

Two new species of the millipede genus *Glyphiulus* Gervais, 1847 from Laos (Diplopoda, Spirostreptida, Cambalopsidae)

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Abstract

Two new species of *Glyphiulus* are described and illustrated from northern Laos. The epigeal *Glyphiulus subbedosae* Likhitrakarn, Golovatch & Panha, **sp. n.** is the second member of the *granulatus*-group to be found in that country and it seems to be especially similar to *G. bedosae* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007. However, it differs from the latter species by a row of several strong setae near the median marginal ridge on the paraprocts, combined with the gnathochilarium being considerably less densely setose on the caudal face, and the anterior gonopods showing a pair of smaller, apical, but larger lateral teeth on the coxosternal plate. *Glyphiulus semicostulifer* Likhitrakarn, Golovatch & Panha, **sp. n.** is the fourth member of the *javanicus*-group to be discovered in Laos, taken from a cave. It seems to be particularly similar to *G. costulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007, but is distinguished by the more sparsely alveolate background fine structure of the metazonae, coupled with the gnathochilarium being considerably less densely setose on the caudal face, much stronger paramedian prongs and 4-segmented telopodites on ♂ coxae 1, the slightly longer and more slender apicoparamedian sternal projections on the anterior gonopods, and the much longer flagella of the posterior gonopods. An identification key to and a distribution map of *Glyphiulus* species in Laos are also presented.

Keywords

Cave, forest, *Glyphiulus*, key, Laos, map, millipede, new species

Introduction

The large southeast Asian millipede genus *Glyphiulus* Gervais, 1847 has recently been reviewed and shown to comprise 57 species ranging from southern China, northern Laos, and northern Thailand in the north to southern Vietnam in the south (Golovatch et al. 2007a, b; 2011a, b; Jiang et al. 2017). Only one species, *G. granulatus* (Gervais, 1847), has attained a pantropical distribution due to numerous anthropochore introductions. Golovatch et al. (2007a, b) divide this genus into two species groups, based on the conformation of ♂ legs 1. The *granulatus*-group is distinguished by these legs being devoid of median structures, but supplied instead with two widely separated prongs, coupled with often 1- or 2-segmented telopodites. In contrast, the *javanicus*-group shows ♂ legs 1 provided with medially contiguous, but not entirely fused coxal processes, coupled with usually 4- or 5-segmented telopodites, along with special carinotaxy patterns of the collum and following metaterga.

The Lao People's Democratic Republic still supports some of the most significant forested areas remaining anywhere in southeast Asia, especially in the mountains in the north and limestone karsts in central parts (Kemp 2011). A distinctive geological feature of the numerous karst landscapes of the country is a multitude of complex cave systems. Such pronounced habitat diversity is also reflected in millipede faunal richness, the diplopod list of Laos being estimated to amount to at least 130 species (Likhitrakarn et al. 2014a).

The first species of *Glyphiulus* to be reported from Laos was *G. bedosae* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007, a cave-dweller described from Tham Pha Kouang Cave, Nong Kiaw (Muang Ngoy), Luang Prabang Province, representing the *granulatus*-group (Golovatch et al. 2007a). Almost simultaneously, a further three new species from the *javanicus*-group were added: *G. costulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007, from Tham Pha Kouang Cave, Nong Kiaw (Muang Ngoy), Luang Prabang Province, *G. subcostulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007, from Tham None Cave, Vang Vieng, Vientiane Province, and *G. percostulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007, from Tham Thè Cave, Ban Nakok (Nakhok), Khammouan Province (Golovatch et al. 2007b). All four species seem to be troglomorphic and endemic to Laos (Fig. 8).

Since the latest catalogue of the Diplopoda of Laos which listed 34 species (Likhitrakarn et al. 2014a), another 29 new species have been added (Likhitrakarn et al. 2014b, 2014c, 2015a, 2015b, 2016a, 2016b; Golovatch 2016a, 2016b; Golovatch et al. 2016a, 2016b; Liu et al. 2017a). Yet neither new *Glyphiulus* species nor records have since been documented from Laos.

The present paper is devoted to descriptions of two new species of *Glyphiulus* from Laos, coupled with a distributional map of and a key to all six species of the genus currently known to occur in that country.

Materials and methods

New material was collected from northern Laos in 2014 by SP and members of the Animal Systematics Research Unit, Chulalongkorn University. Photographs of live animals were taken in the laboratory using a Nikon 700D digital camera with a Nikon AF-S VR 105mm macro lens. Specimens were preserved in 75% ethanol, and morphological observations made under an Olympus SZX7 stereo microscope.

Scanning electron micrographs (SEM) were taken with a JEOL, JSM-5410 LV microscope, and the material returned to alcohol upon examination. Pictures of one of the gonopods of the holotypes were taken in the laboratory and assembled using the “Cell^D” automontage software of the Olympus Soft Imaging Solution GmbH package. The key to all species is principally based on the descriptions by Golovatch et al. (2007a, 2007b, 2010, 2011a, 2011b). The holotypes, as well as most of the paratypes are housed in the Museum of Zoology, Chulalongkorn University (CUMZ), Bangkok, Thailand; paratypes have been donated to the collection of the Zoological Museum, State University of Moscow, Russia (ZMUM), as indicated in the text.

The collecting sites were located by GPS using the WGS84 datum.

The carinotaxy formulae in the descriptions follow those in Golovatch et al. (2007a, 2007b), while body segment counts are after Enghoff et al. (1993).

Taxonomic part

Family Cambalidae Cook, 1895

Genus *Glyphiulus* Gervais, 1847

***Glyphiulus subbedosae* Likhitrakarn, Golovatch & Panha, sp. n.**

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Figs 1A, B, 2–4

Type material. Holotype ♂ (CUMZ), Laos, Luang Prabang Province, Chomphet District, Kacham Waterfall, 442 m a.s.l., 19°38'57"N, 100°04'52"E, 30.08.2014, leg. C. Sutcharit and R. Srisonchai.

