imbrialis* sp. n.**

http://zoobank.org/AB201EF5-3978-4595-88B7-A401A28B2A00
Fig 8, 9

Diagnosis. This species is similar to *W. prolixa* Flint, *W. andrea* Muñoz-Quesada & Holzenthal, and *W. gallardoi* Muñoz-Quesada & Holzenthal, a group of Neotropical *Wormaldia* that was characterized by Muñoz-Quesada and Holzenthal (2015) as having segment IX strongly acute and projecting anterolaterally, the "head" of tergum X convexly subtriangular with its apex subtriangularly widened, and the apical segment of the inferior appendage longer than the basal segment. *Wormaldia imbrialis*, new species, differs from this general character assessment in that segment IX is not strongly projecting anteriorly and the apical segment of the inferior appendage is shorter than the basal. Additionally, the new species differs from other species in the group in having a very long and slender phallic spine, while in the others it is very short and hooked.

Description. Male. Forewing length 3.9 mm. Spur formula 2:4:4, foretibial spurs very short. Wing venation typical for *Wormaldia*: forewing with forks I-V, forks I and II slightly subsessile, *s*, *r-m*, and *m* hyaline and linear, 3A looped to 2A and 2A to 1A, intersecting vein at about midlength, crossveins absent; hind wing with forks I-III and V (fork IV absent), 2A vein absent. General color pale yellowish brown, setae of head and thorax yellowish, with several dark brown setae on postparietal sclerite; palps and antennae darker, palps brown, antennae annulated, with brown setae basally, pale setae apically. Head very short, rounded, eyes conspicuous, with short setae between facets. Postparietal sclerite very short. Both sets of palps very short.

Genitalia. Segment VIII with tergum and sternum very narrowly separated, sternum with numerous short setae, tergum with scattered short setae on posterior half; as viewed laterally, with anterior margin nearly straight, posterior margin concave (conforming with contour of anterior margin of segment IX); as viewed dorsally, with shallow, crescentic posteromesal invagination, bordered laterally by very short spine-like projections and rounded lobes lateral to these. Segment IX synscleritous, dorsal and ventral margins invaginated anteromesally, dorsal margin very short (nearly obsolete), ventral margin about as long as sternum VIII; as viewed laterally, with anterolateral margin broadly rounded, not acutely projecting, posterior margin nearly straight. Tergum X very long, narrow, apex capitate, somewhat recurved dorsally, apex with scattered small sensilla; recurved apical projection acute as viewed laterally, rounded as viewed

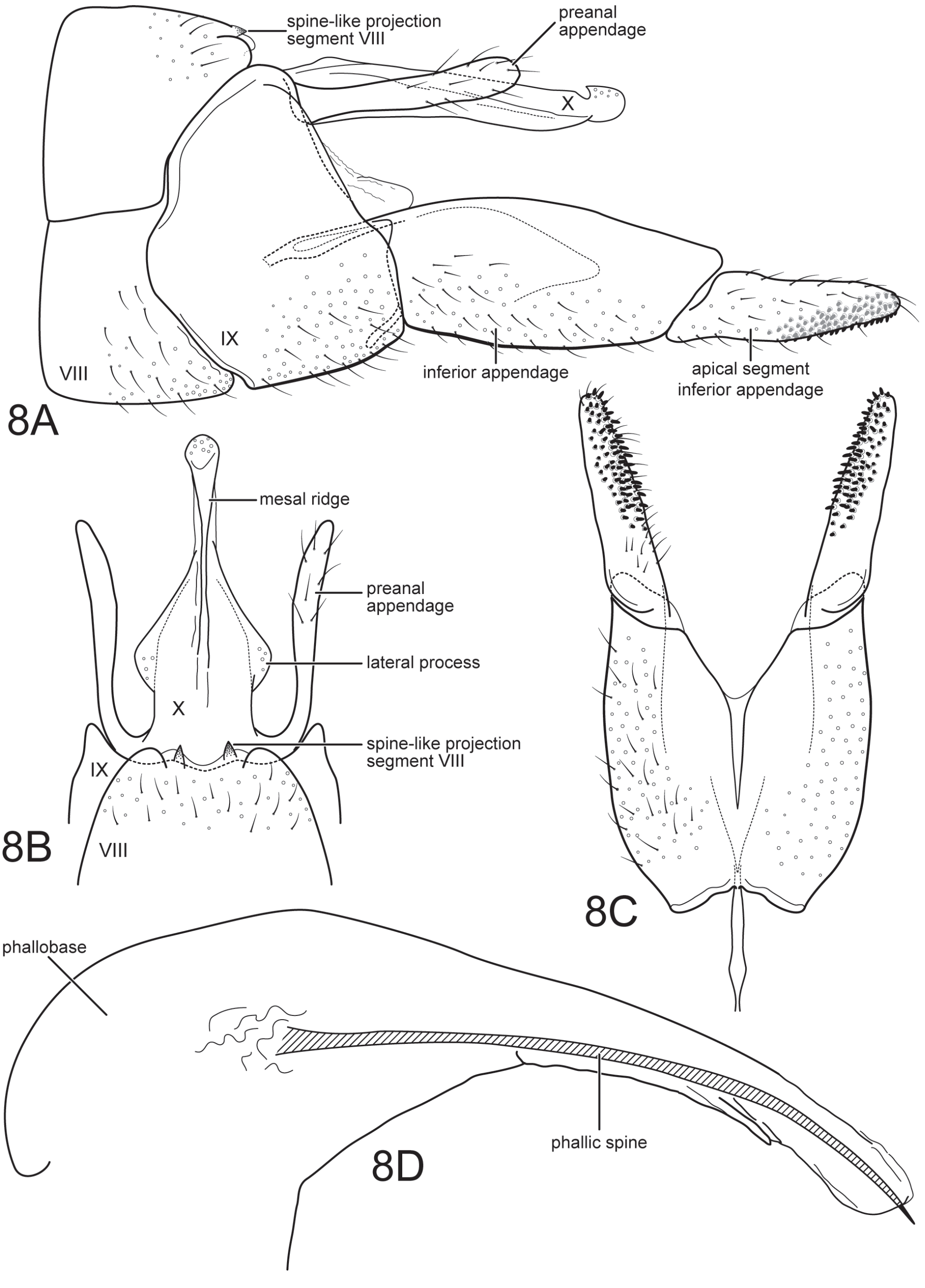


Figure 8. *Wormaldia imbrialis* sp. n. Male genitalia **A** segments VIII-X, lateral **B** segments VIII-X, dorsal **C** inferior appendages, ventral **D** phallus, lateral.

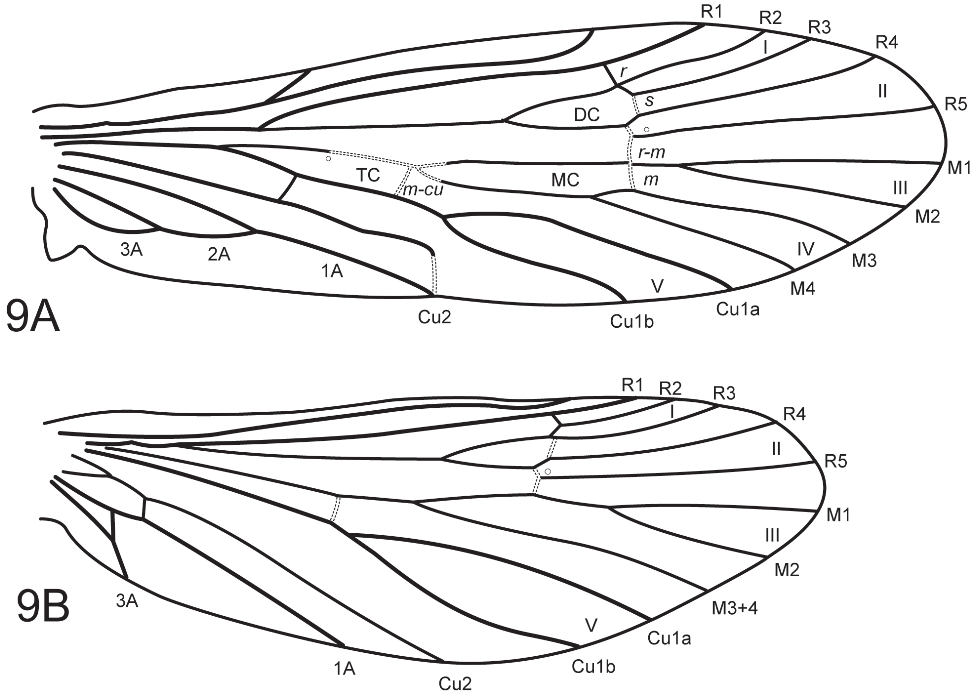


Figure 9. *Wormaldia imbrialis* sp. n. Male wings **A** forewing **B** hind wing.

dorsally; apex of tergum continuous with rod-like mesal ridge, extending nearly to base; basal margins of tergum with rounded (or subangular) lateral projections as viewed dorsally, each with scattered small sensilla. Preanal appendages relatively elongate, digitate, somewhat curved basally (as viewed dorsally). Inferior appendages with basal segment elongate and wide, extending beyond tergum X; apical segment ca. ⅔ length of basal segment and much narrower, tapering apically, apex rounded, mesal surface with short, thick, spine-like setae, extending for ca. apical ⅔ of segment. Phallic apparatus proportionately very large, phallobase with greatly inflated basodorsal projection, narrowing apically; internally with very elongate, narrow spine, apex of spine acuminate.

Female. Unknown.

Holotype. Male. ECUADOR: Pichincha: Amagusa Reserve (private), Río Mashpi Chico "alto", 00.15487°N, 78.85316°W, 1180 m, 17.i.2015, Holzenthal, Huisman, Ríos-Touma (UMSP000146946) (UMSP).

Etymology. From the Latin *imbrialis*, meaning "of rain" and referring to the night of the collection when a huge downpour occurred after the species was captured.

Remarks. Despite the variation of *W. imbrialis*, from others in the *prolixa* group listed above and defined by Muñoz-Quesada and Holzenthal (2015), we note additional characters that indicate its probable inclusion in the group. All four species have similarities of tergum X and also similarities in the apical segment of the inferior appendage, including both its shape and accompanying elongate patch of short, spine-like setae. Also, each of these species has the dorsum of segment VIII with a shallow, crescentic, posteromesal invagination, bordered laterally by very short to short spine-like or thumb-like projections.

New record

Chimarrhodella peruviana (Ross) 1956 1956:69 [Type locality: Perú, Cusco, Paucartambo, Cosnipata Valley; INHS; ♂; in *Protarra*]. —Flint 1991:25 [♂; distribution]. —Blahnik and Holzenthal 1992:121 [♂; ♀; distribution]. —Flint 1996:385 [distribution]. —Muñoz-Quesada 2000:280 [checklist].

New records. ECUADOR: Morona-Santiago: tributary to Río Abanico, Hwy E46 (via Río Bamba-Macas), 2.24985°S, 78.20238°W, el. 1531 m, 12.xi.2015, Ríos-Touma, Thomson, Amigo, 2 males, 2 females (UMSP). **Sucumbios:** Reserva Municipal La Bonita, road from La Bonita to La Sofia, 0.343278°N, 77.6443721°W, el. 1416 m, 16.xi.2017, Thomson, Ríos-Touma, Amigo, 1 female (UMSP); road from La Bonita to Umpaqui, Río Seco, 0.471334°N, 77.558069°W, el. 1777 m, 17.xi.2017, Thomson, Ríos-Touma, Amigo, 1 female (UMSP).

Distribution. Colombia, **Ecuador**, Perú, Venezuela.

Discussion

The description of these taxa, including a new genus and a new continental record of a formerly Australian endemic genus, indicates that there is still much to be learned and discovered of the taxonomy of the Philopotamidae of South America. Similarly, the phylogenetic and historical biogeographic relationships of the South American fauna have yet to be studied. *Hydrobiosella*, at least, shares a similar trans-Antarctic distribution pattern with Hydrobiosidae, several genera of Leptoceridae, Smicrideinae of Hydropsychidae, and *Austrotinodes*, among other groups (Cartwright 2009; Holzenthal et al. 2007; Holzenthal and Blahnik 2010). Of the other South American philopotamids, only the relationships among species of *Chimarrhodella* and *Chimarra* have been studied (Blahnik 1998; Blahnik and Holzenthal 1992; Kjer et al. 2014; Wahlberg and Johanson 2014).

Acknowledgements

This research was supported by University of Minnesota Agricultural Experiment Station projects MIN17-017 and 17-094 and Universidad de Las Americas project AMB. BRT.17.005 “Diversidad y Distribución de Trichoptera de Ecuador.” We are grateful to Los Cedros (Jose DeCoux), Mashpi Lodge (Carlos Moroczh), and Amagusa Biodiversity Reserves (Sergio and Doris Basantes) for the facilities during our field trips. We thank Andrea C. Encalada, Raúl Acosta, Jolanda Huisman, Robin Thomson, and Xavier Amigo (*Nature Experience*) for field assistance.

References

Banks N (1937) Philippine neuropteroid insects. Philippine Journal of Science 63: 125–174.

Blahnik RJ (1998) A revision of the Neotropical species of the genus *Chimarra*, subgenus *Chimarra* (Trichoptera: Philopotamidae). Memoirs of the American Entomological Institute 59: 1–318.

Blahnik RJ (2004) New species of *Chimarrhodella* from Venezuela and Ecuador (Trichoptera: Philopotamidae). Zootaxa 552: 1–7. https://doi.org/10.11646/zootaxa.552.1.1

Blahnik RJ (2005) *Alterosa*, a new caddisfly genus from Brazil (Trichoptera: Philopotamidae). Zootaxa 991: 3–60. https://doi.org/10.11646/zootaxa.991.1.1

Blahnik RJ, Holzenthal RW (1992) Revision of the Neotropical genus *Chimarrhodella* Lestage (Trichoptera: Philopotamidae). Systematic Entomology 17: 109–132. https://doi.org/10.1111/j.1365-3113.1992.tb00325.x

Blahnik RJ, Holzenthal RW (2004) Collection and curation of Trichoptera, with an emphasis on pinned material. Nectopsyche, Neotropical Trichoptera Newsletter 1: 8–20. http://hdl.handle.net/11299/190744

Blahnik RJ, Holzenthal RW, Huisman J (2009) *Chimarra* of Sabah and Sarawak, northern Borneo (Trichoptera: Philopotamidae). Tijdschrift voor Entomologie 152: 109–166. https://doi.org/10.1163/22119434-900000272

Blahnik RJ, Holzenthal RW, Prather AL (2007) The lactic acid method for clearing Trichoptera genitalia. In: Bueno-Soria J, Barba-Álvarez R, Armitage BJ (Eds) Proceedings of the 12th International Symposium on Trichoptera. The Caddis Press, Columbus, Ohio, 9–14.

Cartwright DI (2009) *Austrotinodes* Schmid, a South and Central American caddisfly genus, newly recorded in Australia, with the description of new species (Trichoptera: Ecnomidae). Zootaxa 2142: 1–19.

Cartwright DI (2010) Studies of Australian *Hydrobiosella* Tillyard: a review of the Australian species of the *Hydrobiosella bispina* Kimmins group (Trichoptera: Philopotamidae). Memoirs of Museum Victoria 67: 1–13. https://doi.org/10.24199/j.mmv.2010.67.01

Dumas LL, Nessimian JL (2013) New species of the caddisfly genus *Alterosa* Blahnik 2005 (Trichoptera: Philopotamidae: Philopotaminae) from Brazil. Zootaxa 3609: 26–48. https://doi.org/10.11646/zootaxa.3609.1.2

Flint Jr OS (1991) Studies of Neotropical caddisflies, XLV: The taxonomy, phenology, and faunistics of the Trichoptera of Antioquia, Colombia. Smithsonian Contributions to Zoology 520: 1–113. https://doi.org/10.5479/si.00810282.520

Flint Jr OS (1996) The Trichoptera collected on the expeditions to Parque Manu, Madre de Dios, Peru. In: Wilson DE, Sandoval A (Eds) Manu, the biodiversity of southeastern Peru. Smithsonian Institution, Washington, DC, 369–430.

Gibon F-M (2014) Philopotaminae of Madagascar (Trichoptera: Philopotamidae). Annales de la Societe Entomologique de France 50: 382–398. https://doi.org/10.1080/00379271.2014.982027

Holzenthal RW, Blahnik RJ (2010) Systematics of the Neotropical caddisfly genus *Notidobiella* Schmid (Trichoptera, Sericostomatidae), with the description of 3 new species. ZooKeys 71: 23–47. https://doi.org/10.3897/zookeys.71.791

Holzenthal RW, Calor AR (2017) Catalog of the Neotropical Trichoptera (Caddisflies). ZooKeys 654: 1–566. https://doi.org/10.3897/zookeys.654.9516

Holzenthal RW, Blahnik RJ, Prather AL, Kjer KM (2007) Order Trichoptera Kirby, 1813 (Insecta), caddisflies. Zootaxa 1668: 639–698.

Huisman J (1993) New species of *Gunungiella* (Trichoptera: Philopotamidae) from Sabah, East Malaysia. Zoologische Mededelingen (Leiden) 67: 75–89.

Johanson KA (2010) Description of sixteen new species of Trichoptera with a key to adults of known families and genera recorded in Madagascar. African Entomology 18: 267–301. https://doi.org/10.4001/003.018.0206

Johanson KA, Oláh J (2012) Revision of the Fijian *Chimarra* (Trichoptera, Philopotamidae) with description of 24 new species. Zootaxa 3354: 1–58.

Kjer KM, Zhou X, Frandsen PB, Thomas JA, Blahnik RJ (2014) Moving toward species-level phylogeny using ribosomal DNA and COI barcodes: an example from the diverse caddisfly genus *Chimarra* (Trichoptera: Philopotamidae). Arthropod Systematics & Phylogeny 72: 345–354.

Melnitsky SI, Ivanov VD (2010) New species of the family Philopotamidae (Insecta: Trichoptera) from Malaysia and Indonesia. Trudy Zoologicheskogo Instituta 314: 323–332.

Morse JC (2017) Trichoptera World Checklist. http://entweb.clemson.edu/database/trichopt/index.htm [accessed 25 May 2017]

Muñoz-Quesada F (2000) Especies del orden Trichoptera (Insecta) en Colombia. Biota Colombiana 1: 267–288.

Muñoz-Quesada FJ, Holzenthal RW (2008) Revision of the Nearctic species of the caddisfly genus *Wormaldia* McLachlan (Trichoptera: Philopotamidae). Zootaxa 1838: 1–75.

Muñoz-Quesada FJ, Holzenthal RW (2015) Revision of the Neotropical species of the caddisfly genus *Wormaldia* McLachlan (Trichoptera: Philopotamidae). Zootaxa 3998: 1–138. https://doi.org/10.11646/zootaxa.3998.1.1

Neboiss A (1977) A taxonomic and zoogeographic study of Tasmanian caddis flies (Insecta: Trichoptera). Memoirs of the National Museum of Victoria 38: 1–208. https://doi.org/10.24199/j.mmv.1977.38.01

Neboiss A (1986) Atlas of Trichoptera of the SW Pacific-Australian Region, Series Entomologica 37. Dr W. Junk, Dordrecht, 286 pp. https://doi.org/10.1007/978-94-009-4814-3

Ríos-Touma B, Holzenthal RW, Huisman J, Thomson R, Rázuri-Gonzales E (2017) Diversity and distribution of the Caddisflies (Insecta: Trichoptera) of Ecuador. Peerj 5: e2851. https://doi.org/10.7717/peerj.2851

Ross HH (1956) Evolution and Classification of the Mountain Caddisflies. University of Illinois Press, Urbana, 213 pp.

Schmid F (1968) Le genre *Gunungiella* Ulmer (Trichoptères: Philopotamides). Canadian Entomologist 100: 897–957. https://doi.org/10.4039/Ent100897-9

Schmid F (1991) Quelques philopotamides orientaux ou peu connus (Trichoptera, Annulipalpia). Beaufortia 42: 89–107.

Sun C, Malicky H (2002) 22 new species of Philopotamidae (Trichoptera) from China. Linzer Biologische Beiträge 34: 521–540.

Ulmer G (1957) Köcherfliegen (Trichopteren) von den Sunda-Inseln. Teil III. Larven und Puppen der Annulipalpia. Archiv für Hydrobiologie, Supplement 23: 109–470.

Wahlberg E, Johanson KA (2014) The age, ancestral distribution and radiation of *Chimarra* (Trichoptera: Philopotamidae) using molecular methods. Molecular Phylogenetics and Evolution 79: 433–442. https://doi.org/10.1016/j.ympev.2014.06.023

ZooKeys 780: 109–136 (2018)
doi: 10.3897/zookeys.780.25859
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

A new earless species of *Poyntonophrynus* (Anura, Bufonidae) from the Serra da Neve Inselberg, Namibe Province, Angola

Luis M. P. Ceríaco[1,2,3], Mariana P. Marques[3,4], Suzana Bandeira[2,5], Ishan Agarwal[2], Edward L. Stanley[6], Aaron M. Bauer[2], Matthew P. Heinicke[1], David C. Blackburn[6]

1 *Department of Natural Sciences, University of Michigan-Dearborn, 4901 Evergreen Road, Dearborn, Michigan 48128, USA* **2** *Department of Biology, Villanova University, 800 Lancaster Avenue, Villanova, Pennsylvania 19085-1699, USA* **3** *Museu Nacional de História Natural e da Ciência, Universidade de Lisboa, Rua da Escola Politécnica, 58, 1269-102 Lisboa, Portugal* **4** *Research Center in Biodiversity and Genetic Resources (CIBIO), InBIO, University of Porto, Rua Padre Armando Quintas 7, Vairão, 4485-661 Porto, Portugal* **5** *Instituto Nacional da Biodiversidade e Áreas de Conservação (INBAC), Ministério do Ambiente de Angola, Centralidade do Kilamba, Rua 26 de Fevereiro, Quarteirão Nimi Ya Lukemi, edifício Q11, 3° andar, Angola* **6** *Department of Natural History, Florida Museum of Natural History, University of Florida, Gainesville, Florida 32611, USA*

Corresponding author: *Luis M. P. Ceríaco* (luisceriaco@gmail.com)

Academic editor: *A. Crottini* | Received 17 April 2018 | Accepted 5 July 2018 | Published 8 August 2018

http://zoobank.org/A088FFEB-15D7-4E1D-AECD-09623AE57066

Citation: Ceríaco LMP, Marques MP, Bandeira S, Agarwal I, Stanley EL, Bauer AM, Heinicke MP, Blackburn DC (2018) A new earless species of *Poyntonophrynus* (Anura, Bufonidae) from the Serra da Neve Inselberg, Namibe Province, Angola. ZooKeys 780: 109–136. https://doi.org/10.3897/zookeys.780.25859

Abstract

African pygmy toads of the genus *Poyntonophrynus* are some of the least known species of African toads. The genus comprises ten recognized species endemic to sub-Saharan Africa, five of which are restricted to southwestern Africa. Recent field research in Angola provided new material for three species of *Poyntonophrynus*, including a morphologically distinctive population from the Serra da Neve Inselberg. Based on a combination of external morphology, high-resolution computed tomography scanning, and molecular phylogenetic analysis, the Serra da Neve population is described as new species that is nested within the genus. The most striking character that differentiates the newly described species from its congeners is the lack of a tympanic middle ear, a condition common in the family Bufonidae, but so far not known for *Poyntonophrynus*. The description of this new species from southwestern Angola reinforces the biogeographic importance of the region and further suggests that southwestern Africa is the cradle of diversity for this genus.

Keywords

Africa, Amphibia, columella, osteology, toad

Introduction

African pygmy toads of the genus *Poyntonophrynus* Frost et al., 2006, are a group of 'true' toads (family Bufonidae) that are endemic to sub-Saharan Africa (du Preez and Carruthers 2009, 2017). Similarities among what Poynton (1964) termed the *Bufo* '*vertebralis* group' were recognized long before a genus was erected for them (Boulenger 1905, Mertens 1955, Poynton 1964, Tandy 1972, Poynton and Haacke 1993). Likewise, their similarity to those species today placed in the genus *Mertensophryne* has also long been acknowledged (Tandy 1972, Poynton 1996, Frost et al. 2006). However, the diversity and relationships of taxa in this group have remained contentious and confusing. Tandy (1972, Tandy and Keith 1972) revised Poynton's (1964) '*vertebralis* group' by excluding *Bufo taitanus* but adding both *B. lughensis* and *B. parkeri* due to similarities with *B. dombensis* and *B. fenoulheti*, respectively. The recognized diversity of this group has remained largely static since the description of *B. grandisonae* by Poynton and Haacke (1993) and the short summary by Poynton (1996).

Frost et al. (2006) recognized the genus *Poyntonophrynus* for a group of ten species that have typically been referred to as the '*vertebralis* group' (Poynton 1964, Tandy 1972, Poynton and Broadley 1988, Poynton 1996). However, this was based solely on the results of Cunningham and Cherry (2004), who sampled three of these ten species finding that they form a clade exclusive of other African bufonids. Van Bocxlaer et al. (2010) first confirmed the long-suspected close phylogenetic relationship between the species recognized by Frost et al. (2006) as *Mertensophryne* and *Poyntonophrynus*. This result was expanded upon recently by Liedtke et al. (2017) who included new data for seven of the ten species included by Frost et al. (2006) in *Poyntonophrynus*.

There are currently ten recognized species in the genus *Poyntonophrynus*, all of which are small terrestrial toads with inconspicuous parotoid glands and lacking a tarsal fold. One East African species, however, *Poyntonophrynus lughensis* (Loveridge, 1932), was recently demonstrated to be more closely related to *Mertensophryne* (Liedtke et al. 2017). The remaining nine species are found in sub-Saharan Africa, with most of the diversity concentrated in Angola and Namibia. While the life history of the majority of these species is not well known, at least some species breed in shallow rocky pools and metamorphose relatively quickly (within ~3 weeks; Power 1926, Channing 1976, Channing and Vences 1999, Channing et al. 2012). The currently recognized species include the following: *P. beiranus* (Loveridge, 1932a), distributed in two populations, one in the coastal areas of Mozambique and another in southwestern and central Zambia; *P. damaranus* (Mertens, 1954), known from northwestern Namibia, but potentially also occurring in southwestern Angola; *P. dombensis* (Bocage, 1895), extending from southwestern Angola to central Namibia; *P. fenoulheti* (Hewitt & Methuen, 1912), with five described subspecies (*fenoulheti*, *obtusum*, *albiventris*, *rhodesianus* and *grindleyi*, all currently synonymized with

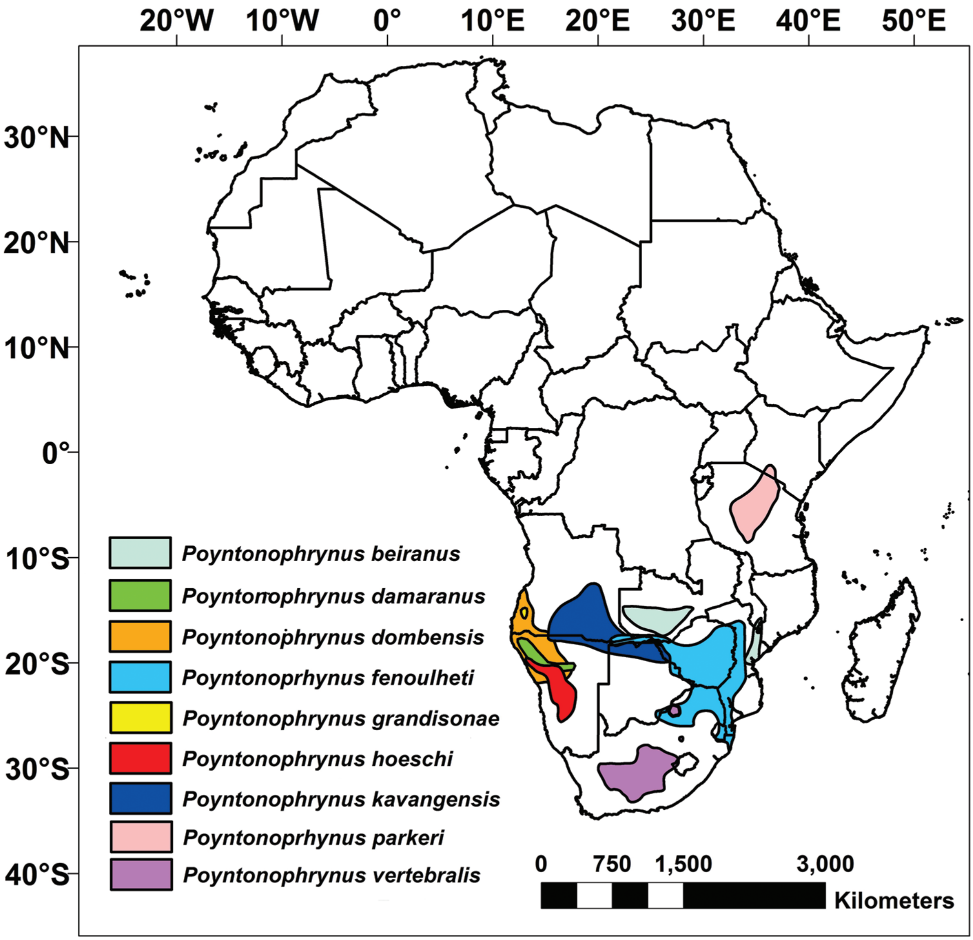


Figure 1. Known distribution of the nine currently accepted *Poyntonophrynus* species in Africa.

the nominotypical form – see Frost 2017), occurring in western Mozambique, northeastern South Africa, Zimbabwe, the Caprivi Strip of Namibia, and portions of eastern and northern Botswana and southern Zambia; *P. grandisonae* (Poynton & Haacke, 1993), endemic to southwestern Angola (Namibe Province); *P. hoeschi* (Ahl, 1934), endemic to the central-western regions of Namibia; *P. kavangensis* (Poynton & Broadley, 1988), occurring in the Kavango River basin, in western Zimbabwe, northern Botswana, northern Namibia and southern Angola; *P. parkeri* (Loveridge, 1932b), restricted to northern Tanzania and southern Kenya; and *P. vertebralis* (Smith, 1848), the type species of the genus, occurring in central South Africa (Figure 1). Our current knowledge of the diversity of *Poyntonophrynus* remains limited and some species, such as *P. grandisonae* and *P. parkeri*, have not been documented since their original descriptions. Notably, five species of *Poyntonophrynus* occur in southwestern Africa, with four occurring in Namibia (*P. dombensis*, *P. hoeschi*, *P. damaranus* and *P.*

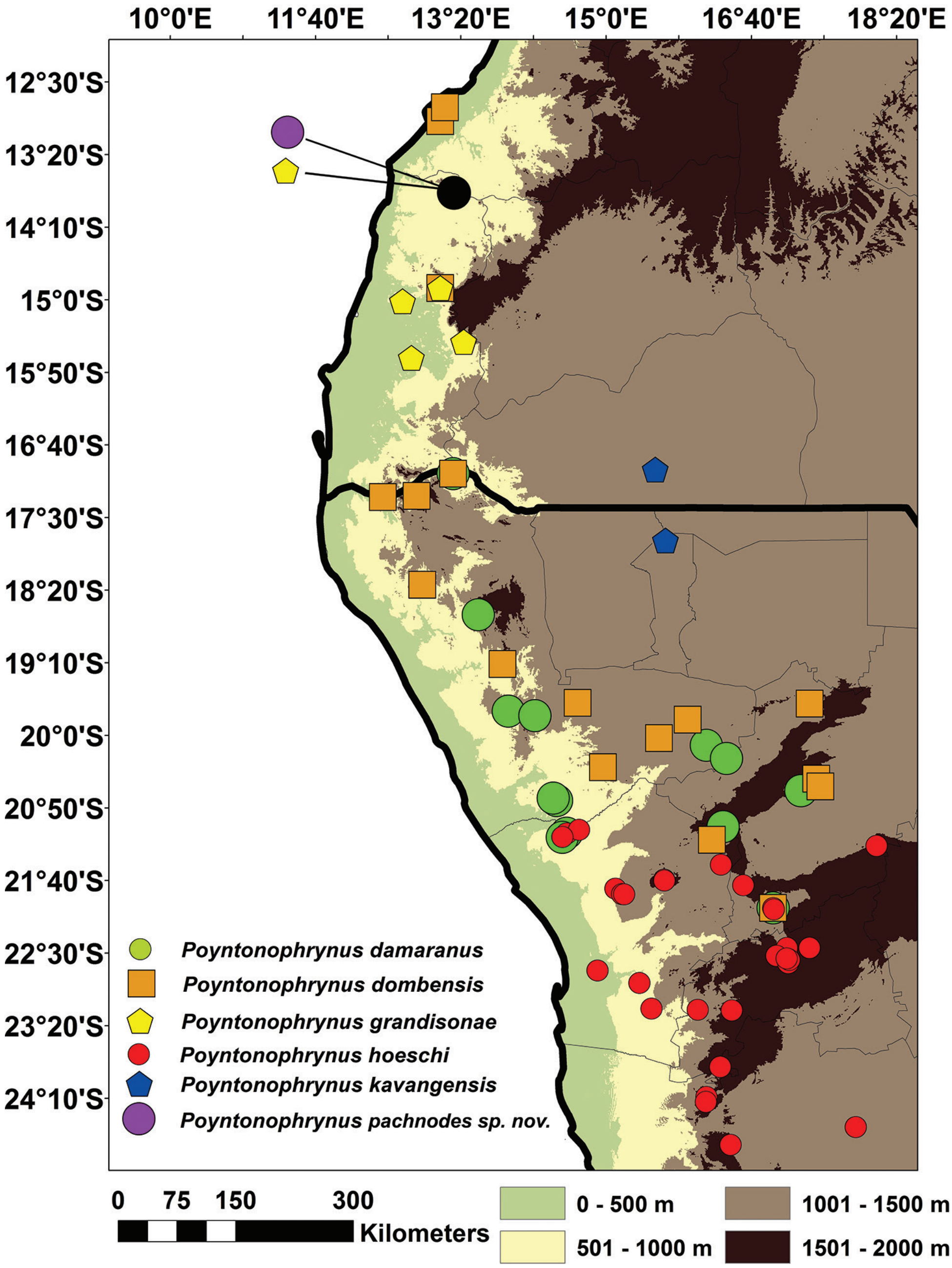


Figure 2. Bibliographic and confirmed museum records of the different *Poyntonophrynus* species occurring in southwestern Angola and northwestern Namibia.

kavangensis; Figure 2) and other four in southern Angola (*P. dombensis*, *P. fenoulheti*, *P. grandisonae*, and *P. kavangensis*). It is possible that other species of *Poyntonophrynus* also occur in Angola (Figure 2).

Despite being among the better explored regions in Angola, there are still new distributional records and undescribed species of reptiles and amphibians being discovered in the coastal lowlands of Namibe and Benguela provinces (Conradie et al. 2012, Ceríaco et al. 2016). These included the Slender Feather-tailed Gecko, *Kolekanos plumicaudus* (Haacke, 2008), the sole representative of the endemic genus *Kolekanos* Heinicke, Daza, Greenbaum, Jackman & Bauer, 2014; Haacke's Sand Lizard, *Pedioplanis haackei* Conradie, Measey, Branch & Tolley, 2012, and Huntley's Sand Lizard, *P. huntleyi* Conradie, Measey, Branch & Tolley, 2012; and the Kaokoveld Girdled Lizard, *Cordylus namakuiyus* Stanley, Ceríaco, Bandeira, Valério, Bates & Branch, 2016. Namibe Province also harbors four other endemic lizard species (Ansorge's Gecko, *Afrogecko ansorgii* (Boulenger, 1907), the Angolan Thick-Toed Gecko, *Pachydactylus angolensis* Loveridge, 1944, the Angolan Namib Day Gecko, *Rhoptropus taeniostictus* Laurent, 1964, and Bogert's Dotted Blind Dart Skink, *Typhlacontias punctatissimus bogerti* Laurent, 1964) and the poorly known endemic Grandison's Pygmy Toad, *Poyntonophrynus grandisonae*. Some species known to occur in neighboring Namibia have also recently been found in Namibe Province, including the Large-Scaled Thick-Toed Gecko, *Pachydactylus scutatus* Hewitt, 1927, and the Damaraland Sand Frog, *Tomopterna damarensis* Dawood & Channing, 2002, previously known only from its type locality in Khorixas, Namibia (Ceríaco et al. 2016, Heinicke et al. 2017a).

During recent field research in Angola, we collected specimens representing several species of *Poyntonophrynus*. These include the second record for Angola of *P. dombensis*, the first specimens of *P. grandisonae* since the type series, and one undescribed species, with which this paper deals (Marques 2015). On Serra da Neve, an isolated inselberg in northern Namibe Province and the second highest peak in Angola (2489 m a.s.l. fide Pereira 1977), we collected specimens of a unique taxon of small toad. These specimens lack an externally visible ear, but otherwise are morphologically similar to species in the genus *Poyntonophrynus*. Despite considerable differences in size and shape, all described species of this genus have a visible tympanum, thus suggesting that the Serra da Neve population represents an unknown taxon. Based on our molecular phylogenetic and morphological studies, we describe this population from Serra da Neve as a new species of pygmy toad. We conclude by briefly discussing the biogeographic importance of the Serra da Neve Inselberg and the arid lowland areas of southwestern Angola.

Materials and methods

Specimens examined

Specimens collected for this study were preserved in 10% neutral buffered formalin in the field and transferred to 70% ethanol for storage. Liver tissue was removed before formalin fixation and preserved in either 95% ethanol or RNA Later. Specimens are deposited in the Florida Museum of Natural History at the University of Florida (**UF**; Gainesville, USA), the California Academy of Sciences (**CAS**; San Francisco, USA), the Instituto Nacional da Biodiversidade e Áreas de Conservação (**INBAC**; Kilamba-Kiaxi, Angola), and the Museu Nacional de História Natural e da Ciência (**MUHNAC**; Lisboa, Portugal). We made comparisons with specimens in the Museum of Comparative Zoology of Harvard University (**MCZ**; Cambridge, USA) as well as consulted data presented in the descriptions of *Poyntonophrynus* species and other relevant works (e.g., Poynton and Broadley 1988, Channing 2001, du Preez and Carruthers 2009, 2017).

Molecular methods

Portions of the mitochondrial 16S gene and nuclear RAG-1 gene were sequenced for newly collected specimens of *Poyntonophrynus grandisonae* and the undescribed samples from Serra da Neve. Methods of tissue extraction, PCR, and sequencing follow Heinicke et al. (2017b). DNA was extracted from preserved liver samples using the Qiagen DNeasy Blood and Tissue kit following the manufacturer's protocol. PCR reactions were performed for 40 cycles at an annealing temperature of 50 °C, using the primer pair 16SA (5'-CGCCTGTTTATCAAAAACAT-3') and 16SB (5'-CCGGTCTGAACTCAGATCACGT) (Palumbi et al. 1996) and the primer pair RAG1-C (5'-GGAGATGTTAGTGAGAARCAYGG) and RAG1-E (5'-TCCGCTGCATTTCCRATGTCRCA) (Biju and Bossuyt 2003). Following PCR, DNA was purified with Axygen AxyPrep magnetic beads, and purified DNA was sequenced at the University of Michigan DNA sequencing core.

Sequence assembly was performed using BioEdit 7.0.5.3 (Hall 1999), and new sequences were deposited in GenBank (Table 1). The new sequences were then integrated into a data set consisting of all *Poyntonophrynus*, *Mertensophryne*, and *Capensibufo* sequences used in Liedtke et al. (2017), which include 16S and RAG-1, but also sequences of 12S, CO1, ND2, and CXCR4 (Table 1). All previously sequenced species of *Poyntonophrynus* and *Mertensophryne* were included in that particular data set. Although Liedtke et al. (2017) provided the first genetic data for several species of *Poyntonophrynus*, there are no voucher specimens associated with these data to compare to our specimens (J. Streicher, pers. comm.). Sequences of each gene were aligned using ClustalX (Larkin et al. 2007). Following alignment, the best performing partition scheme was identified using PartitionFinder 2.1.1 (Lanfear et al. 2012), treating each gene and each codon position of the protein-coding genes as potentially unique character sets, and performing a greedy search on the 56 commonly used models of evolution.