Paratypes. 4 ♂, 7 ♀ (CUMZ), 1 ♂, 2 ♀ (ZMUM), same locality, together with holotype. 4 ♂, 1 ♀ (CUMZ), same District, small waterfall near road, 405 m a.s.l., 19°41'54"N, 102°07'52"E, 01.07.2014, leg. R. Srisonchai.

Etymology. To emphasize the obvious similarities to *G. bedosae* Golovatch, Geofroy, Mauriès & VandenSpiegel, 2007.

Diagnosis. This new species is particularly similar to *G. bedosae*, with which it shares the following diagnostic characters: the presence of a row of several strong setae near the median marginal ridge on the paraprocts, combined with the gnathochilarium being considerably less densely setose on the caudal face, and the anterior gonopods

showing a pair of smaller apical. It differs from *G. bedosae* primarily by the larger lateral teeth on the coxosternal plate. See also Key below.

Description. Length of holotype ca 12.1 mm; that of paratypes 12.1–23.1 (♂) or 12.2–18.3 mm (♀); midbody segments round in cross-section (Fig. 2L), their width (horizontal diameter) and height (vertical diameter) similar, width of holotype 1.0 mm, of paratypes 0.8–1.5 (♂) or 0.9–1.2 mm (♀).

Coloration of live animals brownish yellow (Fig. 1A, B); unfaded specimens variegated, with contrasting dark brownish, lateral, longitudinal stripes above ozopores on each side, both interrupted mid-dorsally by a light wide axial stripe; vertex dark brown, anterior half of collum blackish to dark brown; venter, legs and telson light yellowish to brownish yellow; ocellaria blackish; coloration in alcohol similar, but body brownish yellow to light brownish; vertex dark brown to brown, anterior halves of both collum and head light brown to dark brown; eyes blackish to brownish.

Body with 50p+2a+T segments (holotype); paratypes with 39–58p+2(3)a+T (♂) or 41–47p+2–4a+T (♀) segments. Eye patches transversely ovoid, each composed of 10–18 rather flat ocelli in 4 or 5 irregular longitudinal rows (Fig. 2D). Antennae short and clavate (Figs 1A, 2A, D, E), extending behind segment 3 laterally, antennomeres 5 and 6 each with a small distoventral group or corolla of bacilliform sensilla (Fig. 2F, G). Gnathochilarium with a clearly separated promentum (Figs 2E, 4B).

Head width = segment 2 < collum = midbody segment (close to 13th to 15th) > segment 3 = 6 > 4 < 5 < 7 < 8 = 10; body abruptly tapering towards telson on a few posteriormost segments (Fig. 2P). Postcollar constriction very evident (Fig. 2B).

Collum with 7+7 longitudinal crests starting from anterior edge, but both median crests interrupted in about caudal 1/2–1/3, being replaced there by similar 1+1+1 crests; carinotaxy formula 1–6+7a+pc+ma (Fig. 2B, C).

Following *metaterga* similarly strongly crested (Figs 1A, 2A–C, H, I, O, P), especially from segment 5 on, whence enlarged porosteles commence, these becoming completely absent from legless segments due to loss of ozopores (Fig. 2P). Porosteles large, conical, round, directed caudolaterad, wider than high (Fig. 2N). Midway metatergal crests on segment 5 distinctly divided into two at about 1/3 of metatergal height, each half rather evident and well rounded, nearly undivided and small tubercles in their stead in legless segments in front of telson (Fig. 2B, I, O, P). Carinotaxy formulae 3+I+4+I+3 and 3+i+3+i+3, the former standing for frontal row of crests, the latter for caudal one, both fairly independent (Fig. 2A–C, H, I, O, P).

Tegument extremely delicately and quite sparsely alveolate-areolate (Fig. 2K), dull throughout. Fine longitudinal striations in front of stricture between pro- and metazona, remaining surface of prozona very delicately shagreened (Fig. 2J). Metatergal setae absent. Segments 2 and 3 each with long pleural flaps. Limbus extremely finely and regularly spiculate (Fig. 2K). Epiproct (Fig. 2O–Q) simple, regularly rounded caudally, faintly convex medially. Paraprocts regularly convex, each with premarginal sulci medially and with a row of several strong setae at medial margin (Fig. 2Q). Hypoproct transversely bean-shaped, slightly concave caudally, with 1+1 strongly separated setae near caudal margin (Fig. 2Q).

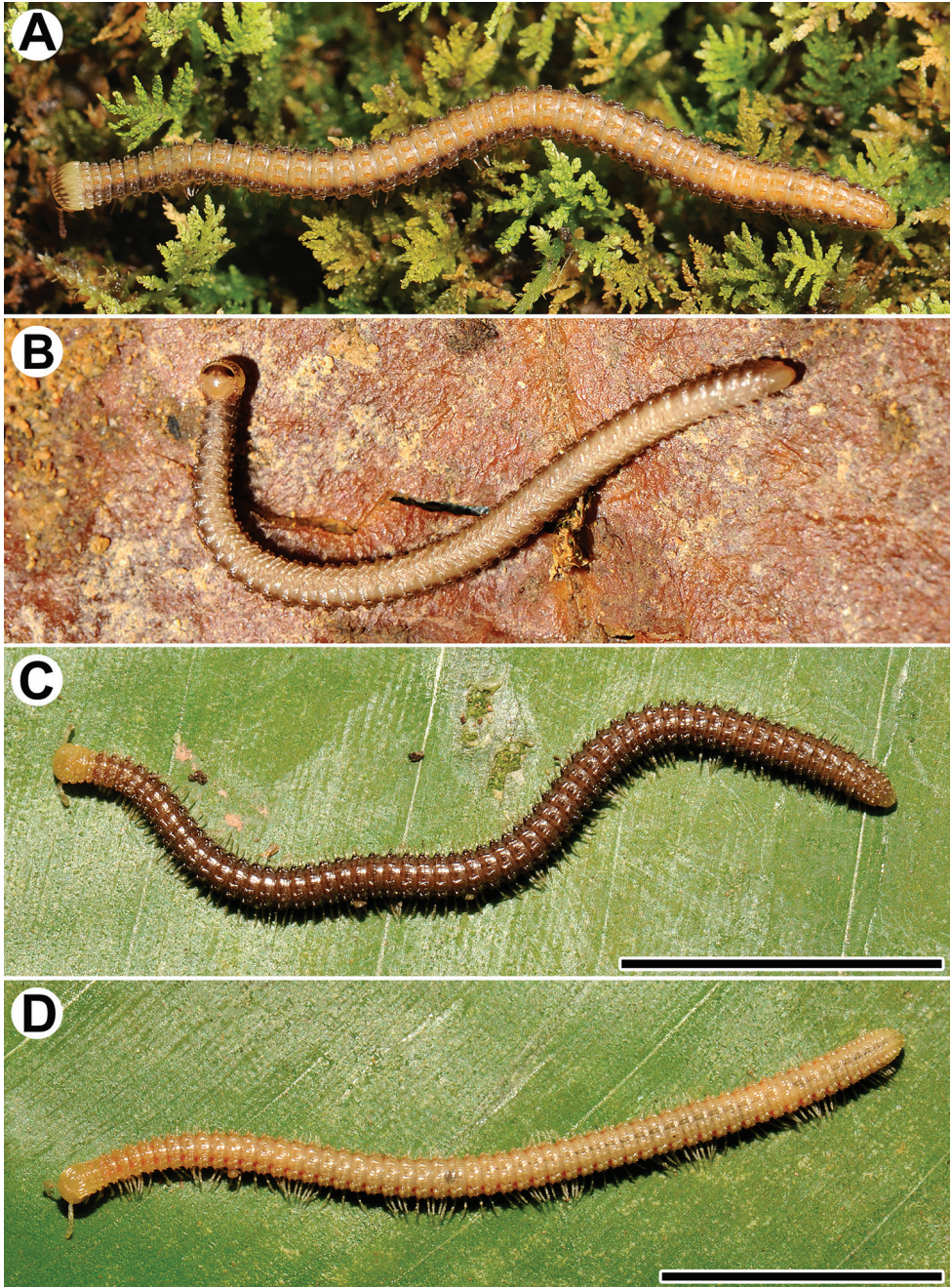


Figure 1. Habitus, live coloration. **A,B** *Glyphiulus subbedosae* sp. n., ♀ paratype from Kacham Waterfall, depicted not to scale **C,D** *Glyphiulus semicostulifer* sp. n., ♀ paratype. Scale bars: 10 mm.