A maximum likelihood phylogenetic analysis was performed using IQ-TREE 1.5 (Nguyen et al. 2015). Partition and model choice were based on the best-fitting scheme as determined by PartitionFinder, resulting in a scheme using the following 11 partitions and models: 12S/16S (GTR+I+G); CO1 position 1 (TrN+I+G); CO1 position 2/CXCR4 position 2 (TrN+I); CO1 position 3 (TIM+G); ND2 position 1 (GTR+G); ND2 position 2 (TIM+I); ND2 position 3 (GTR+G); RAG1 position 2/CXCR4 position1 (HKY); CXCR4 position 3 (HKY+G); RAG1 position 1 (TVM);

Table 1. Sample identifications and GenBank accession numbers of sequences used in phylogenetic analyses. Specimen ID acronyms: KTH – Krystal Tolley Field collection; HF – Harith Farooq field collection; MTSN – Museo Tridentino di Scienze Naturali, Trento, Italy; BM – Natural History Museum, London, United Kingdom; MCZ – Museum of Comparative Zoology, Harvard University, USA; JM – John Measey field collecion; AACRG – Louis Du Preez field collection; AMB – Aaron M. Bauer field collection; BP – Anonymous field collection; VG – Miloslav Jirků field collection; UF – University of Florida, Museum of Natural History, Gainesville, USA.

Species	Specimen ID	12S	16S	CO1	ND2	CXCR4	RAG1
Capensibufo rosei	KTH 09-335	KF664868	KF665294	KF665706	–	KF665976	KF666159
Mertensophryne anotis	HF 33	KY555630	KY555643	KY555662	–	–	KY555712
Mertensophryne howelli	MTSN-T2202	KF664964	KF665247	KF665531	–	KF666045	KF666383
Mertensophryne lindneri	BM 2002.394	KF664736	KF665426	KF665790	–	KF665953	KF666333
Mertensophryne loveridgei	MCZ A-32084	KF664924	KF665338	KF665572	KY555685	KF665947	KF666463
Mertensophryne micranotis	MCZ A-32087	KF665020	KF665240	KF665579	KY555703	KF666123	KF666378
Mertensophryne nyikae	MCZ A-137123	KY555631	KY555647	KY555657	–	–	KY555722
Mertensophryne taitana	JM 773	KF664809	KF665047	KF665612	KY555705	KF665995	KF666310
Mertensophryne usambarae	MTSN 9541	KF665026	KF665336	KF665800	–	KF666115	KF666360
Mertensophryne uzunguensis	BM 2002.157	KF664717	KF665170	KF665699	–	FJ882720	KF666366
Poyntonophrynus beiranus	HF 30	KY555625	KY555650	KY555665	–	–	KY555721
Poyntonophrynus damaranus	n/a	–	AF220905	–	AF463793	–	–
Poyntonophrynus dombensis	n/a	AF220857	AF220907	–	AF463794	–	–
Poyntonophrynus fenoulheti	AACRG 1598	KF664732	KF665265	KF665592	KY555710	KF666066	KF666249
Poyntonophrynus grandisonae	AMB 10337	–	MH469716	–	–	–	MH469717
Poyntonophrynus hoeschi	n/a	AF220828		–	–	–	–
Poyntonophrynus kavangensis	BP-001	KY555627	KY555648	KY555658	–	–	–
Poyntonophrynus lughensis	VG001	KY555626	KY555641	KY555659	KY555700	KY555666	KY555723
Poyntonophrynus pachnodes sp. n.	UF 184184	–	MH469718	–	–	–	MH469719

RAG1 position 3 (TrN+G). Branch support was assessed with 1000 bootstrap replicates. The resulting tree was rooted using *Capensibufo*, which recent published phylogenies suggest to be closely related to but outside of a clade containing *Poyntonophrynus* and *Mertensophryne* (Liedtke et al. 2017).

Morphological methods

Osteological data were obtained from six specimens of the Serra da Neve population, 18 additional *Poyntonophrynus* specimens, and five specimens of *Mertensophryne* (see Suppl. material 1). We performed high-resolution x-ray computed tomography (CT-scanning) at the University of Florida's Nanoscale Research Facility. We used a Phoenix v|tome|x M (GE Measurement & Control, Boston, USA) scanner with a 180 kv x-ray tube with a diamond-tungsten target and with the following settings: Voltage = 75–100 kV, Current = 200 mA, 0.2–0.3 second detector capture time, averaging three images per rotation, and voxel resolution of 17–31 µm (see Suppl. material 1: Table 1 for details). Raw 2D x-ray data were processed using the datos|x software v. 2.3 with post-processing, analyses (including segmentation), and visualization conducted using VG StudioMax v. 3.1 (Volume Graphics, Heidelberg, Germany). Both tomogram stacks (in TIFF format) and surface models for the CT-scanned specimens are available in MorphoSource (see Suppl. material 1).

Measurements and external morphological data followed the standardized protocols presented by Watters et al. (2016). Measurements were taken with an electronic caliper accurate to 0.01 mm, rounded to 0.1 mm. The following measurements were taken of adults:

SVL	snout-vent length;
HW	head width, taken at the angle of the jaw;
HL	head length, from the posterior of the jaws to the tip of the snout;
ED	eye diameter, horizontally from the anterior to posterior corner of the eye;
IND	internarial distance, shortest distance between the inner margins of the nostrils;
EN	eye-nostril distance, from the anterior corner of the eye to the posterior margin of the nostril;
TD	tympanum diameter, greatest horizontal width of the tympanum;
SL	snout length, distance from the tip of the snout to the anterior corner of the eye;
NS	snout-nostril length, distance from the center of the external nares to the tip of the snout;
IOD	interorbital distance, the shortest distance between the anterior corners of the orbits;
UEW	upper eyelid width, greatest width of the upper eyelid margins, measured perpendicular to the anterior-posterior axis;
FLL	forearm length, from the flexed elbow to the base of the outer palmar tubercle;
HAL	hand length, from the base of the outer palmar tubercle to the tip of finger IV;
Fin4L	finger IV length, from the proximal edge of the palmar tubercle to the tip of finger IV;
TL	tibiofibula length, distance from the outer surface of the flexed knee to the heel/tibiotarsal inflection;
THL	thigh length, distance from the vent to the knee;
FL	foot length, from the base of the inner metatarsal tubercle to the tip of toe IV;
Toe4L	Toe IV length, from the metatarsal tubercle to the tip of toe IV.

Results

Molecular phylogenetic and morphological analyses suggest that the pygmy toads collected from the Serra da Neve represent an undescribed species of *Poyntonophrynus*. The phylogenetic analysis reveals that the Serra da Neve population is nested within the genus *Poyntonophrynus* and is most closely related to *P. fenoulheti* (Figure 3) with weak bootstrap support (73%). As expected, since we used data from Liedtke et al. (2017), the eastern African species *P. lughensis* is more closely related to *Mertensophryne* than to its putative congeners. Within the well-supported clade (bootstrap support 80%) of other species of *Poyntonophrynus*, *P. grandisonae* is sister to remaining congeners. However, as our data do not include overlapping sequences between *P. grandisonae* and *P. hoeschi*, our result should be taken with caution.

Morphologically, the Serra da Neve taxon is typical of *Poyntonophrynus* by being a small toad, lacking a tarsal fold, and having indistinct, flattened parotoid glands. However, this population also exhibits distinct morphological characters that clearly distinguish it from all described species of the genus, most notably the lack of tympanum and a combination of several morphological and coloration characters (Table 2). Based on these differences, this population is described here as a new species.

Poyntonophrynus pachnodes sp. n.

http://zoobank.org/3899209A-5389-4CE4-A806-92D5CE61ACF7
Figs 4–7, Table 3

Holotype. A female, UF 184184 (field number AMB 10208), collected on Serra da Neve (-13.77704 S, 13.25905 E; datum WGS 84; 1488 m a.s.l.), 18 November 2016, by Luis M. P. Ceríaco, Suzana Bandeira and Ishan Agarwal.

Paratypes. A male UF 184183 (field number AMB 10191), a juvenile CAS 262729 (field number AMB 10207), a female CAS 262730 (field number AMB 10210), all with the same collecting data as the holotype, a male INBAC/AMB 10209, and male MUHNAC/MB04-000999 (field number AMB 10219) with same locality and collector data as the remaining type series but collected 19 November 2016.

Diagnosis. *Poyntonophrynus pachnodes* sp. n. is a small-bodied bufonid that lacks tarsal folds, a character that distinguishes it from bufonids in Angola except *Mertensophryne* and *Poyntonophrynus*. It differs from all *Mertensophryne* in having inconspicuous parotoid glands, compared to pronounced parotoid glands that form a shelf in the scapular region of *Mertensophryne*, and in lacking reduction of the phalanges (Grandison, 1981). The newly described species differs from all other members of the genus *Poyntonophrynus* in lacking a tympanum and columella.

Description of the holotype. Small (SVL 31.4 mm), robust, stout and gravid female, with moderately robust limbs (Figure 4–5; All measurements in Table 3); head triangular, wider than long; snout projecting slightly beyond upper jaw; rostral tip straight in dorsal, ventral and lateral views; eyes projecting laterally just beyond eyelids and approximately flush with margins of head in dorsal view; eye projecting about 50% above dorsal mar-

Table 2. Comparison between the *Poyntonophrynus pachnodes* sp. n. with its congeners. Data based on our observations of freshly collected material, original descriptions, and the revisionary works of Poynton and Broadley (1988), Channing (2001), and du Preez and Carruthers (2009, 2017).

	***P. pachnodes* sp. n**	***P. dombensis***	***P. hoeschi***	***P. damaranus***	***P. vertebralis***	***P. kavangensis***	***P. beiranus***	***P. fenoulheti***	***P. parkeri***	***P. grandisonae***
Maximum Snout-vent length	31 mm	40 mm	37 mm	37 mm	36 mm	33 mm	28 mm	43 mm	30 mm	46 mm
Parotoid glands	Inconspicuous, flattened	Conspicuous, flattened	Conspicuous to completely flattened	Conspicuous, with well defined edges but flattened	Inconspicuous, flattened	Inconspicuous, of constant width, with outer edge straight and not extending below pupil	Inconspicuous to hardly discernible	Inconspicuous, flattened	Inconspicuous to hardly discernible	Inconspicuous to hardly discernible
Tympanum	Not present	Present, conspicuous, diameter smaller than internarial distance	Present, inconspicuous	Present, inconspicuous	Present, inconspicuous	Present, conspicuous, diameter smaller than internarial distance	Present, inconspicuous	Present, conspicuous, diameter smaller than internarial distance	Present, inconspicuous	Present, conspicuous, diameter equal or bigger than internarial distance
Skin on snout	Granular	Smooth	Smooth	Granular	Granular	Smooth	Smooth	Granular	Granular	Smooth
Skin on venter	Granular	Smooth to slightly granular	Smooth to slightly granular	Granular	Slightly granular	Granular	Very granular	Smooth to slightly granular	Smooth to slightly granular	Smooth to slightly granular
Vertebral Line	Not present	Usually not present	Not present	Not present	Present	Present	Usually present	Usually not present	Not present	Not present
Dorsal coloration	Dark brown with coppery to brown mottling and dark brown blotches especially in anterior regions , and a pale scapular patch	Light to dark brown, with small dark blotches and pale scapular patch	Brown to reddish-brown with light and dark marking	Olive-brown with symmetrical to irregular dark blotches, dark interorbital band	Grey to brown with orange and reddish markings, pale scapular patch, single or a pair of patches in lower back	Three pairs of dark patches with dark interorbital band, light colored scapular patch with pale projections upper eyelids	Dark grey and with a pale scapular patch	Light grey to brown, with small scattered dark blotches, pale scapular patch, sometimes with a single or a pair of patches in lower back	Light grey to brown, with small scattered dark blotches, pale scapular patch, sometimes with a single or a pair of patches in lower back	Light-grey to brown, with dark patches in the scapular and poster parts of the dorsum, top of the head cream

	***P. pachnodes* sp. n**	***P. dombensis***	***P. hoeschi***	***P. damaranus***	***P. vertebralis***	***P. kavangensis***	***P. beiranus***	***P. fenoulheti***	***P. parkeri***	***P. grandisonae***
Ventral coloration	Cream-colored, juveniles whitish with distinct black blotches	Immaculate	Immaculate	Yellowish-white	Whitish with distinct black blotches	Cream-colored	Pale without marking	Immaculate, occasionally with black blotches or spots	Cream-colored	Immaculate
Webbing	Toes without a margin of web, webbing between toes vestigial	Scanty, only reaching base of fourth toe	Toes with distinct margin of webbing	Moderately well developed, three to three and a half phalanges of longest toe free of webbing	Toes scantly webbed, two segments of the third toe are free of web	Toes scantly webbed with serrated margins, broad web between toes three and four	Two or three segments of the longest toe free of webbing	Scantly webbed	Toes without a margin of web, webbing between toes vestigial	Toes without a margin of web, webbing between toes vestigial
Subarticular tubercles	Double	Usually double	Double	Well defined, usually double	Usually double	Usually double	Usually double	Usually double	Single	Single, except distal tubercle of third finger
Metatarsal tubercles	Inner three times bigger than outer	Smaller than outer but substantially larger than other palmer tubercles.	Inner similar in size or smaller than outer	Inner bigger than the outer	Inner three times bigger than outer	Inner elongated towards the medial surface below base of first finger. Outer , rounded to triangular shape. Inner two to three times smaller than the outer	Inner not present, but a tubercle at base of first finger may be slightly larger than other tubercles. Outer markedly enlarged	Inner three times bigger than outer	Inner two to three times smaller than outer	Inner bigger than the outer

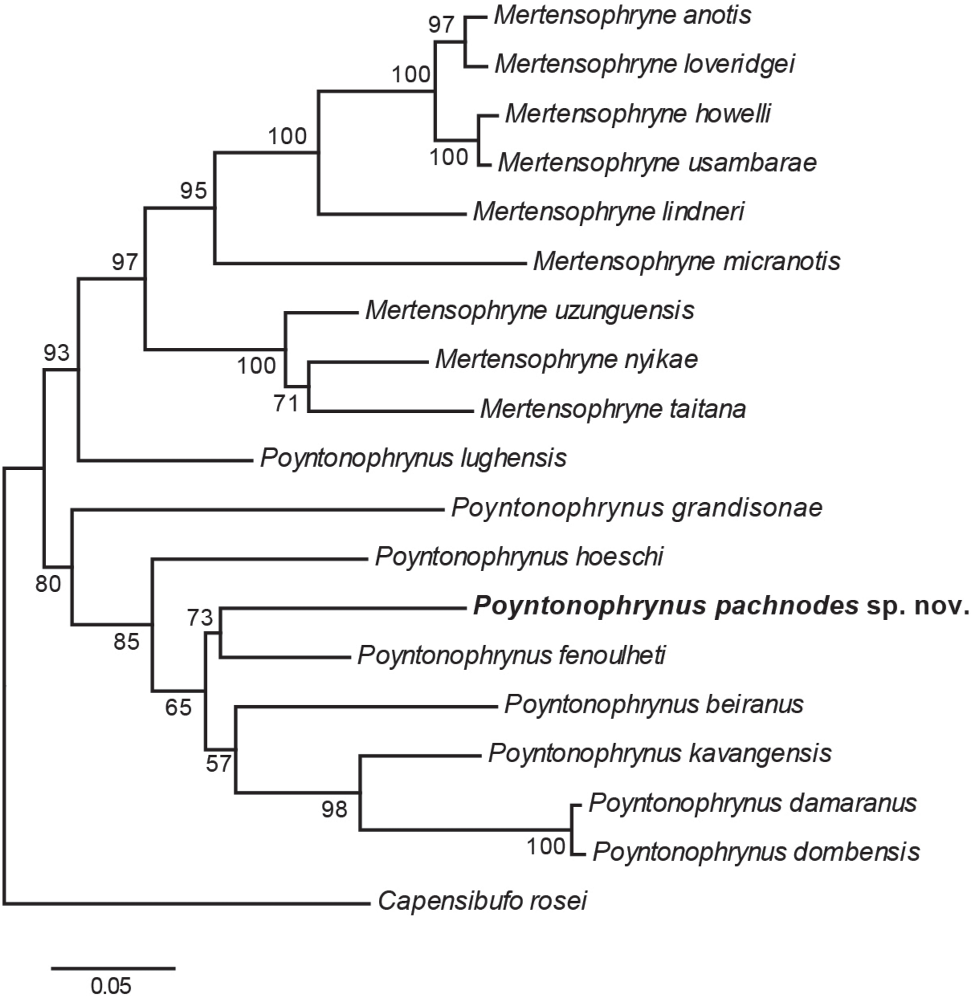


Figure 3. Maximum likelihood tree of the genus *Poyntonophrynus*. Support values at nodes are bootstrap percentages; scale bar in substitutions per site.

gin of head in lateral view; interorbital distance 1.1 times eye diameter; pupil large and ellipsoid in life and preservative; loreal region concave; naris small, triangular, directed dorsolaterally; canthus rostralis short, eye diameter 1.2 times eye-narial distance; eye diameter 1.6 times naris to rostral tip; internarial region flat with rounded lateral margins; interorbital distance approximately 1.7 times internarial distance; tympanum and middle ear structures (tympanum, columella) absent. Marginal and vomerine teeth absent.

Skin of venter with evenly scattered miniscule asperities; skin of gular region smooth; skin of limbs, dorsal and dorsolateral surface of head and body with scattered tubercles, being larger on dorsum; inconspicuous and flattened parotoid glands, elliptical, and weakly elevated, placed dorsolaterally and extending from posterior corner of mouth to level of axilla.

Table 3. Measurements of the type series of *P. pachnodes* sp. n. For measurement abbreviations see Materials and methods section. All measurements in mm.

Catalog number	**UF 184184**	**UF 184183**	**CAS 262730**	**CAS 262729**	**MUHNAC/ MB04-000999**	**INBAC/AMB 10209**
Type status	Holotype	Paratype	Paratype	Paratype	Paratype	Paratype
SEX	Female	Male	Juvenile	Female	Male	Male
HW	9.9	9.5	8.9	9.2	9.9	10.3
SVL	31.4	31.3	29.7	28	33.7	30.0
TL	11.7	12.1	10.9	11.6	12.3	12.5
IOD	3.2	3.2	3.3	3.3	4.5	4.2
HL	8.7	8.1	8.8	9.1	11.7	10.6
ED	2.8	2.9	2.7	2.9	3.0	3.0
IND	1.9	2.3	2.2	1.9	2.5	2.0
EN	2.6	2.2	2.4	2.6	2.8	2.7
FL	11.8	12.0	11.7	11.7	12.1	12.5
THL	11.6	11.0	10.7	11.2	12.0	13.0
SL	3.9	3.7	4.2	4.5	3.9	4.0
HAL	7.4	7.1	6.8	6.9	7.4	7.2
FLL	7.2	6.0	6.5	6.6	6.7	7.8
UEW	2.8	2.2	2.6	2.9	2.2	2.4
FIN4L	4.6	4.9	4.0	4.5	4.7	4.3
TOEL4L	5.9	7.3	6.2	6.7	7.7	6.1
NS	1.7	1.8	1.0	1.2	1.5	1.4

Figure 4. Ventral and dorsal view of the holotype (UF 184184) of *Poyntonophrynus pachnodes* sp. n.

Limbs and digits well-developed; digits of both manus and pes stout; tarsal fold not present; relative length of fingers: III > I > IV = II; finger tips not expanded, but with rounded tips; fingers with rounded, prominent double subarticular tubercles; two palmar

Figure 5. Ventral view of the right hand and left foot of the holotype (UF 184184) of *Poyntonophrynus pachnodes* sp. n.

tubercles distinct and widely separated from one another, one at ventromedial surface of first finger and other at proximal plantar surface, latter being about 4 times larger than first; webbing between manual digits absent; relative length of toes IV > III > II > I = V; toe tips slightly expanded; toes with prominent, single, and subarticular tubercles; webbing between toes vestigial, not reaching first joint of first phalanx; prominent and globular inner metatarsal tubercle, length 50% of first toe length; tarsal tubercle prominent and projecting, near medial edge and positioned at distal fourth of tarsus.