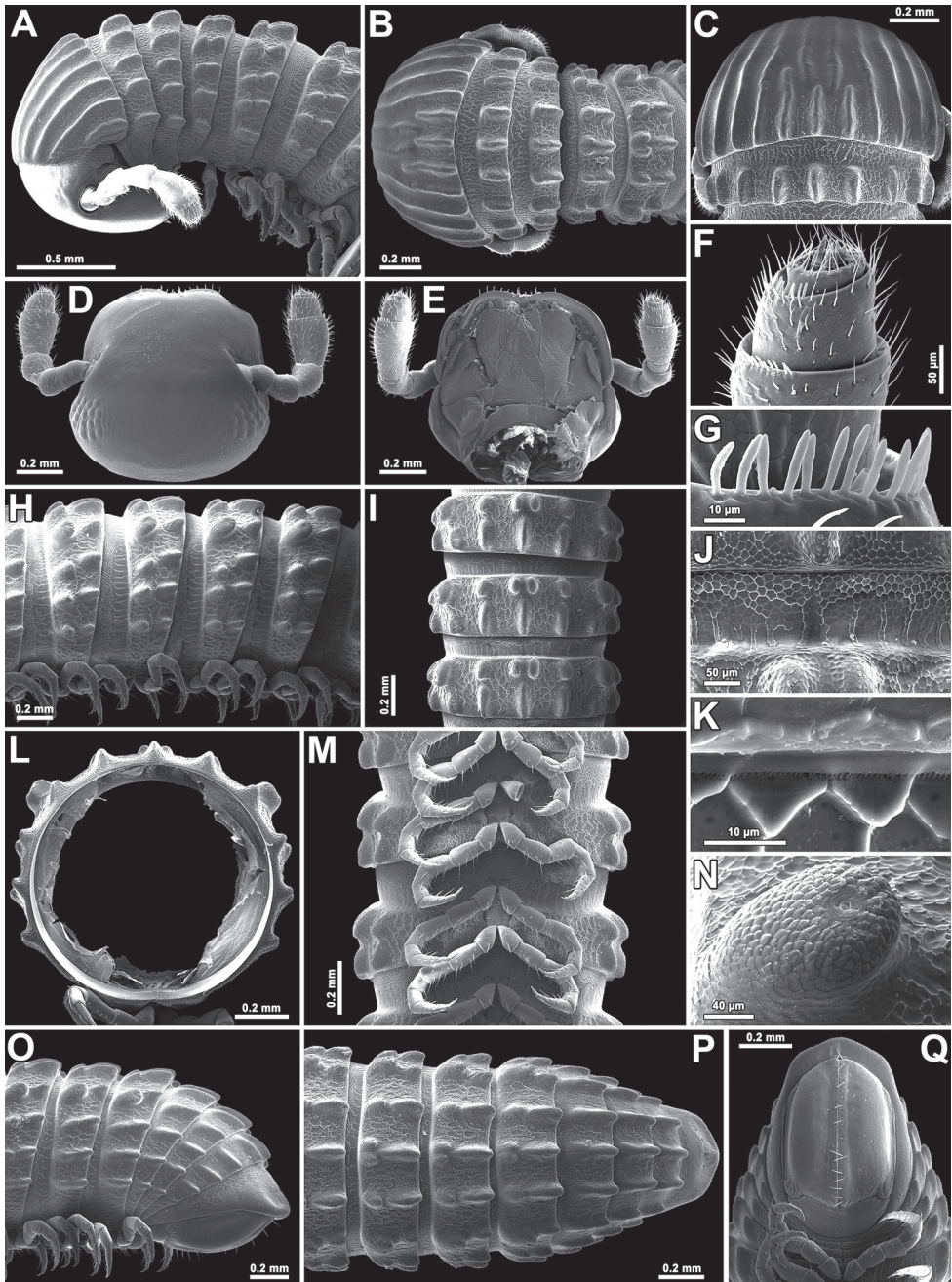


Figure 2. *Glyphiulus subbedosae* sp. n., **A–C, H–Q** ♀ paratype from Kacham Waterfall **D–G** ♂ holotype **A, B** anterior part of body, lateral and dorsal views, respectively **C** collum and body segment 2, dorsal view **D** cephalic capsule, dorsal view **E** gnathochilarium, ventral view **F** apical part of antenna, ventral view **G** bacilliform sensilla on antennomere 5, lateral view **H, I, M** midbody segments, lateral, dorsal and ventral views, respectively **J** midbody prozonite enlarged, dorsal view **K** limbus **L** cross-section of midbody segment **N** enlarged ozopore region, lateral view **O–Q** posterior part of body, lateral, dorsal and ventral views, respectively.

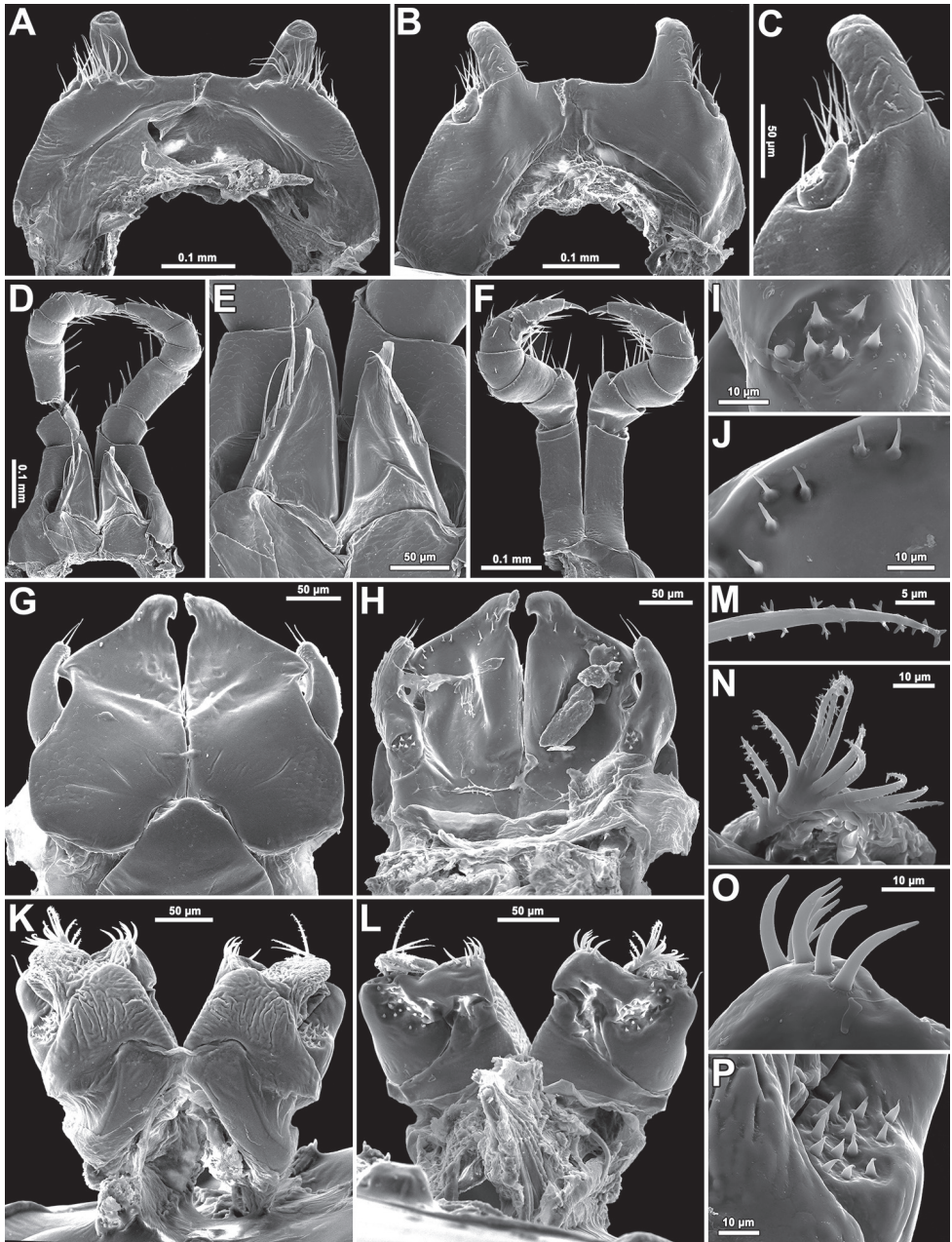


Figure 3. *Glyphiulus subbedosae* sp. n., ♂ holotype. **A, B** legs 1, caudal and frontal views, respectively **C** leg 1, frontal view **D** legs 2, caudal view **E** penes, caudal view **F** legs 3, frontal view **G, H** anterior gonopods, frontal and caudal views, respectively **I** microsetae at base of telopodite of anterior gonopod **J** microsetae on posterior coxosternum of anterior gonopod **K, L** posterior gonopods, frontal and caudal views, respectively **M** plumose seta on flagellum **N** distal part of flagellum of posterior gonopod **O** median lobe of posterior gonopod **P** microsetae at base of posterior gonopod, caudal view.