Coloration. In life, dorsal ground color dark brown with coppery to brown mottling and dark brown blotches especially in anterior regions (Figure 6); whitish chevron extending between eyes (scapular patch), directed posteriorly (faded but visible in preservative); iris dark green with dark brown pupil (dark grey and pale gray in preservative, respectively); snout similar in color and pattern to dorsum; dorsal surface of forelimbs and fingers III and IV whitish with dark brown blotches; dorsal surface of fingers I and II white; posterior to head, distinctive white blotch at midbody; dorsum and lateral surface dark brown speckled with coppery markings, becoming faint towards venter; dorsal surface of hind limbs (thighs and crus) greyish white with distinctive dark brown markings; three dark blotches on thigh, crus and feet touching when legs flexed; base color of dorsal foot grayish, with scattered dark brown blotches, extending across toes; region surrounding cloaca cream colored. Lateralmost margin of upper jaw white interrupted by brown markings posterior and anterior to eye; throat immaculate white; ventral surface of forearm and arm whitish; ventral surface of hand

Figure 6. Photograph in life of *Poyntonophrynus pachnodes* sp. n., paratype UF 184183 (AMB 10191). Photo by Ishan Agarwal.

and fingers white; venter unpigmented and whitish; anterior part of thighs and ventral crus cream colored; ventral side of legs and plantar surface of pes unpigmented and whitish in appearance.

Variation. The coloration of the remaining paratypes do not differ in any important details from those of the holotype. Measurements of the remaining type series in Table 3.

Osteology. Based on CT scan of UF 184184 (holotype; gravid female; Figure 7). The skull is wider than long, incompletely ossified, and lacks ornamentation on the dermal roofing bones. The jaw joint is anterior to the otic region. The parotic plate is incompletely ossified but synostosed to the frontoparietal. The premaxillae lack teeth, and have both a robust pars dentalis and a robust alary process that is taller than wide and widely separated from the nasals. The maxillae lack teeth and are weakly concave (with apex directed labially). The quadratojugals are thin and elongate with a broad articulation with the maxillae and reaching anterior to the articulation of the maxilla and pterygoid. The pterygoids are slender, with a long medially curved anterior ramus with a broad articulation with the adjacent maxilla, a short posterior ramus approaching, but not articulating with, the cartilages of the jaw joint, and a short medial ramus approaching but not articulating with the prootic. Vomers are large and plate-like, lacking teeth. The neopalatine is a thin flat rod, not articulating with adjacent bones. The curved and triradiate septomaxillae are present at the anterior margin of the nasal capsule. The prominent sphenethmoid is coosified across the midline and visible in dorsal view between the nasals and frontoparietals. The parasphenoid narrows anteriorly and exhibits a small bifurcation at its rostral extent. The squamosals are greatly reduced with only the dorsalmost otic region and a small reduced zygomatic ramus present. The prootic is poorly ossified and has a poorly defined fenestra ovalis. Neither a bony operculum nor a columella is present. The posteromedial processes of the hyoid are ossified and slender, and expanded weakly at their articulation with the cartilaginous hyoid plate.

There are eight distinct, procoelous, non-imbricating presacral vertebrae that are not synostosed. The atlas lacks transverse processes and has widely separated cotyles. The sacrum is procoelous with laterally expanded transverse processes. No sesamoid is observed at the sacroiliac joint. The urostyle is long and thin with a weakly developed dorsal ridge.

The pectoral girdle is fermisternal with widely spaced and slender coracoids. The clavicles are slender, nearly reaching one another. The scapulae are stout, directed laterally but strongly curving dorsally at their lateral extent. Neither an ossified sternum nor omosternum is present.

The pelvic girdle comprises the ilium, pubis, and ischium, which are not synostosed to one another. The acetabulum is incompletely ossified. The shaft of the ilium is long and slender, lacking a dorsal crest, and with a small prominent dorsal protuberance. The synostosed ischia form a broad posteriorly directed plate.

The radioulna is shorter than the humerus. The radiale and ulnare are large and subequal in size, though the other carpals are difficult to distinguish as they are incompletely ossified. The phalangeal formula for the manus is 2–2–3–3, and there is both a single ossified prepollex and a small palmar sesamoid. The tips of the terminal manual phalanges are weakly expanded into small knobs. The tibiofibula is slightly shorter than the femur. There are two small distal tarsals. The phalangeal formula for the pes is 2–2–3–4–3 and there is a single small ossified prehallux and a plantar sesamoid. The tips of the terminal pedal phalanges are weakly expanded as in the fingers.

Distribution and ecology. The species is currently only known from the Serra da Neve Inselberg (Figs 2, 8) in northern Namibe Province. Specimens were found on moist soil under rocks and leaf-litter at dusk in a semi-open miombo forest area. Grandvaux-Barbosa (1970) considered that Serra da Neve is characterized by a "sparse Miombo," dominated by trees of the genera *Julbernardia* spp. and *Brachystegia* spp., and shrubs like *Combretum* spp. or *Annona* spp., which were observed at the site. The species was found sympatrically with the frogs *Sclerophrys gutturalis* and *Tomopterna tuberculosa*, the lizards *Agama schacki*, *Trachylepis sulcata*, *Chondrodactylus pulitzerae*, *Hemidactylus benguellensis*, *Pachydactylus angolensis*, and *Heliobolus lugubris*, and the snake *Hemirhagerrhis viperina*.

Etymology. The specific name *pachnodes* (Gr.) means "frosty" and is used as an adjective (Brown 1954). This is a reference to both the cool climate at the higher elevation where this species occurs (1488 m) and that Serra da Neve (Port.) translates to "mountain of snow." We suggest "Serra da Neve Pygmy Toad" and "Sapo Pigmeu da Serra da Neve" as the English and Portuguese common names respectively.

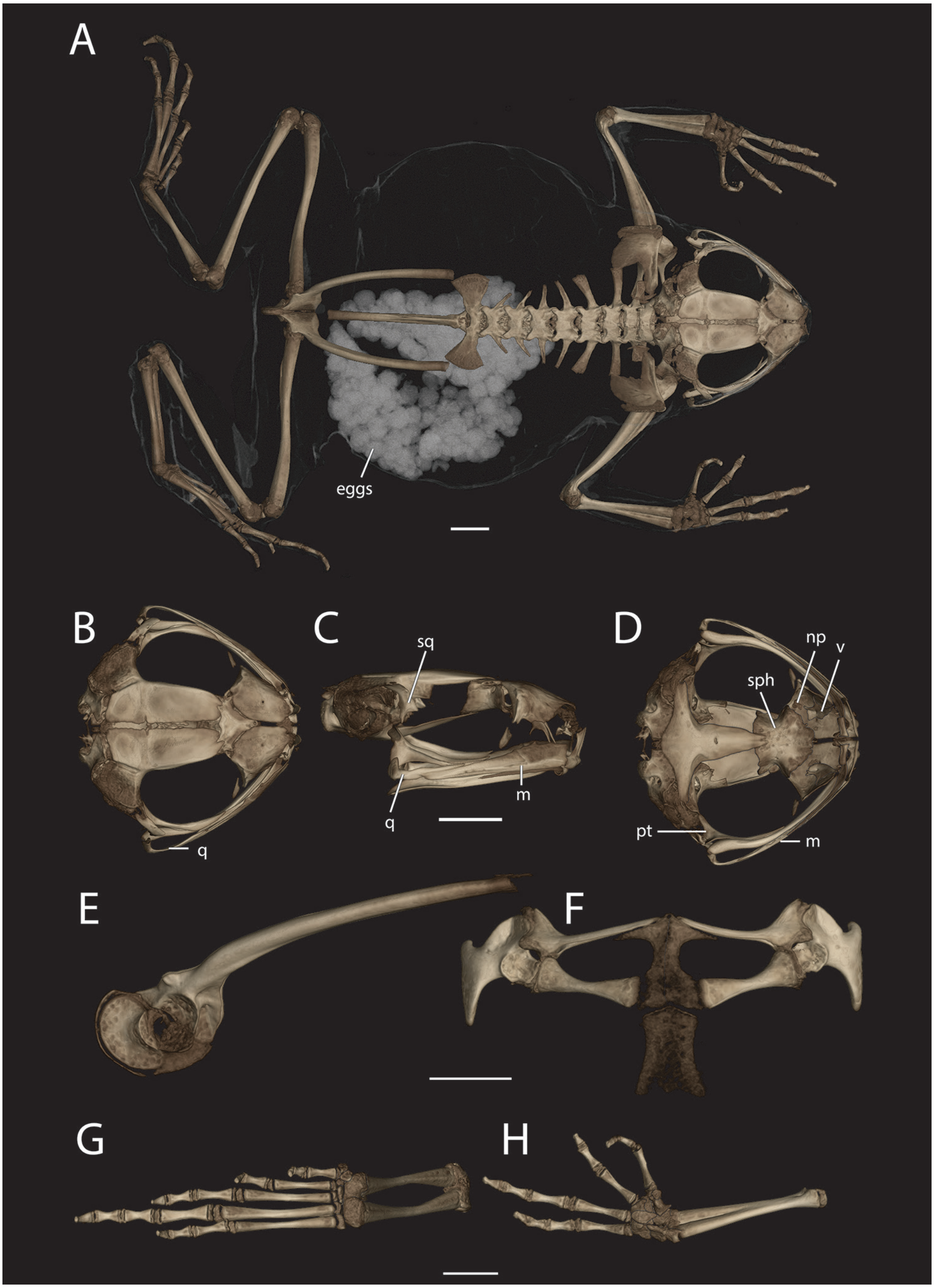


Figure 7. High-resolution Computed Tomography reconstructions showing the skeleton of the holotype (UF 184184) of *Poyntonophrynus pachnodes* sp. n. in dorsal view (**A**), skull in dorsal (**B**), right lateral (**C**) and ventral (**D**) views, pelvis in right lateral view (**E**), pectoral girdle in ventral view (**F**), and right foot (**G**) and right hand (**H**) in ventral views. Selected skeletal elements are labeled based on discussion in the text. Panel A also highlights the eggs that are visible within the oviducts. Abbreviations: m – maxilla; np – neopalatine; pt – pterygoid; q – quadrate; sph – sphenethmoid; sq – squamosal; v – vomer. Scale bars in each row equal 2 mm.

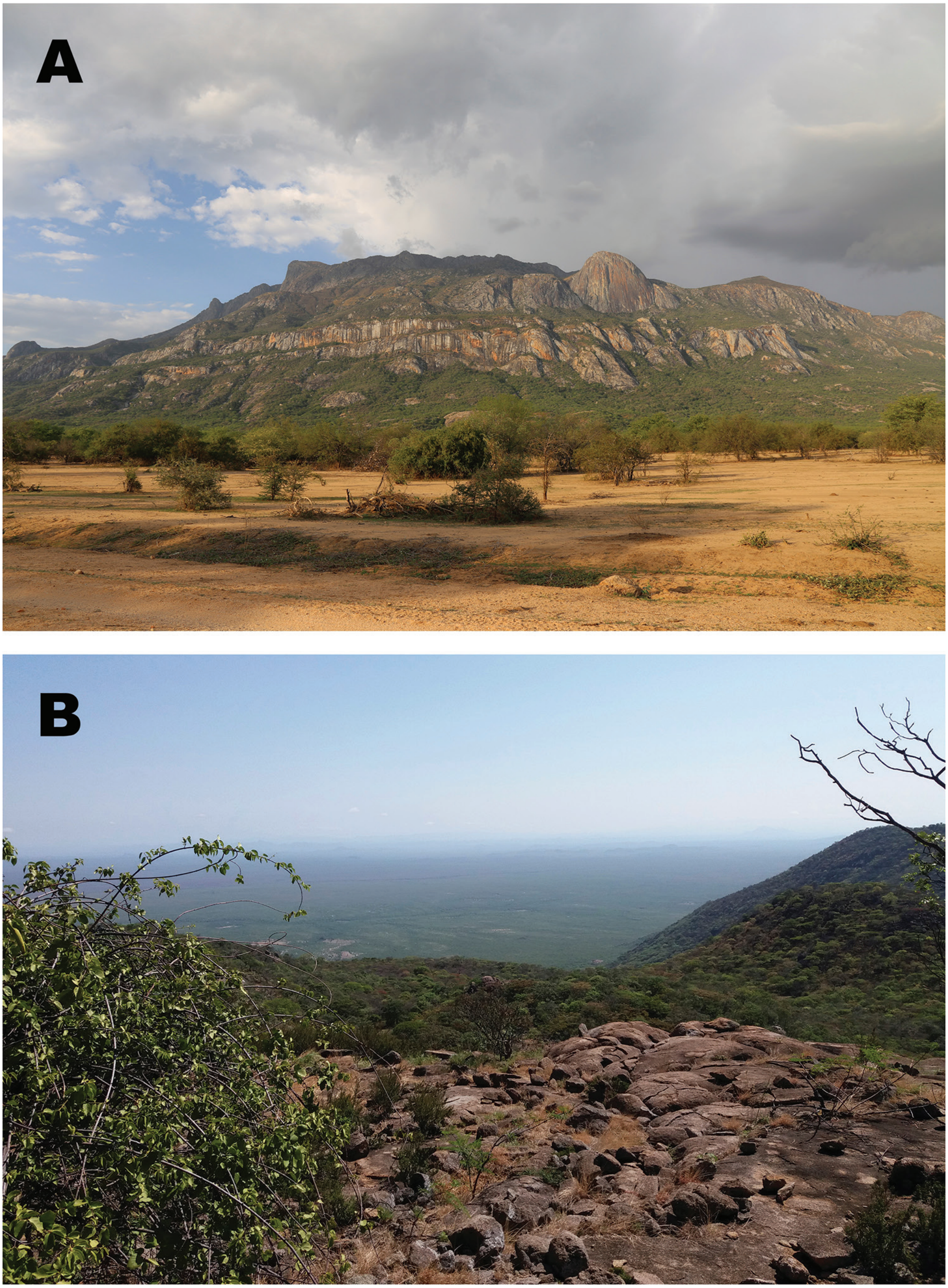


Figure 8. Southern view of the base of the Serra da Neve Inselberg (**A**), and habitat of the type locality at about 1500 m a.s.l. (**B**). Photos by Luis Ceríaco.

Discussion

Despite several decades of interest in African pygmy toads (e.g., Poyton 1964, Tandy 1972, Poynton and Haacke 1993), there has been little attention paid to the systematics of the species now referred to as *Poyntonophrynus*. Until recently, there has been no serious attempt to evaluate the monophyly of this genus. The molecular phylogenetic analysis of Liedtke et al. (2017) demonstrates that *P. lughensis* is more closely allied to *Mertensophryne*, and if true then this species should be treated as part of that genus. However, as the sample used in that analysis is not associated with a voucher specimen to confirm the identification, we refrain from taxonomic changes. It still remains uncertain whether *B. parkeri*, which Tandy (1972, Tandy and Keith 1972) included in the '*vertebralis* group,' should be included in *Poyntonophrynus*; Tandy (1972) provided no specific arguments regarding this assignment. While we have contributed new molecular genetic data for *P. grandisonae*, we still lack phylogenetic information for several species. In lieu of new genetic resources for molecular phylogenetic analyses, a thorough systematic revision based on morphological data, including osteology, is needed to evaluate the monophyly of *Poyntonophrynus* and the relationships among its species.

Unlike most African anuran taxa, the species diversity of *Poyntonophrynus* is concentrated in arid southwestern Africa. Five species (*P. damaranus*, *P. dombensis*, *P. grandisonae*, *P. hoeschi*, and *P. pachnodes* sp. n.) are strictly endemic to this region, whereas the others (*P. vertebralis*, *P. beiranus*, *P. kavangensis*, *P. fenoulheti*, and *P. parkeri*) are found in arid or mesic habitats extending across southern and eastern Africa. This pattern of species distributions, combined with the fact that *P. grandisonae* represents the earliest known diverging lineage within the genus, suggests that the origin of this group might have been in southwestern Africa. While a highly unusual pattern for an anuran, this is similar to several squamate taxa for which the arid zones of southwestern Angolan and northwestern Namibia form a center of endemism and diversity (Roll et al. 2017, Marques 2015). Southwestern Angola hosts a large number of endemic species of lizards, including one endemic genus, and ongoing work reveals additional cryptic and endemic diversity among several lizard taxa (Figure 9).

In addition to *Poyntonophrynus*, the few examples of amphibians found in these xeric areas include *Phrynomantis annectens*, several species of *Sclerophrys*, and *Tomopterna* (Ceríaco et al. 2016, Heinicke et al. 2017a). Within Namibe Province, there are 91 documented species of reptiles, representing one-third of the reptile species known for Angola, but only 15 amphibian species, which represent <13% of the amphibian diversity of the country (Marques 2015). Neighboring Benguela Province has similar species diversity (102 reptiles, 36 amphibians) and contains similar habitats. The herpetofaunal diversity of these provinces mostly comprises taxa found in southern Africa (Marques 2015). Though Namibe Province is generally well explored, little is known of the diversity of its inselbergs. The biodiversity of Serra da Neve remains largely undocumented with only two expeditions to it in the last few years (Barker et

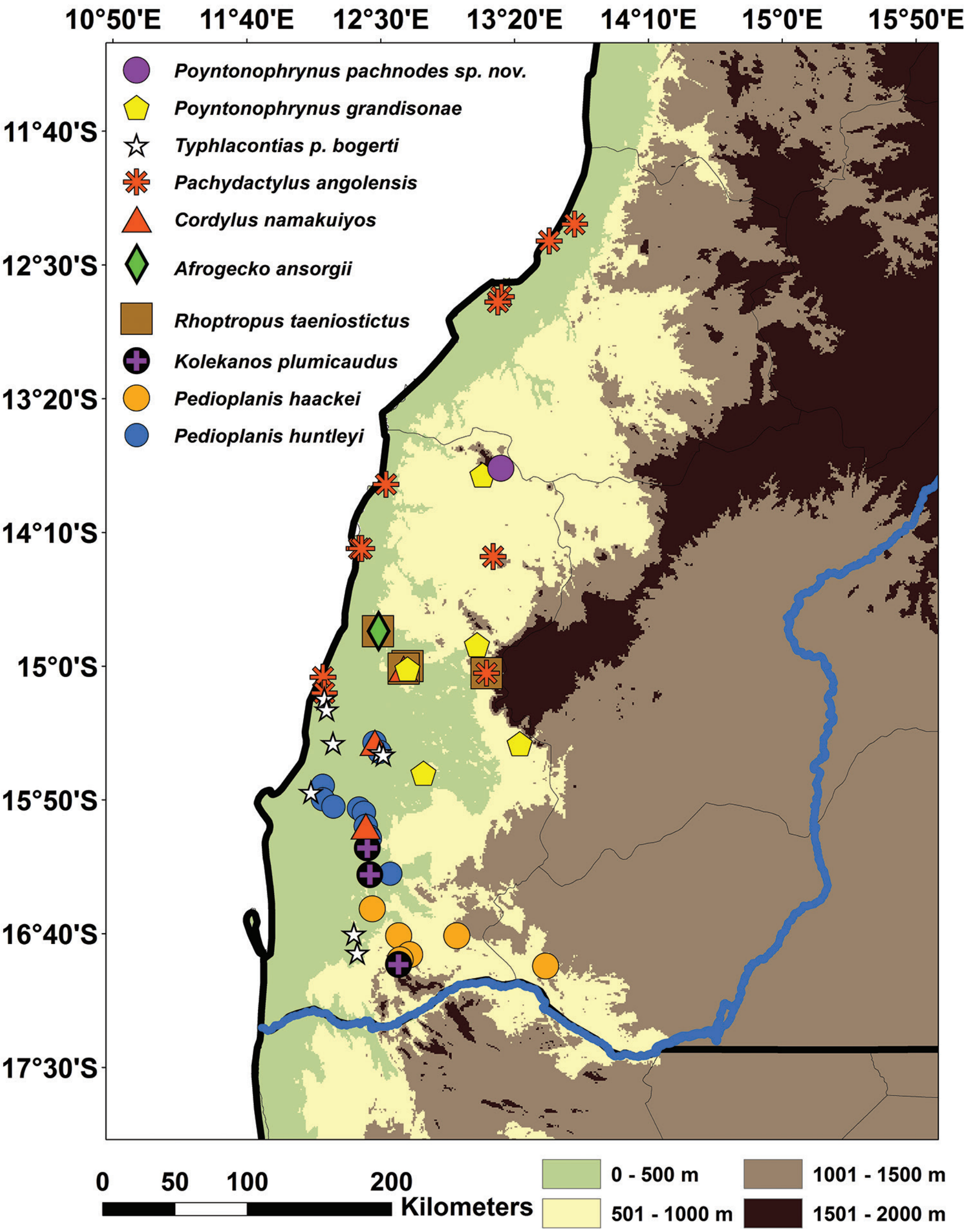


Figure 9. Bibliographic (Marques 2015), museum and new field records of the amphibian and reptile taxa endemic to the coastal arid lowlands of southwestern Angola. The blue line represents the Cunene/Kunene River.

al. 2015, this study), according to available literature. Other inselbergs and highlands found along the Angolan escarpment, including Mount Moco (Huambo Province) and the highlands of Gabela-Seles and the Kumbira Forest (Kwanza Sul Province), are known to harbor a significant number of endemics and relict populations of various taxa (Marx 1956, Hall 1960, Hall and Moreau 1970, Huntley 1974, Sekercioglu and Riley 2005, Maiato 2009, Mills 2010, Mills et al. 2011, Cáceres et al. 2015, Carleton et al. 2015, Gonçalves and Goyder 2016, Svensson et al. 2017). While the biogeographic affinities of these areas are not completely understood, there is a general pattern of relictual distributions for taxa otherwise found in central or eastern Africa. Yet due to its southern geographic position, surrounding arid habitats, and the limited existing data on occurring taxa, it appears that the affinities of the flora and fauna of Serra da Neve have more similarities to taxa found typically in southern Africa, as for example representatives of the gekkonid genera *Rhoptropus*, *Chondrodactylus* and *Pachydactylus*, or southwestern African endemics including *Hemirhagerrhis viperina* and *Trachylepis laevis*; this new species of *Poyntonophrynus* provides an additional example. We are, however, still far from understanding the biogeographic affinities of Serra da Neve.

The osteology of both *Poyntonophrynus* and its sister taxon *Mertensophryne* are poorly documented in comparison to other African bufonid taxa. The skeleton of *P. pachnodes* exhibits features characterized by Grandison (1981) as common in the *vertebralis* group, though she was not explicit about the species she included in that group. Those features include the reduction or loss of the shaft of the squamosal and an elongate quadratojugal that attains the articulation between the maxilla and the pterygoid at its anterior extent (Poynton 1991, Graybeal and Cannatella 1995). Similar to the condition documented by Grandison (1981) for *P. vertebralis*, the neopalatines are reduced in *P. pachnodes* (Figure 7D), in contrast to its well-developed state in *Mertensophryne* (Grandison 1981, Poynton 1991). All of the species that are currently recognized as *Mertensophryne* lack external ears (Tandy 1972, Tandy and Keith 1972, Frost et al. 2006), though it is not clear whether all of these species might also lack other structures such as the columella (Tihen 1960). *Poyntonophrynus pachnodes* does not exhibit reduction in the number of presacral vertebrae, a character which is present at least some *Mertensophryne* (e.g. Figure 10; Tihen 1960, Grandison 1978), nor does it exhibit any of the ornamentation found in the dorsal skull bones, as in *Mertensophryne anotis* (Poynton 1991). The newly described species represents the first known case of complete loss of the Tympanic Middle Ear (TME) within the genus *Poyntonophrynus* (Figure 10), though all of the species in the sister-genus *Mertensophryne* lack the TME (Tandy and Keith 1972). This condition is generally rare among amniotes, but it is fairly common among anurans, including the Bufonidae (Pereyra et al. 2016). In some cases, the TME is not completely lost, and some portions of the middle ear may remain. The reduction of TME structures in anurans follows a consistent pattern (Pereyra et al. 2016): the absence of more medial structures (e.g., columella) is associated with the absence of lateral structures such as the tympanic annulus and membrane, but the absence of the lateral structures are not necessarily associated with the reduction or loss of the columella. The evolutionary loss of TME and the alternative auditory mechanisms that might be used by these taxa have received substantial recent attention (Boistel et al. 2011, 2013, Thomas et al. 2014, Pereyra et al. 2016, Goutte et al. 2017, Womack

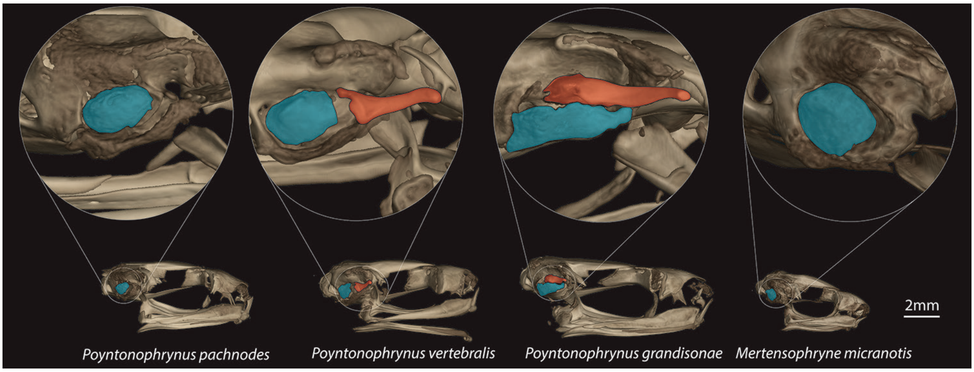


Figure 10. Comparisons of the skulls of *Poyntonophrynus pachnodes* sp. n. (UF 184184) in comparison to *P. vertebralis* (MCZ A-10007), *P. grandisonae* (AMB 10340), and *Mertensophryne micranotis* (CAS 162553). Light blue indicates the otic plate and orange indicates the columella, which is absent in both *P. pachnodes* and *Mertensophryne*.

et al. 2017). Given the loss of the TME in *Mertensophryne* and at least once species of *Poyntonophrynus*, this clade may provide an opportunity for further examination of the causes of loss and reduction of the TME and other correlated features (e.g., Womack et al. 2018).

Acknowledgements

The Angolan Ministry of Environment and INBAC provided logistical support and necessary permits for carrying out this research. The Provincial Government of Namibe province, especially the Governor Dr. Rui Falcão, as well as the provincial office of the Ministry of Environment, provided necessary logistical and bureaucratic support during our work. We thank Álvaro 'Varito' Baptista for assistance in field research on Serra da Neve. Marius Burger and an anonymous reviewer present valuable comments and suggestions that led to the improvement of the manuscript. This work was funded by US National Science Foundation grants to DCB (DEB 1202609, 1556559) AMB (DEB 1019443, 1556255), and MPH (DEB 1556585) and a grant to DCB and AMB from the JRS Biodiversity Foundation. MPM is currently supported by FCT contract SFRH/BD/129924/2017.

References

Ahl E (1934) Über eine kleine Froschsammlung aus Deutsch Südwestafrika. Zoologischer Anzeiger 107: 333–336.

Barker N, Clark R, Neef G, Maiato F, Francisco D, Goyder D (2015) Learning the ABCs: Angolan botanical collecting – part 2: bush pilots and old volcanoes. Veld & Flora 101(3): 116–119.

Biju SD, Bossuyt F (2003) New frog family from India reveals an ancient biogeographical link with the Seychelles. Nature 425: 711–714. https://doi.org/10.1038/nature02019

Bocage JVB (1895) Sur une espèce de crapaud à ajouter à faune herpétologique d'Angola. Jornal de Sciencias Mathematicas, Physicas e Naturaes, Série 2, 4: 51–53.

Boistel R, Aubin T, Cloetens P, Langer M, Gillet B, Josset P, Pollet N, Herrel A (2011) Whispering to the deaf: Communication by a frog without externa vocal sac or tympanum in noisy environments. PLoS ONE 6(7): e22080. https://doi.org/10.1371/journal.pone.0022080

Boistel R, Aubin T, Cloetens P, Peyrin F, Scotti T, Herzog P, Gerlach J, Pollet N, Aubry J-F (2013) How minute sooglossid frogs hear without a middle ear. Proceedings of the National Academy of Sciences of the United States 110(38): 15360–15364. https://doi.org/10.1073/pnas.1302218110

Boulenger GA (1905) A list of batrachians and reptiles collected by Dr. W. J. Ansorge in Angola, with descriptions of new species. Annals and Magazine of Natural History, Series 7, 16: 105–115. https://doi.org/10.1080/03745480509443656

Boulenger GA (1907) Descriptions of three new lizards and a frog, discovered by Dr. W.J. Ansorge in Angola. Annals and Magazine of Natural History, Series 7, 19: 212–214. https://doi.org/10.1080/00222930709487258

Brown, RW (1954) Composition of Scientific Words. Published by the author, Washington, 882 pp.

Cáceres A, Melo M, Barlow J, Cardoso P, Maiato F, Mills MSL (2015) Threatened birds of the Angolan Central Escarpment: distribution and response to habitat change at Kumbira Forest. Oryx 49(4): 727–734. https://doi.org/10.1017/S0030605313001415

Carleton MD, Banasiak RA, Stanley WT (2015) A new species of the rodent genus *Hylomyscus* from Angola, with a distribution summary of the *H. anselli* species group (Muridae: Murinae: Praomyni). Zootaxa 4040(2): 101–128.

Ceríaco LMP, De Sá, S AC, Bandeira S, Valério H, Stanley EL, Kuhn AL, Marques MP, Vindum JV, Blackburn DC, Bauer AM (2016) Herpetological survey of Iona National Park and Namibe Regional Natural Park, with a synoptic list of the Amphibians and Reptiles of Namibe Province, southwestern Angola. Proceedings of the California Academy of Sciences, Series 4, 63: 15–61.

Channing A (1976) Life histories of frogs in the Namib Desert. Zoologica Africana 11: 299–312. https://doi.org/10.1080/00445096.1976.11447536

Channing A (2001) Amphibians of Central and Southern Africa. Cornell University Press, Ithaca, 470 pp.

Channing A, Rödel M-O, Channing J (2012) Tadpoles of Africa. Edition Chimaira, Frankfurt am Main, 402 pp.

Channing A, Vences M (1999) The advertisement call, breeding biology, description of the tadpole and taxonomic status of *Bufo dombensis*, a little-known dwarf toad from southern Africa. South African Journal of Zoology 34: 74–79. https://doi.org/10.1080/02541858.1999.11448491

Conradie W, Measey GJ, Branch WR, Tolley KA (2012) Revised phylogeny of African sand lizards (*Pedioplanis*), with the description of two new species from south-western Angola. African Journal of Herpetology 61(2): 91–112. https://doi.org/10.1080/21564574.2012.676079

Cunningham MJ, Cherry MI (2004) Molecular systematics of African 20-chromossome toads (Anura: Bufonidae). Molecular Phylogenetics and Evolution 32: 671–685. https://doi.org/10.1016/j.ympev.2004.03.003

Dawood A, Channing A (2002) Description of a new cryptic species of African sand frog, *Tomopterna damarensis* (Anura: Ranidae), from Namibia. African Journal of Herpetology 51(2): 129–134. https://doi.org/10.1080/21564574.2002.9635468

du Preez L, Carruthers V (2009) A Complete Guide to the Frogs of Southern Africa. Struik Nature, Cape Town, 488 pp.

du Preez L, Carruthers V (2017) Frogs of Southern Africa, A Complete Guide. Struik Nature, Cape Town, 519 pp.

Felsenstein J (1985) Phylogenies and the comparative method. The American Naturalist 125(1): 1–15. https://doi.org/10.1086/284325

Frost DR, Grant T, Faivovich J, Bain RH, Haas A, Haddad CFB, De Sá RO, Channing A, Wilkinson M, Donnellan SO, Raxworthy CJ, Campbell JA, Blotto BL, Moler P, Drewes RC, Nussbaum RA, Lynch JD, Green DM, Wheeler WC (2006) The amphibian tree of life. Bulletin of the American Museum of Natural History 297: 1–370. https://doi.org/10.1206/0003-0090(2006)297[0001:TATOL]2.0.CO;2

Frost DR (2017) Amphibian Species of the World: an Online Reference. Version 6.0. [5 November 2017]. http://research.amnh.org/herpetology/amphibia/index.html

Gonçalves FMP, Goyder DJ (2016) A brief botanical survey into Kumbira Forest, an isolated patch of Guineo-Congolian biome. PhytoKeys 65: 1–14. https://doi.org/10.3897/phytokeys.65.8679

Goutte S, Mason MJ, Christensen-Dalsgaard J, Montealegre-Z F, Chives BD, Sarria-S FA, Antoniazzi MM, Jared C, Sato LA, Toledo LF (2017) Evidence of auditory insensitivity to vocalization frequencies in two frogs. Scientific Reports 7: 12121. https://doi.org/10.1038/s41598-017-12145-5

Grandison AGC (1978) The occurrence of *Nectophrynoides* (Anura: Bufonidae) in Ethiopia. A new concept of the genus with a description of a new species. Monitore zoologico italiano (supplement) 11: 119–172.

Grandison AGC (1981) Morphology and phylogenetic position of the West African *Didynamipus sjoestedsti* Andersson, 1903 (Anura: Bufonidae). Monitore Zoologico Italiano (supplement) 15: 187–215.

Grandvaux-Barbosa LA (1970) Carta fitogeográfica de Angola. Instituto de Investigação Científica de Angola, Luanda, 323 pp.

Graybeal A, Cannatella DC (1995) A new taxon of Bufonidae from Peru, with descriptions of two new species and a review of the phylogenetic status of supraspecific bufonid taxa. Herpetologica 51: 105–131.

Haacke WD (2008) A new leaf-toed gecko (Reptilia: Gekkonidae) from south-western Angola. African Journal of Herpetology 57(2): 85–92. https://doi.org/10.1080/21564574.2008.9635571

Hall TA (1999) BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symposium Series 41: 95–98.

Hall BP (1960) The faunistic importance of the scarp of Angola. Ibis 102: 420–442. https://doi.org/10.1111/j.1474-919X.1960.tb08418.x

Hall BP, Moreau RE (1970) An atlas of speciation in African passerine birds. British Museum (Natural History), London, 421 pp.

Heinicke MP, Daza JD, Greenbaum E, Jackman TR, Bauer AM (2014) Phylogeny, taxonomy and biogeography of a circum-Indian Ocean clade of leaf-toed geckos (Reptilia: Gekkota), with a description of two new genera. Systematics and Biodiversity 12(1): 23–42. https://doi.org/10.1080/14772000.2013.877999

Heinicke MP, Ceríaco LMP, Moore IM, Bauer AM, Blackburn DC (2017a) *Tomopterna damarensis* (Anura: Pyxicephalidae) is broadly distributed in Namibia and Angola. Salamandra 53: 461–465.

Heinicke MP, Turk D, Bauer AM (2017b) Molecular phylogeny reveals strong biogeographic signal and two new species in a Cape Biodiversity Hotspot endemic mini-radiation, the pygmy geckos (Gekkonidae: *Goggia*). Zootaxa 4312: 449–470.

Hetherington TE, Lindquist ED (1999) Lung-based hearing in an "earless" anuran amphibian. Journal of Comparative Physiology A 184: 395–401. https://doi.org/10.1007/s003590050338

Hewitt J (1927) Further descriptions of reptiles and batrachians from South Africa. Records of the Albany Museum (Grahamstown) 3(5): 371–415.

Hewitt J, Methuen PA (1912) Descriptions of some new Batrachia and Lacertilia from South Africa. Transactions of the Royal Society of South Africa 3: 107–111. https://doi.org/10.1080/00359191309519682

Huelsenback JP, Hillis DM (1993) Success of phylogenetic methods in the four-taxon case. Systematic Biology 42: 247–264. https://doi.org/10.2307/2992463

Huntley BJ (1974) Outlines of wildlife conservation in Angola. Journal of the Southern African Wildlife Management Association 5: 157–166.

Lanfear R, Calcott B, Ho SYW, Guindon S (2012) PartitionFinder: combined selection of partitioning schemes and substitution models for phylogenetic analysis. Molecular Biology and Evolution 29: 1695–1701. https://doi.org/10.1093/molbev/mss020

Larkin MA, Blackshields G, Brown NP, Chenna R, McGettigan PA, McWilliam H, Valentini F, Wallace JM, Wilm A, Lopez R, Thompson JD, Gibson TJ, Higgins DG (2007) Clustal W and Clustal X versions 2.0. Bioinformatics 23: 2947–2948. https://doi.org/10.1093/bioinformatics/btm404

Laurent RF (1964) Reptiles et amphibiens de l'Angola (Troisème contribution). Publicações Culturais da Companhia de Diamantes de Angola 67: 1–165.

Liedtke HC, Müller H, Rödel M-O, Menegon M, Gonwouo NL, Barej MF, Gvoždík V, Schmitz A, Channing A, Nagel P, Loader SP (2016) No ecological opportunity signal on a continental scale? Diversification and life-history evolution of African true toads (Anura: Bufonidae). Evolution 70(8): 1717–1733. https://doi.org/10.1111/evo.12985

Liedtke HC, Müller H, Hafner J, Penner P, Gower DJ, Mazuch T, Rödel M-O, Loader SP (2017) Terrestrial reproduction as an adaptation to steep terrain in African toads. Proceedings of the Royal Society B 284(1851): 20162598. https://doi.org/10.1098/rspb.2016.2598

Lindquist ED, Hetherington TE (1998) Semaphoring in an earless frog: the origin of a novel visual signal. Animal Cognition 1(2): 83–87.

Loveridge A (1932a) Eight new toads of the genus *Bufo* from east and central Africa. Occasional Papers of the Boston Society of Natural History 8: 43–54.

Loveridge A (1932b) New reptiles and amphibians from Tanganyika Territory and Kenya Colony. Bulletin of the Museum of Comparative Zoology 72: 375–387.

Loveridge A (1944) New geckos of the genera *Afroedura*, new genus, and *Pachydactylus* from Angola. American Museum Novitates 1254: 1– 4.

Lombard RE, Straughan IR (1974) Functional aspects of anuran middle ear structures. Journal of Experimental Biology 61(1): 71–93.

Maiato F (2009) Conservação da floresta afromontana do Morro Moco: Uma abordagem baseada na comunidade local da aldeia de Kajonde. http://www.mountmoco.org/downloads/MocoMaiato.pdf

Marques MP (2015) Geographical distribution of the amphibians and reptiles of Angola. MSc thesis, Évora, Portugal: Universidade de Évora.

Marx H (1956) A new lacertid lizard from Angola. Fieldiana: Zoology 39: 5–9. https://doi.org/10.5962/bhl.title.3092

Mills MSL (2010) Angola's central scarp forests: patterns of bird diversity and conservation threats. Biodiversity and Conservation 19: 1883–1903. https://doi.org/10.1007/s10531-010-9810-4

Mills MSL, Olmos F, Melo M, Dean WRJ (2011) Mount Moco: its importance to the conservation of Swierstra's Francolin *Pternistis swierstrai* and the Afromontane avifauna of Angola. Bird Conservation International 21: 119–133. https://doi.org/10.1017/S0959270910000493

Mertens R (1954) Eine neue Kröte aus Südwestafrika. Senckenbergiana Biologica 35: 9–11.

Mertens R (1955) Die Amphibien und Reptilien Südwestafrikas. Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 490: 1–172.

Nguyen L-T, Schmidt HA, von Haeseler A, Minh BQ (2015) IQ-TREE: A fast and effective stochastic algorithm for estimating maximum likelihood phylogenies. Molecular Biology and Evolution 32: 268–274. https://doi.org/10.1093/molbev/msu300

Palumbi SR (1996) Nucleic acids II: the polymerase chain reaction. In: Hillis DM, Moritz C, Mable BK (Eds) Molecular Systematics (2nd edn). Sinauer Associates, Sunderland, 205–247.

Pereira E (1977) Serra da Neve (Angola) – Nota sobre a geomorfologia da região e idade das aplanações. Boletim da Sociedade Geológica de Portugal 20(3): 277–282.