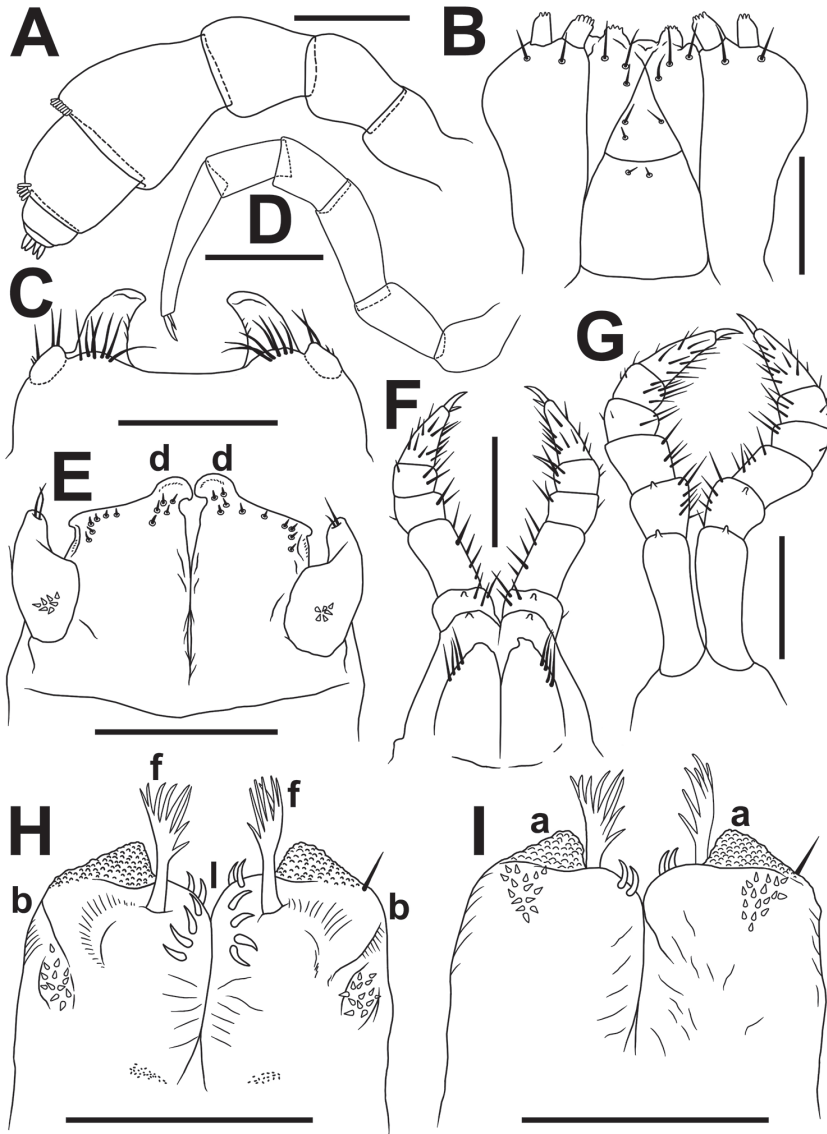


Figure 4. *Glyphiulus subbedosae* sp. n., ♂ paratype from small waterfall near road. **A** antenna, lateral view **B** gnathochilarium, ventral view **C** legs 1, frontal view **D** midbody leg **E** anterior gonopods, caudal view **F** legs 2, caudal view **G** legs 3, caudal view **H, I** posterior gonopods, caudal and frontal views, respectively. Scale bars: 0.2 mm.

Ventral flaps behind gonopod aperture on ♂ segment 7 barely distinguishable as low swellings forming no marked transverse ridge.

Legs short, on midbody segments about 2/3 length of body height (Figs 2A, H, M, O, 4D). Claw at base with a strong accessory spine almost half as long as main claw (Fig. 4D). Tarsi and tarsal setae very delicately fringed.

♂ legs 1 highly characteristic (Figs 3A–C, 4C) in being very strongly reduced, represented only by a sternum devoid of any median or paramedian structures, but carrying 1+1 strongly separated prongs, both evidently curved posteriad and bearing several strong setae and rudimentary, 2-segmented leg vestiges at base on caudal face (Figs 3B, C, 4C).

♂ legs 2 very slightly hypertrophied (Figs 3D, E, 4F), only claw and, anteriorly, coxa somewhat reduced; penes broad, oblong-subtrapeziform, each with 4–6 strong setae distolaterally (Figs 3D, E, 4D).

♂ legs 3 modified in having coxa especially slender and elongate (Figs 3F, 4G).

Anterior *gonopods* (Figs 3G–J, 4E) with a typical shield-like coxosternum which is rather sparsely microsetose on caudal face (Fig. 3H, J) and shows its inner, somewhat elevated, axe-shaped processes, as well as small, but obvious, apicolateral teeth. Telopodite small, but movable, 1-segmented, lateral in position, with 2 or 3 strong apical setae and a field of microsetae at base (Fig. 3H, I), modestly higher than adjacent lateral corner of coxosternum.

Posterior gonopods (Figs 3K–P, 4H, I) compact, broadly subquadrate, coxite medio-apically with a long, plumose, apical flagellum (f) (Fig. 3M, N) with evident spikes paramedially (Fig. 3K–O); caudal piece (telopodite) (b) microsetose laterally, both b and strongly setose lobes (l), lower than frontal, microsetose, median piece (a).

Remarks. The *granulatus*-group currently encompasses 34 described species. The above new one is only the second species in this group to be reported from Laos. Two populations have been found, each from near a forest at a waterfall, and both show the remarkable colour pattern as described above.