Pereyra MO, Womack MC, Barrionuevo JS, Blotto BL, Baldo D, Targino M, Ospina-Sarria JJ, Guayasamin JM, Coloma LA, Hoke KL, Grant T, Faivovich J (2016) The complex evolutionary history of the tympanic middle ear in frogs and toads (Anura). Scientific Reports 6: 34130. https://doi.org/10.1038/srep34130

Posada D, Crandall KA (1998) MODELTEST: testing the model of DNA substitution. Bioinformatics 14 (9): 817–818. https://doi.org/10.1093/bioinformatics/14.9.817

Power JH (1926) Notes on the habits and life histories of South African Anura with descriptions of the tapdoles. Transactions of the Royal Society of South Africa 14: 237–247. https://doi.org/10.1080/00359192609519631

Poynton JC (1964) The Amphibia of southern Africa: a faunal study. Annals of the Natal Museum 17: 1–334.

Poynton JC (1991) Amphibians of southeastern Tanzania, with special reference to *Stephopaedes* and *Mertensophryne* (Bufonide). Bulletin of the Museum of Comparative Zoology 152: 451–473.

Poynton JC (1996) Diversity and conservation of African bufonids (Anura): some preliminary findings. African Journal of Herpetology 45: 1–7. https://doi.org/10.1080/21564574.1996.9649958

Poynton JC, Broadley DG (1988) Amphibia Zambesiaca 4. Bufonidae. Annals of the Natal Museum 29: 447–490.

Poynton JC, Haacke WD (1993) On a collection of amphibians from Angola, including a new species of *Bufo* Laurenti. Annals of the Transvaal Museum 36: 1–16.

Roll U, Feldman A, Novosolov M, Allison A, Bauer A, Bernard R, Bohm M, Chirio L, Collen B, Colli GR, Dabul L, Das I, Doan T, Grismer L, Herrera FC, Hoogmoed M, Itescu Y, Kraus F, LeBreton M, Lewin A, Martins M, Maza E, Meirte D, Nagy Z, Nogueira CC, Pauwels OSG, Pincheira-Donoso D, Powney G, Sindaco R, Tallowin O, Torres-Carvajal O, Trape JF, Uetz, P, Vidan E, Wagner P, Wang YZ, Orme D, Grenyer R, Meiri S (2017) The global distribution of tetrapods reveals a need for targeted reptile conservation. Nature Ecology & Evolution 1: 1677–1682. https://doi.org/10.1038/s41559-017-0332-2

Simon C, Frati F, Beckenbach A, Crespi B, Liu H, Flook P (1994) Evolution, weighting and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. Annals of the Entomological Society of America 87: 651–701. https://doi.org/10.1093/aesa/87.6.651

Sekercioglu CH, Riley A (2005) A brief survey of birds in Kumbira Forest, Gabela, Angola. Ostrich 76: 3–4. https://doi.org/10.2989/00306520509485483

Smith A (1848) Illustrations of the Zoology of South Africa; Consisting Chiefly of Figures and Descriptions of the Objects of Natural History Collected during an Expedition into the Interior of South Africa, in the Years 1834, 1835, and 1836. Reptilia. Part 27. Smith, Elder, & Co., London, 16 pp.

Svensson MS, Bersacola E, Mills MS, Munds RA, Nijman V, Perkin A, Masters JC, Couette S, Nekaris KA-I, Bearder SK (2017) A giant among dwarfs: a new species of galago (Primates: Galagidae) from Angola. American Journal of Physical Anthropology 2017:1–14. https://doi.org/10.1002/ajpa.23175

Stanley EL, Ceríaco LMP, Bandeira S, Valério H, Bates MF, Branch WR (2016) A review of *Cordylus machadoi* (Squamata: Cordylidae) in southwestern Angola, with the description of a new species from the Pro-Namib desert. Zootaxa 4061(3): 201–226. https://doi.org/10.11646/zootaxa.4061.3.1

Stevens RA (1974) An annotated check list of the amphibians and reptiles known to occur in south-eastern Malawi. Arnoldia 30(6): 1–22.

Tamura K, Stecher G, Peterson D, Filipski A, Kumar S (2013) MEGA6: Molecular Evolutionary Genetics Analysis Version 6.0. Molecular Biology and Evolution 30: 2725–2729. https://doi.org/10.1093/molbev/mst197

Tandy M (1972) The Evolution of African *Bufo*. PhD Thesis, University of Texas, Austin.

Tandy M, Keith R (1972) *Bufo* of Africa. In: Blair WF (Ed.) Evolution in the genus *Bufo*. University of Texas Press, Austin & London, 119–170.

Thomas A, Suyesh R, Biju SD, Bee MA (2014) Vocal behavior of the elusive Purple Frog of India (*Nasikabatrachus sahyadrensis*), a fossorial species endemic to the Western Ghats. PLoS ONE 9(2): e84809. https://doi.org/10.1371/journal.pone.0084809

Tihen JA (1960) Two new genera of African bufonids, with remarks on the phylogeny of related genera. Copeia 1960: 225–233. https://doi.org/10.2307/1439662

Van Bocxlaer I, Loader SP, Roelants K, Biju SD, Menegon M, Bossuyt F (2010) Gradual adaptation toward a range-expansion phenotype initiated the global radiation of toads. Science 327: 679–682. https://doi.org/10.1126/science.1181707

Watters JL, Cummings ST, Flanagan RL, Siler CD (2016) Review of morphometric measurements used in anuran species descriptions and recommendations for a standardized approach. Zootaxa 4072(4): 477–495. https://doi.org/10.11646/zootaxa.4072.4.6

Womack MC, Christensen-Dalsgaard J, Coloma LA, Chaparro JC, Hoke KL (2017) Earless toads sense low frequencies but miss the high notes. Proceedings of the Royal Society B 284(1864): 20171670. https://doi.org/10.1098/rspb.2017.1670

Womack MC, Fiero TS, Hoke KL (2018) Trait independence primes convergent trait loss. Evolution. [In press] https://doi.org/10.1111/evo.13442

Supplementary material 1

CT-Scan settings

Authors: Luis M. P. Ceríaco, Mariana P. Marques, Suzana Bandeira, Ishan Agarwal, Edward L. Stanley, Aaron M. Bauer, Matthew P. Heinicke, David C. Blackburn

Data type: specimens data

Explanation note: CT-Scan settings for the different specimens used in this study.

Link: https://doi.org/10.3897/zookeys.780.25859.suppl1

ZooKeys 780: 137–154 (2018)
doi: 10.3897/zookeys.780.25593
http://zookeys.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
ZooKeys
Launched to accelerate biodiversity research

A new rare species of the *Rhadinaea decorata* group from the Sierra Madre del Sur of Guerrero, Mexico (Squamata, Colubridae)

Uri Omar García-Vázquez[1], Carlos J. Pavón-Vázquez[2,5],
Jean Cristian Blancas-Hernández[3], Epifanio Blancas-Calva[4], Eric Centenero-Alcalá[1]

1 *Laboratorio de Sistemática Molecular, Unidad Multidisciplinaria de Investigación Experimental, Facultad de Estudios Superiores Zaragoza, Universidad Nacional Autónoma de México, Batalla 5 de Mayo s/n, Col. Ejército de Oriente, Ciudad de México 09230, México* **2** *Museo de Zoología and Departamento de Biología Evolutiva, Facultad de Ciencias, Universidad Nacional Autónoma de México, Apartado Postal 70-153, Ciudad de México 04510, México* **3** *Colegio de Biólogos de Guerrero A.C. Calle Laureles No. 69, Colonia Los Sauces. Chilpancingo, Guerrero 39060, México* **4** *Instituto de Investigación Científica Área de Ciencias Naturales, Universidad Autónoma de Guerrero, Av. Lázaro Cárdenas s/n, interior del Jardín Botánico, Ciudad Universitaria, Chilpancingo, Guerrero 39087, México* **5** *Current address: Division of Ecology and Evolution, Research School of Biology, Australian National University, 46 Sullivans Creek Road, Canberra, Australian Capital Territory 2601, Australia*

Corresponding author: *Uri Omar García-Vázquez* (urigarcia@gmail.com)

Academic editor: *R. Jadin* | Received 7 April 2018 | Accepted 14 June 2018 | Published 8 August 2018

http://zoobank.org/E04375D4-A432-4097-A389-2BA17FF6BF34

Citation: García-Vázquez UO, Pavón-Vázquez CJ, Blancas-Hernández JC, Blancas-Calva E, Centenero-Alcalá E (2018) A new rare species of the *Rhadinaea decorata* group from the Sierra Madre del Sur of Guerrero, Mexico (Squamata, Colubridae). ZooKeys 780: 137–154. https://doi.org/10.3897/zookeys.780.25593

Abstract

A new species of the *Rhadinaea decorata* group is described based on two specimens from the Sierra Madre del Sur, Guerrero, Mexico. The new species differs from all other members of the genus *Rhadinaea* by having: eight supralabials; 149–151 (male) ventrals; 63–77 (male) subcaudals; two large pale nuchal blotches, forming an incomplete collar that occupies two scales laterally and is bissected along the dorsal midline; a postocular pale marking consisting of a well-defined, narrow line beginning behind the upper posterior margin of the eye and extending posteriorly nearly horizontally until connecting with the nuchal blotches; and the dark ground color of the flanks extending to the lateral portion of the ventrals. The large nuchal blotches distinguish the new species from the other members of the *R. decorata* group, except for *R. cuneata* and some individuals of *R. hesperia* (pale nuchal marking one-scale wide in *R. mar-*

cellae, absent in the other species). The condition of the postocular pale marking distinguishes it from *R. cuneata* and *R. hesperia* (postocular pale marking wedge-shaped in *R. cuneata*, not connected with the pale post-cephalic markings in *R. hesperia*). Furthermore, the number of subcaudals and the coloration of the lateral portion of the ventrals distinguish it from *R. omiltemana* and *R. taeniata*, the remaining congeners found in Guerrero (85–90 in males of *R. omiltemana* and 91–121 in *R. taeniata*; dark color of the flanks not reaching ventrals in the former species, occasionally and faintly in *R. taeniata*). Additionally, a new combination for *R. stadelmani* is proposed. The new species is the first described in the genus *Rhadinaea* in more than 40 years.

Keywords

Description, reptile, snake, systematics, taxonomy

Introduction

Snakes of the genus *Rhadinaea* Cope, 1863 (Colubridae: Dipsadinae) are distributed throughout Mesoamerica, ranging from the Sierra Madre Occidental of southern Sinaloa and Sierra Madre Oriental of northern Nuevo León in Mexico to northwestern Ecuador in South America, with an isolated species, *R. flavilata* (Cope, 1871), in the southeastern USA (Myers 1974). According to Myers (2011), the genus contains 20 species arranged in six species groups, mainly on the basis of their external morphology. These groups are (number of species in each group in parentheses) the *R. calligaster* (1), *R. decorata* (11), *R. flavilata* (2), *R. taeniata* (3), and *R. vermiculaticeps* (3) groups. Five species described after the publication of Myers's (1974) revision and originally placed in *Rhadinaea* have been transferred to *Rhadinella* (Myers 2011). Thus, no new species of *Rhadinaea* (sensu Myers 2011) has been described since Myers' systematic monograph of the group in 1974.

The *Rhadinaea decorata* group is characterized by the following combination of traits (Myers 1974): the hemipenis is single, without special features; a subpreocular is usually present; supracloacal ridges are usually present in males. The body is either striped or lined, with at least a hint of a narrow, linear dark marking involving dorsal scale rows 4 or 5, occasionally bordered above by a pale streak or series of small pale spots. A pale postocular marking extends from, or lays a short distance behind, the upper rear edge of the eye. The line may extend horizontally toward the neck or obliquely toward the corner of the mouth. Dorsal scales are arranged in 17-17-17 rows. Ventrals are 110–175 in males and 114–186 in females. Subcaudals are 56–137 in males and 60–120 in females. The tail comprises between 25% and 48% of the total length.

The *Rhadinaea decorata* group is the most diverse assemblage within the genus. Members of the group collectively range from the Mexican states of Tamaulipas and Sinaloa south and east to northwestern Ecuador, where they are mainly found in high mountains. All the species occur in Mexico and only *R. decorata* (Günther, 1858) is not endemic to the country (Myers 1974): *R. bogertorum* Myers, 1974 is known from northern Oaxaca (Myers 1974); *R. myersi* Rossman, 1965 from eastern Guerrero and southern Oaxaca (García-Vázquez et al. 2009); *R. macdougalli* Smith & Langebartel, 1949 from northern Oaxaca with an isolated population from Los Tuxtlas, Veracruz (Myers 1974, Pérez-Higareda et al. 2002); *R. cuneata* Myers, 1974 and *R. forbesi* Smith, 1942 from central Veracruz (Myers 1974); *R. marcellae* Taylor, 1949 from southern San Luis Potosí, Hidalgo, and northern Puebla (Nieto-Montes de Oca and Mendelson III 1997); *R. quinquelineata* Cope, 1886 from Hidalgo and northern Puebla (Myers 1974); *R. gaigeae* Bailey, 1937 from southern Tamaulipas, San Luis Potosí, Querétaro, and northern Hidalgo (Myers 1974); *R. montana* Smith, 1944 from central Nuevo León and western Tamaulipas (Myers 1974, García-Vázquez 2012); *R. hesperia* Bailey, 1940 from the Sierra Madre del Sur of Guerrero and Oaxaca, the Pacific coast from southeastern Sinaloa to Oaxaca, and the Balsas Basin of Morelos and Puebla; and *R. decorata* from the Atlantic coast of southeastern San Luis Potosí, Mexico, southwards into northwestern Ecuador (Myers 1974).

During fieldwork conducted in the Sierra Madre del Sur, Guerrero, between 2006 and 2008 we collected an unusual individual of *Rhadinaea* in the vicinity of El Molote. In eleven trips to the locality we were unable to locate another specimen. Eight years after concluding our fieldwork another specimen with similar characteristics was collected ca. 3 km NW (in straight line) of where the first specimen was found. The snakes show a unique combination of characters and are apparently allopatric with respect to closely related species of *Rhadinaea* (see comparison section). These two individuals possess a unique combination of characteristics leading us to conclude they represent a new species that we describe below.

Materials and methods

Acronyms for herpetological collections follow Sabaj (2016), except for MZFC-HE for the Museo de Zoología of the Facultad de Ciencias, Universidad Nacional Autónoma de México. The specimens of the new species were fixed in 10% buffered formalin, subsequently transferred to 70% ethanol for permanent storage, and deposited in the herpetological collection of the MZFC-HE. We compared the new species with all the other species of *Rhadinaea*, based on the examination of 68 specimens belonging to 11 species, and also benefitted from data contained in the relevant literature (i.e. Myers 1974, Holm and Cruz 1994, Mendelson III and Kizirian 1995, Nieto-Montes de Oca and Mendelson III 1997, McCranie 2006, Myers 2011). We provide a list of the specimens examined in Supplementary material 1.

We follow Myers (1974) for scale nomenclature. We performed scale counts under a dissecting microscope. We counted the ventrals as suggested by Myers (1974). We scored bilateral characters on both sides. When the condition of a given character was not identical on both sides, we give the conditions on the left and right sides, in that order, separated by a slash (/). We recorded measurements with a ruler (nearest 1 mm), digital callipers (nearest 0.1 mm), or an ocular micrometer to the nearest 0.1 mm. We measured head length from the tip of the snout to the angle of the jaw. We measured all scale dimensions at their maximum. We examined the hemipenial morphology in the new species after removal of the right hemipenis from the preserved holotype. The hemipenes were partially everted in the preserved specimens and therefore we could not record characters that are only visible in the retracted organs. We followed Pesantes (1994), Myers and Cadle (2003), Zaher and Prudente (2003), and Angarita-Sierra (2014) for hemipenial preparation. We follow Zaher (1999) and Myers and McDowell (2014) for hemipenial morphological terminology.

Results

Our review of the literature revealed the need to update the binomial name of *Rhadinaea stadelmani* Stuart & Bailey, 1941. The species was placed in the synonymy of *Rhadinaea hempsteadae* Stuart & Bailey, 1941 (= *Rhadinella hempsteadae*) by Myers (1974), but Mendelson III and Kizirian (1995) resurrected it based on additional material. Later, Myers (2011) resurrected the genus *Rhadinella* Smith, 1941 to accommodate the former members of the *Rhadinaea godmani* group, including *Rhadinella hempsteadae*. However, he did not comment on the generic placement of *Rhadinaea stadelmani*. Given the apparent close relationship of *Rhadinaea stadelmani* and *Rhadinella hempsteadae* and the morphological agreement of *Rhadinaea stadelmani* with the diagnosis of *Rhadinella* (Stuart and Bailey 1941, Myers 1974, 2011, Mendelson III and Kizirian 1995), we propose a new combination for *Rhadinaea stadelmani* as follows: *Rhadinella stadelmani* (Stuart & Bailey, 1941), comb. n.

Morphological examination of the specimens from El Molote supported their inclusion in the genus *Rhadinaea* (sensu Myers 2011), based on the following combination of traits (Myers 1974): hemipenis symmetrical, distally calyculate, unicapitate, spinose; sulcus spermaticus bifurcate; pupil round; full complement of colubrid head plates; subpreocular present; dorsal scales smooth, arranged in 17 rows with no posterior reduction; head with distinctive markings; body brown with longitudinal dark lines. Additionally, the specimens agree with Myers's (1974) definition of the *R. decorata* group presented above. However, the snakes share the presence of a unique set of character states that distinguish them from all known species of *Rhadinaea* (see below). The new species may be known subsequently as:

Rhadinaea nuchalis **sp. n.**

http://zoobank.org/0D170649-DD52-49A3-B331-34892F887ADF
Figs 1–5

Type material. Holotype. MZFC-HE 22161, (original field number JCBH 015) an adult male, from 0.36 km SE of El Molote, municipality of Atoyac de Álvarez, Guerrero, México (17.4167°N; 100.1672°W), ca. 1720 m elevation, collected by J.C. Blancas-Hernández on July 19, 2006. **Paratype.** MZFC-HE 34958, (original field number CIG 1078) an adult male, from El Molote, municipality of Atoyac de Álvarez, Guerrero, México (17.4376°N; 100.1891°W), ca. 1680 m elevation, collected by Christoph I. Grünwald, Héctor Franz-Chávez, and Karen I. Morales-Flores on September 11, 2016.

Diagnosis. A colubrid snake of the *Rhadinaea decorata* group (sensu Myers 1974) that may be distinguished from all other members of the genus *Rhadinaea* by the following combination of character states: eight supralabials; 149–151 ventrals in males; 63–77 subcaudals in males; presence of two large pale nuchal blotches, forming an incomplete collar that occupies two scales laterally and bissected along the dorsal midline; postocular pale marking consisting of a well-defined and narrow line beginning anteriorly behind the upper posterior margin of the eye and extending posteriorly nearly horizontally until connecting with the nuchal blotches; and ground color of the flanks extending to the lateral portion of the ventrals.

Comparison. *Rhadinaea nuchalis* sp. n. may be distinguished from all other members of the genus *Rhadinaea* (except *R. cuneata* and some individuals of *R. hesperia* and *R. omiltemana* Günther, 1894) by the presence of two large pale nuchal blotches forming an incomplete collar that occupies two scales laterally and is bissected along the dorsal midline (pale nuchal marking one-scale long in *R. laureata* (Günther, 1868) and *R. marcellae*, absent in the other species). *Rhadinaea nuchalis* can be further distinguished from the members of the *R. flavilata* group by the presence of eight supralabials (usually seven in the *R. flavilata* group). Additionally, it differs from *R. calligaster* (Cope, 1875), *R. forbesi*, *R. hesperia*, *R. marcellae*, *R. macdougalli*, and *R. montana* by the presence of a well-defined, pale postocular line beginning anteriorly behind the upper posterior margin of the eye and extending nearly horizontally posteriorly until connecting with the nuchal blotches (pale postocular line oblique in *R. calligaster* [if present], *R. forbesi*, *R. macdougalli*, and *R. marcellae*; not connected with the pale post-cephalic markings in the other species [except for one side in one specimen of *R. montana*]).

Furthermore, *Rhadinaea nuchalis* can be distinguished from members of the *R. vermiculaticeps* group by having more ventrals in males (149–151 vs. 117–124 ventrals in males of the *R. vermiculaticeps* group). *Rhadinaea nuchalis* differs from *R. cuneata* by having less subcaudals in males (63–77 vs. 106–115) and by having a narrow postocular pale marking in the form of a nearly horizontal line (postocular pale marking wedge-shaped in *R. cuneata*). Specifically, *R. nuchalis* differs from other congeners that inhabit Guerrero except *R. myersi* by having fewer subcaudals in males (63–77 vs. 110–137 in *R. hesperia*; 85–90 in *R. omiltemana*; 91–121 in *R. taeniata* Peters, 1863). Additionally, it differs from *R. myersi*, *R. omiltemana*, and *R. taeniata* by having the dark ground color of the flanks extending to the lateral portion of the ventrals (dark ground color of the flanks not reaching ventrals in *R. omiltemana*, occasionally and faintly so in *R. myersi* and *R. taeniata*).

Description of holotype (Figs 1, 2). Male; adult; head length = 12.2 mm, snout-vent length (SVL) = 275 mm, tail length = 104 mm. Head distinct from neck; snout long, contained 2.5 times in head length, rounded from above, projecting anteriorly beyond lower jaw; rostral broader than high, portion visible from above 0.6 times as long as its distance from frontal, 0.5 times as long as internasal common suture, upper edge slightly above level of upper margin of nostrils; internasals

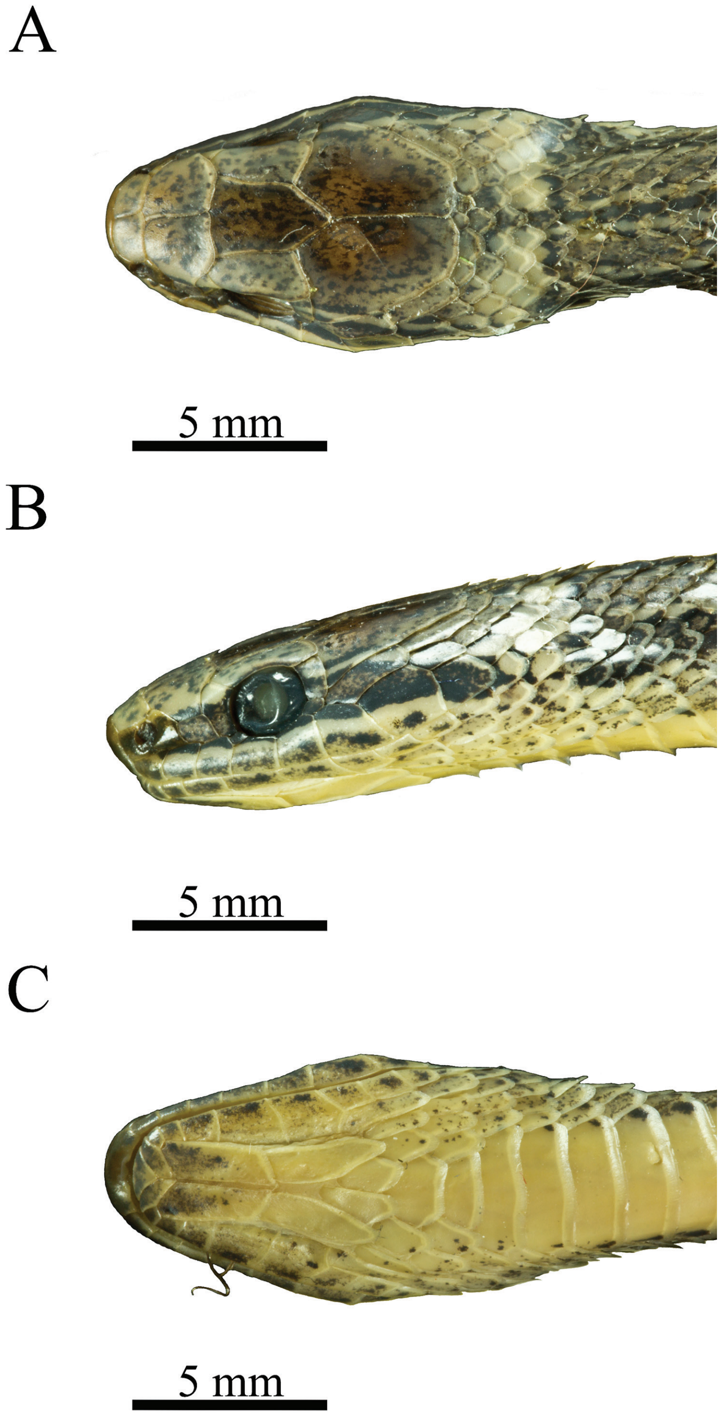


Figure 1. Head of *Rhadinaea nuchalis* sp. n. Holotype (MZFC-HE 22161) in dorsal (**A**), left lateral (**B**), and ventral (**C**) views.

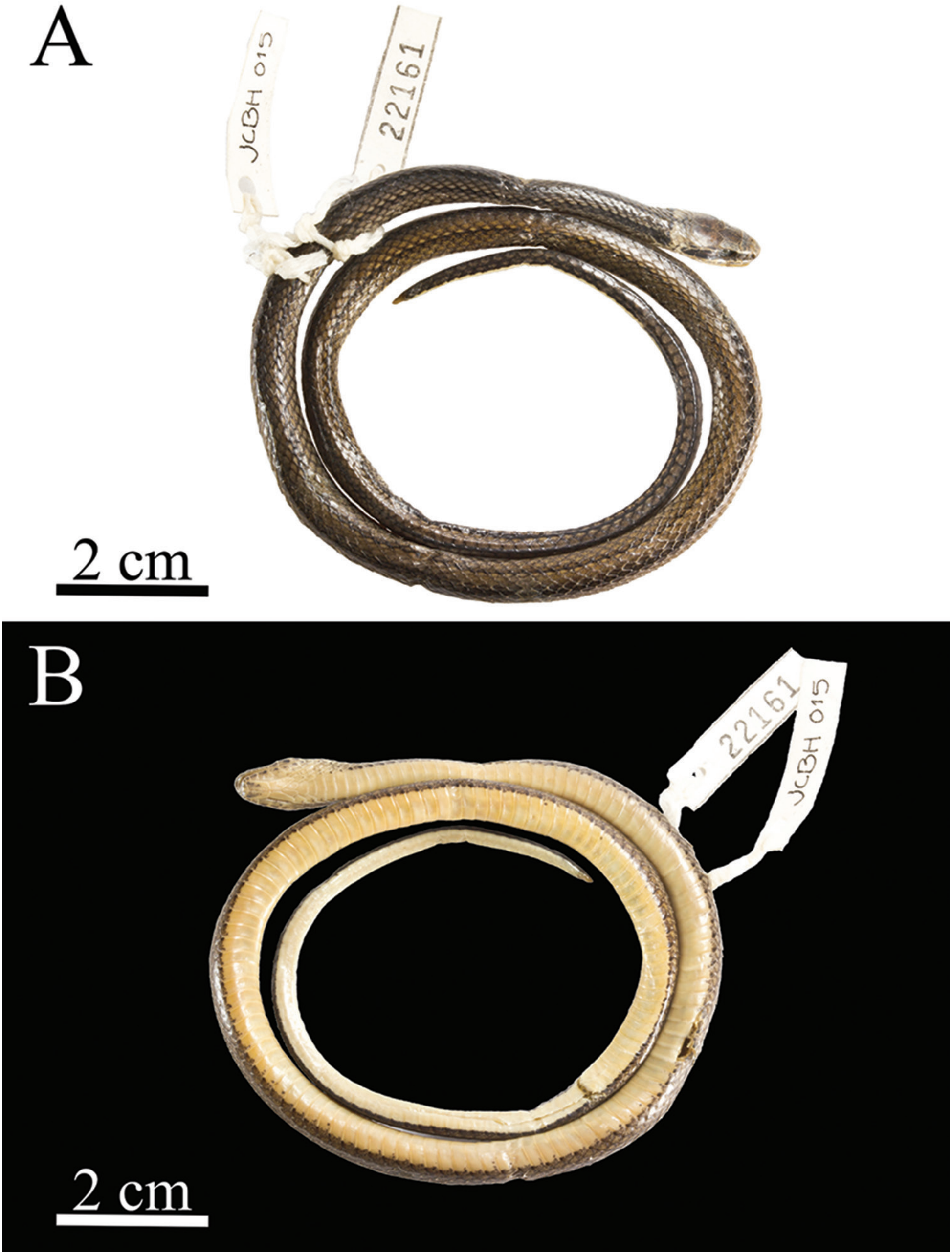


Figure 2. *Rhadinaea nuchalis* sp. n., holotype (MZFC-HE 22161). Dorsal (**A**) and ventral (**B**) views.

broader than long (width / length = 1.5), rounded laterally, contacting anterior and posterior nasals laterally, length and common suture ca. 0.8 and 0.4 times as long as prefrontal common suture, respectively; prefrontal contacting postnasal and loreal laterally, length ca. 0.3 times length of snout, common suture ca. 0.5 times frontal length; frontal longer than broad (width / length = 3.6/2.3), angulate posteriorly; supraocular large, contacting prefrontal, frontal, parietal, and upper postocular broadly, length ca. 1.3 times length of horizontal diameter of eye, 1.3/1.3 times as long as loreal, ventral margin projecting anteriorly and posteriorly beyond margins of orbit; parietals 1.6 times longer than broad, length approximately 0.4 times head length, common suture as long as frontal; nasal divided; prenasal 1.3/1 times as long as postnasal; prenasal and postnasal combined length ca. 2.3 times loreal length; loreal as high as long, contained 1.1 times in snout length, 0.4 times as long as horizontal diameter of eye, dorsal margin nearly straight; preocular single, 1.8 times higher than long; subpreocular present, tiny, separating preocular and fourth supralabial; postoculars two; upper postocular 1.4 times higher than long, 2.3 times longer than lower postocular; lower postocular 2.25 times longer than high; eye large, contained 4.1 times in snout length, vertical diameter 2.0 times distance from lip; supralabials 8/8, first and second contacting postnasal, second and third contacting loreal, fourth and fifth entering orbit, seventh largest, contacting anterior temporal, eight contacting lower posterior temporal; temporals 1 + 2; anterior temporal separating sixth and seventh supralabials from parietal; upper posterior temporals separated posteriorly by five nuchals; lower posterior temporal contacting anterior temporal and seventh supralabial anteriorly, eight supralabial ventrally. Mental 1.5 times broader than long, rounded anteriorly, separated from chinshields by first infralabials; infralabials 10/10, first to third contacting anterior chinshields, fourth to sixth separated from chinshields by interstitial skin, seventh to tenth separated by other scales; anterior chinshields 3.3 times longer than broad, as long as posterior chinshields; posterior chinshields separated from each other by two midgular scales.

Transverse dorsal scale rows 17-17-17, smooth; apical pits absent; ventrals 151; cloacal scute divided; paired subcaudals 63.

Color (in life; Figs 3–4). Dorsum of head ochre, extending to rostral anteriorly, to third dorsal scale posterior to parietals posteriorly along the dorsal midline, narrowing occupying one dorsal scale laterally; extending to upper half of nasal, lateral portion of prefrontal, upper third of preocular, lateral edge of supraocular, uppermost portion of upper postocular, lateral portion of parietal, and ventral portion of upper secondary temporal and dorsal scale posterior to it ventrolaterally; irregular dark markings present, except on ventral border anteriorl to orbit (creating the appearance of a faint preocular line). Postocular pale marking consisting of a nearly horizontal, black-bordered, cream line; beginning anteriorly on rear upper fourth of orbit; passing along upper portion of upper postocular, lateral portion of parietal, and upper portion of primary temporal, connecting with nuchal blotches posteriorly. Lateral stripe dark brown, black-bordered; ventrally bordering faint preocular line and postocular pale marking; extending anteriorly to posterior nasal, eighth supralabial posteriorly; occupying upper border of supralabials 1–6, upper half of supralabial 7, and entire surface of supralabial 8 except for anteroventral corner. Ground coloration below dark lateral stripe white, interspaces between each scale bright pink; supralabials 1–7, mental, infralabials, and anterior chinshields with irregular dark markings.

Figure 3. *Rhadinaea nuchalis* sp. n., holotype (MZFC-HE 22161) in life.

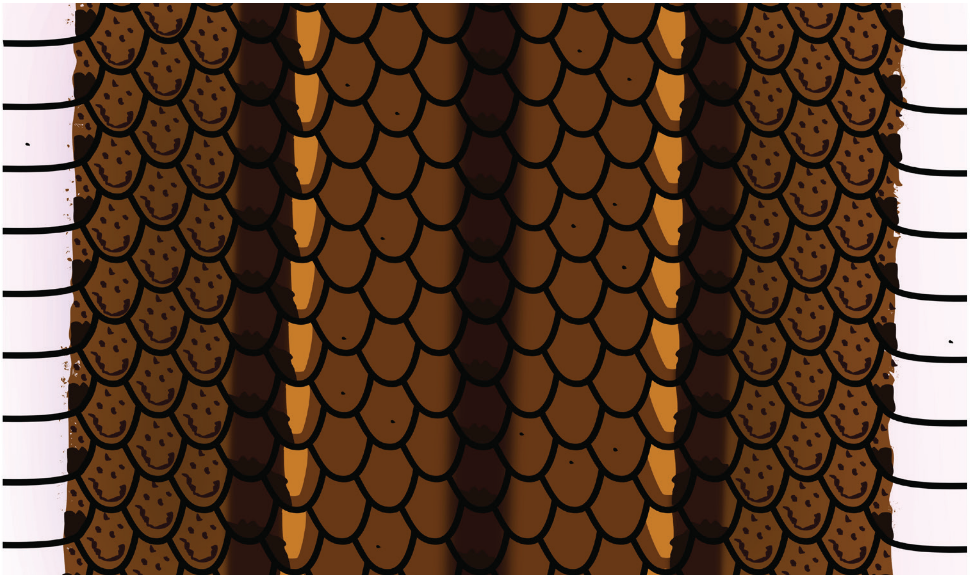


Figure 4. Diagram of coloration at level of midbody in *Rhadinaea nuchalis* sp. n. Based on holotype (MZFC-HE 22161).

Nuchal blotches brownish orange; separated dorsally by median dark line; one dorsal scale long dorsally, widening laterally to two dorsal scales; nearly immaculate dorsally, with abundant dark speckling at level of supralabials; connected to pale ventral coloration. First and second transverse dorsal scale rows posterior to nuchal blotches reddish brown, slightly darker than rest of body.

Coloration of rest of body and tail: median dark line dark brown, with darker spots on tip of each dorsal scale in vertebral row; extending to third mid-dorsal scale posterior to parietals anteriorly, to tip of tail posteriorly; narrower anteriorly and posteriorly (confined to vertebral dorsal scale row near head and to medial edges of innermost dorsal scale rows in tail), wider at midbody (occupying vertebral dorsal scale row entirely and dorsal edges of adjacent dorsal scale rows). Dorsolateral stripe ochre; failing to contact nuchal blotches anteriorly by two scales, extending to tip of tail posteriorly; extending between upper portion of fifth and lower portion of eighth longitudinal dorsal scale rows at level of mid-body, between upper portion of second and lower portion of third longitudinal dorsal scale rows at level of mid-tail. Scales on fifth longitudinal dorsal scale row at level of mid-body and second at level of mid-tail exhibiting prominent orange spots. Lateral dark line bordering dorsolateral stripe ventrally; contacting nuchal blotches anteriorly, extending to tip of tail posteriorly; occupying three longitudinal dorsal scale rows just posteriorly to head, upper portion of fourth and lower edge of fifth longitudinal dorsal scale rows at level of mid-body, upper edge of first and lower edge of second longitudinal dorsal scale rows at level of tail. Flanks dark ochre, slightly darker than dorsolateral stripes, presenting abundant dark speckling. Ground color of flanks extending ventrally onto lateral portions of ventrals and subcaudals. Lateral portion of ventrals with black spots posteriorly at level of ventral edge of color of flanks. Conspicuous dark line passing along lateral edge of subcaudals. Remaining surface of ventrals and subcaudals white, suffused lightly with bright pink from head to level of mid-body, with sparse tiny dark dots.

Hemipenes (Figure 5). Hemipenes unilobed, unicapitate, length ≈ 5 mm. Sulcus spermaticus centripetal basally, centrolineal distally; bifurcating at level of distal end of basal third of capitulum, terminating distally at level of basal end of distal third of capitulum; sulcus spermaticus walls smooth, well-defined; intrasulcar region nude. Capitulum calyculate, longer on sulcate side (≈ 2.5 mm, vs. ≈ 1.2 mm on asulcate side); calyces papillate in most of capitulum, spinulate near base of capitulum. Hemipenial body covered in spines distally; enlarged spines 30, slightly curved, larger and more abundant on lateral surfaces of hemipenial body and asulcate side than on sulcate side; area of hemipenial body below spinose section covered in small spinules; spinules surrounding sulcus spermaticus walls, covering larger area on sulcate and asulcate sides than on lateral surfaces of hemipenial body, separated from enlarged spines by triangular nude patch on asulcate side. Basal-most portion of hemipenial body nude.

Variation. The paratype differs from the holotype by having the upper posterior temporal divided into two small scales on the right side, 10/9 infralabials, the posterior chinshields separated from first ventral by two rows of small scales, 149 ventrals, and 77 subcaudals. No remarkable differences in color pattern are present in the paratype with respect to the holotype.

Etymology. The specific name *nuchalis* comes from the Latin *nucha*, meaning nape. It makes reference to the large nuchal blotches present in the new species.

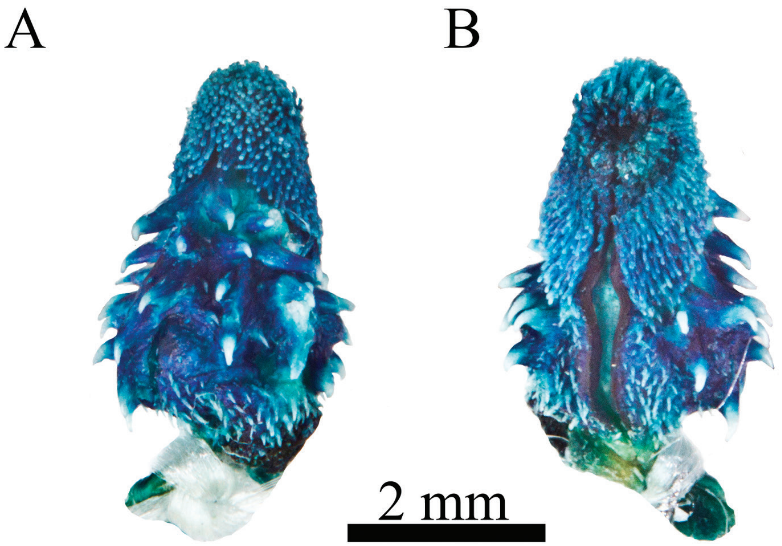


Figure 5. Right hemipenis of *Rhadinaea nuchalis* sp. n., holotype (MZFC-HE 22161). Asulcate (**A**) and sulcate (**B**) sides.