***Glyphiulus semicostulifer* Likhitrakarn, Golovatch & Panha, sp. n.**

<http://zoobank.org/6FCD27DF-7566-42F4-92D5-63F6EDDBA66B>

Figs 1C, D, 5–7

Type material. Holotype ♂ (CUMZ), Laos, Luang Namtha Province, Viengphoukha District, Kao Rao Cave, 737 m a.s.l., 20°43'30"N, 101°09'04"E, 12.10.2014, leg. C. Sutcharit and R. Srisonchai.

Paratypes: 6 ♂, 16 ♀, 8 juveniles (CUMZ), 1 ♂, 2 ♀ (ZMUM), same locality, together with holotype.

Etymology. To emphasize the obvious similarities to *G. costulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007.

Diagnosis. This new species is particularly similar to *G. costulifer*, with which it shares the following diagnostic characters: the unique carinotaxy formulae, coupled with anterior gonopod structural details. It differs from *G. costulifer* by the more sparsely alveolate background fine structure of the metazonae, coupled with the gnathochilarium being considerably less densely setose on the caudal face, the paramedian coxal prongs on ♂ legs 1 much stronger and their telopodites 4-segmented, the apicoparamedian sternal projections on the anterior gonopods slightly longer and more slender, and the flagella of the posterior gonopods much longer. See also Key below.

Description. Length of holotype ca 19.4 mm; adult paratypes 17.2–25.3 (♂) or 17.5–25.6 mm long (♀), juveniles 1.34–1.79 mm long; midbody segments round in cross-section (Fig. 5L), their width (horizontal diameter) and height (vertical diameter) similar, width in holotype 1.4 mm; paratypes 1.1–1.5 (♂), 0.9–1.5 (♀) or 0.9–1.1 mm (juveniles).

Coloration of live animals dark brown to red-brownish (Fig. 1C), with contrasting light yellow head, antennae, collum, segments 2 and 3, sometimes segment 4 as well; telson yellow-brown, venter and legs brownish yellow to brownish red, ocellaria blackish, lateral longitudinal stripes above porosteles brownish; a thin axial line traceable due to darker median crests, sometimes body uniformly yellowish to brownish yellow (Fig. 1D); coloration in alcohol, after three years of preservation similar, but telson light brownish, venter and legs brownish yellow to brownish, lateral longitudinal stripes brownish to brownish red.

Body with 52p+4a+T (holotype); paratypes with 52–67p+2–4a+T (♂), 49–60p+2–4a+T (♀) or 41–50+5a+T (juveniles). Eye patches transversely ovoid, each composed of 7–11 blackish, rather flat ocelli in 4 or 5 irregular longitudinal rows (Fig. 5D). Antennae short and clavate (Figs 1C, D, 5A–E, 7A), extending behind segment 3 laterally, antennomeres 5 and 6 each with a small distoventral group or corolla of bacilliform sensilla (Fig. 5F, G). Gnathochilarium with a clearly separated promentum (Figs 5E, 6B, 7B).

Head width = segment 2 < collum = midbody segment (close to 8th to 10th) > segment 3 = 5 > 4 < 7 < 8 = 10; body abruptly tapering towards telson on a few posterior-most segments (Fig. 5P). Postcollar constriction very evident (Fig. 5B).

Collum nearly smooth, carinotaxy formula 1+2c+3–4+5c+6a+pc+ma (Fig. 5A–C), with 6+6 longitudinal crests starting from anterior edge, but both median crests interrupted in about caudal 2/3–3/4, being replaced there by similar 1+1+1 crests.

Following *metaterga* similarly strongly crested (Figs 1C, D, 5A–C, H, I, O, P), especially from segment 5 on, whence porosteles commence (Fig. 5A, B), smaller tubercles in their stead on legless segments in front of telson due to loss of ozopores (Fig. 5P). Porosteles large, conical, round, directed caudolaterad, wider than high (Fig. 5N), ozoporiferous crests distinctly divided into two about midway, their frontal halves being higher (Fig. 5A, B, H, I, O, P). Carinotaxy formulae 2+I/i+3/3+I/i+2 on segments 2–3, as well as on the last 1–2 leg-bearing and legless segments (Fig. 5A, B, O, P); midbody segments showing all dorsal crests subdivided transversely (carinotaxy formulae 2/2+I/i+3/3+I/i+2/2) and sharper, especially so lateral crests (Fig. 5H, I).

Tegument delicately alveolate-areolate (Fig. 5A, B, H–J, M, O, P), dull throughout. Fine longitudinal striations in front of stricture between pro- and metazona, and remaining surface of prozona very delicately shagreened (Fig. 5J). Metatergal setae absent. Segments 2 and 3 with long pleural flaps. Limbus extremely finely and more or less regularly denticulate (Fig. 5K). Epiproct (Fig. 5O, P) simple, with an evident lateral tubercle placed level with ozoporiferous crests, also with a rounded ridge in caudal part and an evident axial rib dorsally. Paraprocts rather regularly convex, each

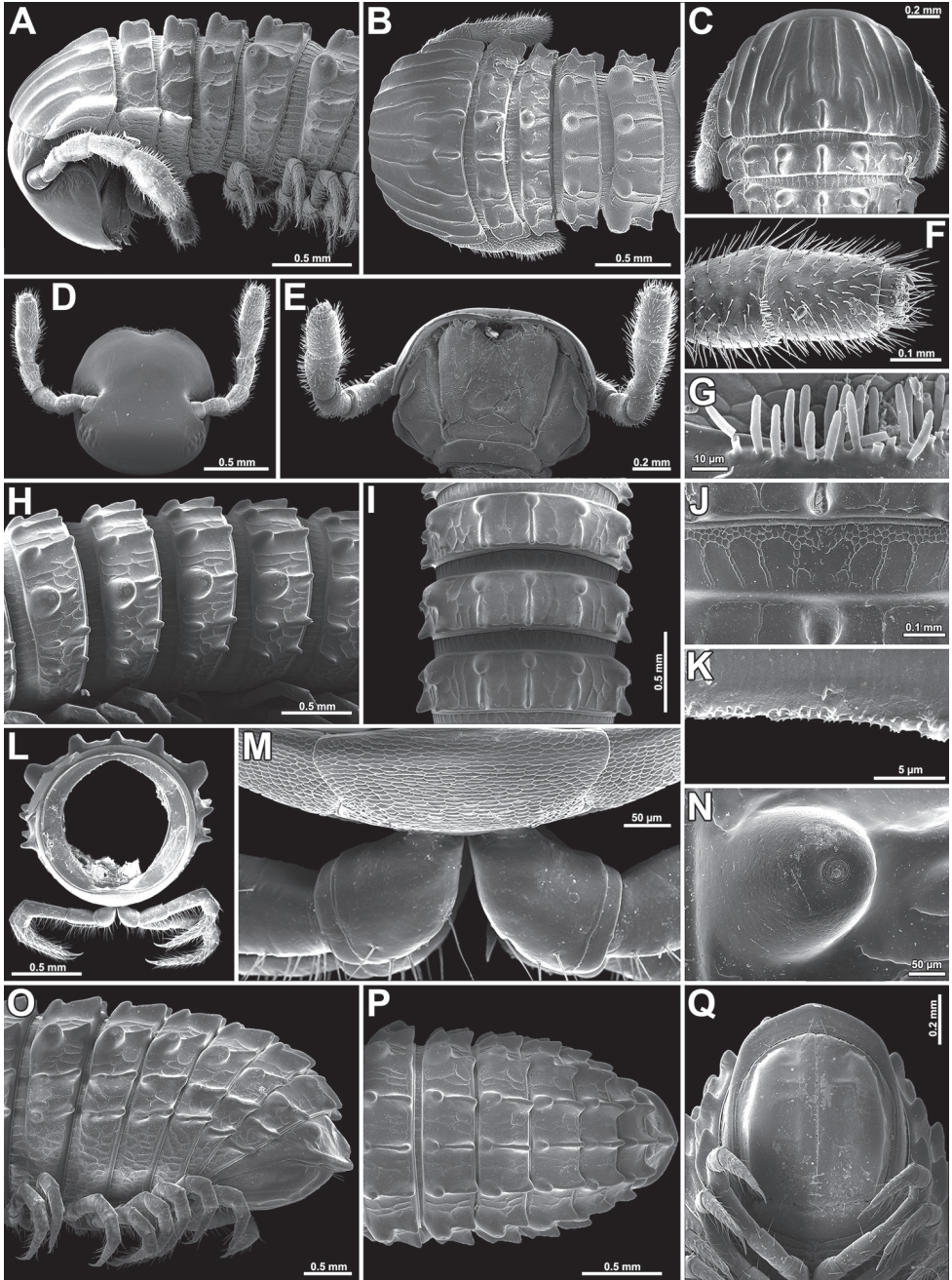


Figure 5. *Glyphiulus semicostulifer* sp. n., **A–C, H–Q** ♀ paratypes **D–G** ♂ paratype **A–B** anterior part of body, lateral and dorsal views, respectively **C** collum and body segments 2 and 3, dorsal view **D** cephalic capsule, dorsal view **E** gnathochilarium, ventral view **F** apical part of antenna, ventral view **G** bacilliform sensilla on antennomere 5, lateral view **H, I** midbody segments, lateral and dorsal views, respectively **J** midbody prozona enlarged, dorsal view **K** limbus, dorsal view **L** cross-section of midbody segment **M** midbody sternite and coxae, frontal view **N** porostele, lateral view **O–Q** posterior part of body, lateral, dorsal and ventral views, respectively.