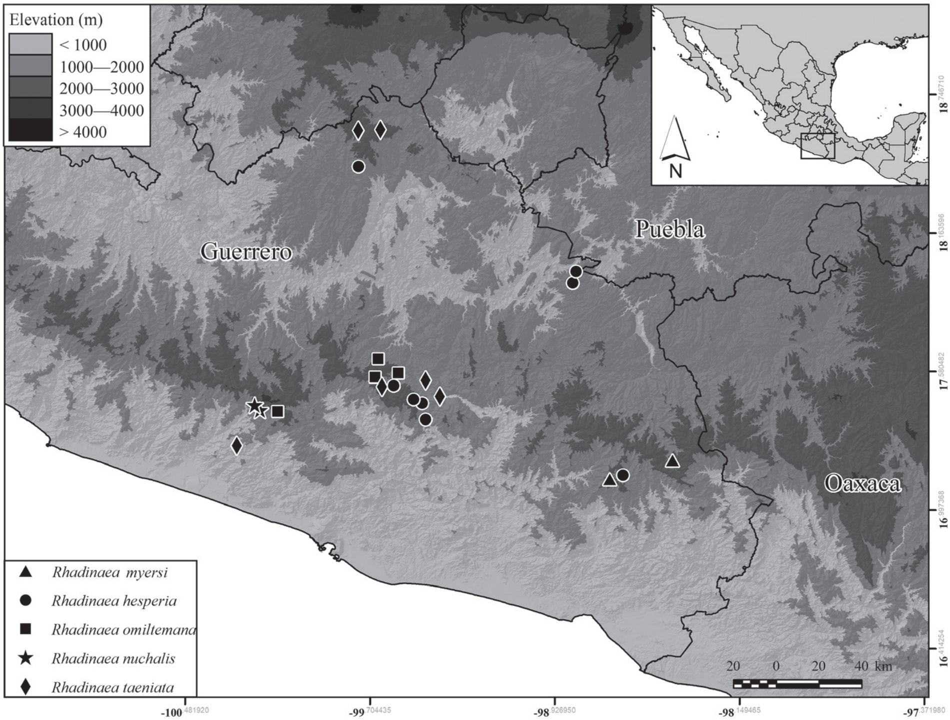


Figure 6. Collection localities of the species of the genus *Rhadinaea* in Guerrero. Black lines represent state limits.

Figure 7. Habitat of *Rhadinaea nuchalis* sp. n. in the type locality.

Distribution and ecology. *Rhadinaea nuchalis* sp. n. is known only at intermediate elevations from the vicinity of El Molote in the western portion of the Sierra Madre del Sur of Guerrero. The species appears to be allopatric with the other species of the *R. decorata* group. The closest *Rhadinaea* record to *R. nuchalis* is that of *R. omiltemana* from El Tambor, Coyuca de Benítez, Guerrero, approximately 8 km E in straight line from the type locality of *R. nuchalis* (Palacios-Aguilar et al. 2016). The second closest record is that of *R. taeniata* from 1.5 mi N San Vicente de Jesus, Guerrero, about 18 km SSW in straight line from the type locality of *R. nuchalis* (Myers 1974). Other close records are those of *R. omiltemana* from Omiltemi and Asoleadero, *R. hesperia* from Acahuizotla and Chilpancingo, and *R. taeniata* from Chilpancingo, all in Guerrero (Fig. 6). All the three are about 72 km, straight line, from the type locality of *R. nuchalis* The closest records of species in the *R. decorata* group, excluding those of *R. hesperia*, to the type locality of *R. nuchalis* are those of *R. myersi* from Malinaltepec, Guerrero, and southwestern Oaxaca (García-Vázquez et al. 2006); and those of *R. macdougalli* and *R. bogertorum* from northern Oaxaca (Myers 1974, Ramírez-Bautista et al. 1998).

The region of El Molote is characterized by rugged topography and the presence of numerous permanent streams that flow into the Atoyac and Coyuca rivers, whose basins belong to the Costa Grande hydrologic region (Lozada et al. 2003). Additional descriptions of the climate and other ecological aspects of El Molote can be found in Meza and López (1997) and Pavón-Vázquez et al. (2011). Coffee plantations have replaced most of the original cloud forest. The forest is dense and tall in undisturbed places, with the canopy reaching 25–30 m in height (Fig. 7). *Pinus ayacahuite*, *P. strobus* var. *chiapensis*, and *Ulmus mexicana* are emergent species, and *Alfaroa costaricensis*, *Sloanea* sp., *Quercus salicifolia*, *Cojoba arborea*, *Magnolia schiedeana*, and *Zanthoxylum melanostictum* are dominant species (Lozada et al. 2003).

Identification key

An identification key to the species of *Rhadinaea* was included in Myers's (1974) revision of the genus. Examination of the known specimens of *R. nuchalis* would lead to couplet number 40 in Myers's (1974) key for North American species. Modifying number 40 as follows would allow the identification of *R. nuchalis*:

40	Pair of large pale nuchal blotches, forming a collar broken on the dorsal midline .... ***R. nuchalis* sp. n.**
–	Post-cephalic pale markings not significantly enlarged, not as described above **41**

Former number 40, a bracket including *R. bogertorum* and *R. myersi*, would become number 41.

Discussion

Color pattern has been considered one of the most informative characters for distinguishing between species and species groups within *Rhadinaea*: "…once some idea has been gained of intraspecific variation, color pattern offers the most generally reliable method of identifying species because no two forms have identical patterns…" (Myers 1974). Our own examination of eleven species of *Rhadinaea*, including all of those distributed in Guerrero, and a review of the relevant literature for the whole genus revealed the existence of intraspecific variation in color pattern for some species, but not a single specimen of another species exhibits the combination of coloration characters present in *R. nuchalis*. Additionally, *R. nuchalis* can be distinguished from morphologically similar species, except for *R. forbesi*, and its geographically closest congeners by the presence of a low number of subcaudals in males (see Comparison), and from *R. forbesi* by having a greater number of ventrals in males (149–151, vs. 136–149 in males of *R. forbesi*).

DNA sequences of *Rhadinaea* have been included in studies looking at phylogenetic relationships above the generic level (e.g., Lawson et al. 2005, Pyron et al. 2013), but a molecular assessment of the monophyly of *Rhadinaea* (sensu Myers 2011) and its species groups is still pending. However, species groups within *Rhadinaea* are divergent morphologically and assignment of *R. nuchalis* to the *R. decorata* group is relatively straightforward based on external and hemipenial morphology (see above). Thus, the definition of the group provided by Myers (1974) does not need to be modified by the inclusion of *R. nuchalis*.

The presence of a continuous median dark line, the extension of the dark ground color of the flanks onto the ventrals, the darker coloration of the flanks with respect to the stripes surrounding the median dark line, the relative length of the capitulum and sulcus spermaticus, and the high number of hemipenial spines suggest that *Rhadinaea nuchalis* may be closely related to *R. hesperia* (Myers 1974), its geographically closest congener within the *R. decorata* group. However, *R. hesperia* can be differentiated from *R. nuchalis* by the number of subcaudals in males (see Comparison) and ventral coloration (white anteriorly, grading to deep reddish posteriorly vs. white, suffused lightly with bright pink from head to level of mid-body in *R. nuchalis*). Additionally, although *R. hesperia* occasionally has a pair of slightly enlarged white blotches on the neck, in all cases the pale postocular marking does not coalesce with them.

The congeners geographically closest to *Rhadinaea nuchalis* outside the *R. decorata* group are *R. omiltemana* and *R. taeniata*, members of the *R. taeniata* group. They differ from *R. nuchalis* by having more subcaudals in males; the dark ground color of the flanks usually not reaching the ventrals, except for some individuals of *R. taeniata* in which case the color is faint (see Comparison); a broad (involving at least five dorsal scale rows) dorsal stripe darker than the flanks (median dark line flanked by two stripes paler than the flanks and occupying only the vertebral row and the innermost portions of adjacent scale rows in *R. nuchalis*); and a relatively small capitulum, comprising between two-sevenths and two-fifths of the length of the sulcate side of the hemipenis (capitulum comprising approximately half of length of the sulcate side in *R. nuchalis*).

The Sierra Madre del Sur of Guerrero has received scant attention from herpetologists and most expeditions have focused on the central region of the state, particularly in the Chilpancingo region (i.e. Campbell and Armstrong 1979, Adler 1996). However, the west and east portions of the Sierra have been largely ignored. Recent visits to the west portion have yielded a number of discoveries of new species (e.g., Campbell and Flores-Villela 2008, Campbell et al. 2009, Pavón-Vázquez et al. 2011, Feria-Ortiz and García-Vázquez 2012, Campbell et al. 2014). This suggests that the diversity of the Sierra Madre del Sur of Guerrero is higher than currently known (Palacios-Aguilar and Flores-Villela 2018), particularly for small and secretive snakes as exemplified by the present work and the recent descriptions of *Epictia schneideri* Wallach, 2016, *Geophis occabus* Pavón-Vázquez, García-Vázquez, Blancas-Hernández & Nieto-Montes de Oca, 2011, and *Rhadinella dysmica* Campillo, Dávila-Galavíz, Flores-Villela & Campbell, 2016.

Acknowledgments

Support for fieldwork in which comparative material was collected was provided by a grant from the Dirección General de Apoyo al Personal Académico, Universidad Nacional Autónoma de México (PAPIIT-IN 221016) to Uri O. García-Vázquez. We thank Herp.mx and Biodiversa A.C. for assistance in the field and for donating the paratype, Ian G. Brennan for reviewing our manuscript for proper use of English, Jonathan A. Campbell and Robert C. Jadin for commenting on preliminary versions of this manuscript, and Luis Canseco Márquez and Ricardo Palacios Aguilar for sharing relevant literature. Fieldwork was conducted under a collecting permit issued to Uri O. García-Vázquez by the Secretaría de Medio Ambiente y Recursos Naturales (permit number FAUT-0243).

References

Adler K (1996) The salamanders of Guerrero, Mexico, with descriptions of five new species of *Pseudoeurycea* (Caudata: Plethodontidae). Occasional Papers of the Natural History Museum, University of Kansas 177: 1–28.

Angarita-Sierra T (2014) Hemipenial morphology in the semifossorial snakes of the genus *Ninia* and a new species from Trinidad, West Indies (Serpentes: Dipsadidae). South American Journal of Herpetology 9: 114–130. https://doi.org/10.2994/SAJH-D-12-00004.1

Bailey JR (1937) A new species of *Rhadinaea* from San Luis Potosi. Copeia 1937: 118–119. https://doi.org/10.2307/1436952

Bailey JR (1940) The Mexican snakes of the genus *Rhadinaea*. Occasional Papers of the Museum of Zoology, University of Michigan 412: 1–19.

Campbell JA, Armstrong BL (1979) Geographic variation in the Mexican Pygmy Rattlesnake, *Sistrurus ravus*, with the description of a new subspecies. Herpetologica 35: 304–317.

Campbell JA, Flores-Villela O (2008) A new long-tailed rattlesnake (Viperidae) from Guerrero, Mexico. Herpetologica 64: 246–257. https://doi.org/10.1655/07-054.1

Campbell JA, Blancas-Hernández JC, Smith EN (2009) A new species of stream-breeding treefrog of the genus *Charadrahyla* (Hylidae) from the Sierra Madre del Sur of Guerrero, Mexico. Copeia 2009: 287–295. doi.org/10.1643/ch-08-143

Campbell JA, Brodie Jr. ED, Blancas-Hernández JC, Smith EN (2014) Another new salamander of the genus *Pseudoeurycea* from the State of Guerrero, Mexico. South American Journal of Herpetology 8: 198–202. https://doi.org/10.2994/sajh-d-13-00026.1

Campillo G, Dávila-Galavíz LF, Flores-Villela O, Campbell JA (2016) A new species of *Rhadinella* (Serpentes: Colubridae) from the Sierra Madre del Sur of Guerrero, Mexico. Zootaxa 4103: 165–173. https://doi.org/10.11646/zootaxa.4103.2.6

Cope ED (1863) Descriptions of new American Squamata, in the Museum of the Smithsonian Institution, Washington. Proceedings of the Academy of Natural Sciences of Philadelphia 15: 100–106.

Cope ED (1871) Ninth contribution to the herpetology of tropical America. Proceedings of the Academy of Natural Sciences of Philadelphia 23: 200–224.

Cope ED (1886) Thirteenth contribution to the herpetology of tropical America. Proceedings of the American Philosophical Society 23: 271–287.

Cope ED (1875) On the Batrachia and Reptilia of Costa Rica with notes on the herpetology and ichthyology of Nicaragua and Peru. Journal of the Academy of Natural Sciences of Philadelphia 8: 93–183. https://doi.org/10.5962/bhl.title.47043

Feria-Ortiz M, García-Vázquez UO (2012) A new species of *Plestiodon* (Squamata: Scincidae) from Sierra Madre del Sur of Guerrero, México. Zootaxa 3339: 57–68.

García-Vázquez UO, Durán-Fuentes I, Nieto Montes de Oca A, Smith HM (2009) *Rhadinaea myersi* (Squamata: Colubridae) in Guerrero and Oaxaca, Mexico. The Southwestern Naturalist 54: 345–346. https://doi.org/10.1894/gc-192.1

García-Vázquez UO (2012) Geographic distribution. *Rhadinaea montana*. Herpetological Review 43: 309.

Günther ACLG (1858) Catalogue of Colubrine Snakes in the British Museum. Taylor and Francis, London, 281 pp. https://doi.org/10.5962/bhl.title.20953

Günther ACLG (1868) Sixth account of new species of snakes in the collection of the British Museum. Annals Magazine of Natural History 1: 413–429. https://doi.org/10.1080/00222936808695725

Günther ACLG (1885–1902) Reptilia and Batrachia. In: Godman FD, Salvin O. (Eds) Biologia Centrali-Americana. Taylor and Francis, London, 1–326. https://doi.org/10.5962/bhl.title.730

Holm PA, Cruz DGA (1994) A new species of *Rhadinaea* (Colubridae) from a cloud forest in northern Honduras. Herpetologica 50: 15–23.

Lawson R, Slowinski JB, Crother BI, Burbrink FT (2005) Phylogeny of the Colubroidea (Serpentes): new evidence from mitochondrial and nuclear genes. Molecular Phylogenetics and Evolution 37: 581–601. https://doi.org/10.1016/j.ympev.2005.07.016

Lozada L, León ME, Rojas J, de Santiago R (2003) No. 13: Bosque Mesófilo de Montaña en El Molote. In: Diego-Pérez N, Fonseca RM (Eds) Estudios Florísticos en Guerrero. Facultad de Ciencias, UNAM, México, 1–39.

McCranie JR (2006) New species of snake of the colubrid genus *Rhadinaea* (*godmani* group) from Parque Nacional El Cusuco, Honduras. Proceedings of the Biological Society of Washington 119: 528–533. https://doi.org/10.2988/0006-324x(2006)119[528:nsosot]2.0.co;2

Mendelson III JR, Kizirian DA (1995) Geographic variation in *Rhadinaea hempsteadae* (Serpentes: Colubridae) with the description of a new species from Chiapas, Mexico. Herpetologica 51: 301–313.

Meza L, López J (1997) No. Especial 1: Vegetación y Mesoclima de Guerrero. In: Diego-Pérez N, Fonseca RM (Eds) Estudios Florísticos en Guerrero. Facultad de Ciencias, UNAM, México, 1–53.

Myers CW (1974) The systematics of *Rhadinaea* (Colubridae), a genus of New World snakes. Bulletin of the American Museum of Natural History 133: 1–262.

Myers CW (2011) A new genus and new tribe for *Enicognathus melanauchen* Jan, 1863, a neglected South American snake (Colubridae: Xenodontidae), with taxonomic notes on some Dipsadinae. American Museum Novitates 3715: 1–33. https://doi.org/10.1206/3715.2

Myers CW, Cadle JE (2003) On the snake hemipenis, with notes of *Psomophis* and techniques of eversion: a response to Dowling. Herpetological Review 34: 295–302.

Myers CW, McDowell SB (2014) New taxa and cryptic species of Neotropical snakes (Xenodontinae), with commentary on hemipenes as generic and specific characters. Bulletin of the American Museum of Natural History 385: 1–112. https://doi.org/10.1206/862.1

Nieto-Montes de Oca A, Mendelson III JR (1997) Variation in *Rhadinaea marcellae* (Squamata: Colubridae), a poorly know species from the Sierra Madre Oriental of México. Journal of Herpetology 31: 124–127. https://doi.org/10.2307/1565341

Palacios-Aguilar R, Flores-Villela O (2018) An updated checklist of the herpetofauna from Guerrero, Mexico. Zootaxa 4422: 1–24. https://doi.org/10.11646/zootaxa.4422.1.1

Palacios-Aguilar R, Santos-Bibiano R, Beltrán-Sánchez E (2016) Distribution notes. Notable distributional records of amphibians and reptiles from Guerrero, Mexico. Mesoamerican Herpetology 3: 527–531.

Pavón-Vázquez CJ, García-Vázquez UO, Blancas-Hernandez JC, Nieto-Montes de Oca A (2011) A new species of the *Geophis sieboldi* group (Squamata: Colubridae) exhibiting color pattern polymorphism from Guerrero, Mexico. Herpetologica 67: 332–343. https://doi.org/10.1655/herpetologica-d-11-00003.1

Pérez-Higareda G, López-Luna MA, Chiszar D, Smith HM (2002) Additions to and notes on the herpetofauna of Veracruz, Mexico. Bulletin of the Chicago Herpetological Society 37: 67–68.

Pesantes OS (1994) A method for preparing the hemipenis of preserved snakes. Journal of Herpetology 28: 93–95. https://doi.org/10.2307/1564686

Peters W (1863) Über einige neue oder weniger bekannte Schlangenarten des zoologischen Museums zu Berlin. Monatsberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin 1863: 272–289.

Pyron RA, Burbrink FT, Wiens JJ (2013) A phylogeny and updated classification of Squamata, including 4161 species of lizards and snakes. BMC Evolutionary Biology 13: 1–93. https://doi.org/10.1186/1471-2148-13-93

Ramírez-Bautista A, Mancilla-Moreno M, Van Breukelen F (1998) Morphological variation and relationship of *Rhadinaea bogertorum* (Squamata: Colubridae), an endemic snake of the Sierra de Juárez, Oaxaca, Mexico. Bulletin of the Maryland Herpetological Society 34: 99.

Rossman DA (1965) Two new colubrid snakes of the genus *Rhadinaea* from southern Mexico. Occasional Papers of the Museum of Zoology, Louisiana State University 32: 1–8.

Sabaj MH (2016) Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an online reference. Version 6.5 (16 August 2016). American Society of Ichthyologists and Herpetologists, Washington, DC. http://www.asih.org/ [accessed 8 September 2016]

Smith HM (1941) A new genus of Mexican snakes related to *Rhadinaea*. Copeia 1941: 7–10. https://doi.org/10.2307/1437694

Smith HM (1942) Descriptions of new species and subspecies of Mexican snakes of the genus *Rhadinaea*. Proceedings of the Biological Society of Washington 55: 185–192.

Smith HM (1944) Snakes of the Hoogstraal Expeditions to northern Mexico. Field Museum of Natural History, Zoological Series 29: 135–152.

Smith HM, Langebartel DA (1949) Notes on a collection of reptiles and amphibians from the Isthmus of Tehuantepec, Oaxaca. Journal of the Washington Academy of Sciences 39: 409–416.

Stuart LC, Bailey JR (1941) Three new species of the genus *Rhadinaea* from Guatemala. Occasional Papers of the Museum of Zoology, University of Michigan 442: 1–11.

Taylor EH (1949) A preliminary account of the herpetology of the state of San Luis Potosí, Mexico. The University of Kansas Science Bulletin 33: 169–215. https://doi.org/10.5962/bhl.part.16126

Wallach V (2016) Morphological review and taxonomic status of the *Epictia phenops* species group of Mesoamerica, with description of six new species and discussion of South American *Epictia albifrons*, *E. goudotii*, and *E. tenella* (Serpentes: Leptotyphlopidae: Epictinae). Mesoamerican Herpetology 3: 216–374.

Wilson LD, Mata-Silva V, Johnson JD (2013) A conservation reassessment of the reptiles of Mexico based on the EVS measure. Amphibian & Reptile Conservation 7: 1–47.

Zaher H, Prudente ALC (2003) Hemipenes of *Siphlophis* (Serpentes, Xenodontinae) and techniques of hemipenial preparation in snakes: a response to Dowling. Herpetological Review 34: 302–307.

Zaher H (1999) Hemipenial morphology of the South American xenodontinae snakes, with a proposal for a monophyletic Xenodontinae and reappraisal of colubroid snakes. Bulletin of the American Museum of Natural History 240: 1–168.

Supplementary material 1

Specimens examined

Authors: Uri Omar García-Vázquez, Carlos J. Pavón-Vázquez, Jean Cristian Blancas-Hernández, Epifanio Blancas-Calva, Eric Centenero-Alcalá

Data type: specimens data

Link: https://doi.org/10.3897/zookeys.780.25593.suppl1