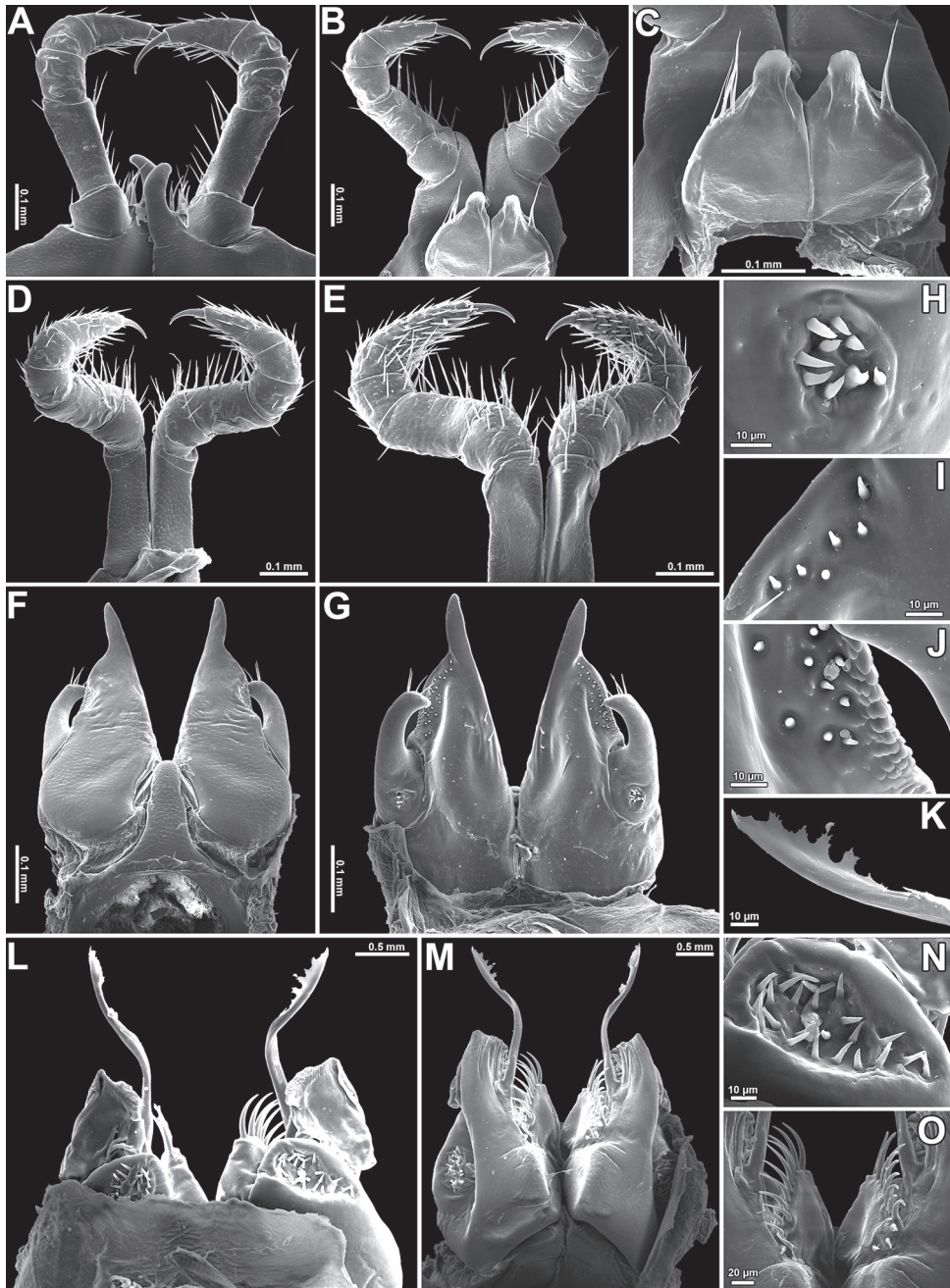


Figure 6. *Glyphiulus semicostulifer* sp. n., ♂ paratype. **A** legs 1, frontal view **B** legs 2, caudal view **C** penes, caudal view **D, E** legs 3, caudal and frontal views, respectively **F, G** anterior gonopods, frontal and caudal views, respectively **H** microsetae at base of telopodite on anterior gonopod **I, J** microsetae on posterior coxosternum of anterior gonopod **L, M** posterior gonopods, caudal and frontal views, respectively **K** distal part of flagellum of posterior gonopod **N** microsetae at base of posterior gonopod, frontal view **O** paramedian lobes on posterior gonopods.

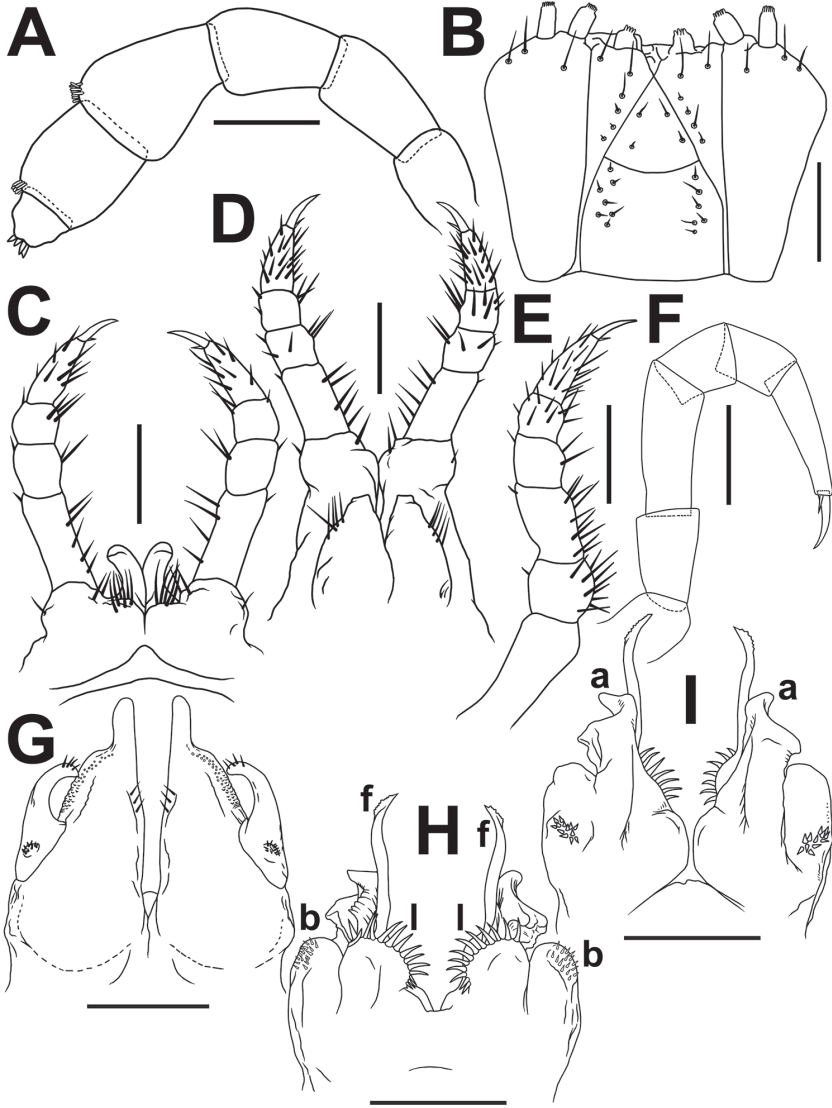


Figure 7. *Glyphiulus semicostulifer* sp. n., ♂ holotype. **A** antenna, lateral view **B** gnathochilarium, ventral view **C** legs 1, frontal view **D** legs 2, caudal view **E** leg 3, caudal view **F** midbody leg **G** anterior gonopods, caudal view **H, I** posterior gonopods, frontal and caudal views, respectively. Scale bars: 0.2 mm.

with a faint premarginal sulcus medially (Fig. 5Q). Hypoproct bean-shaped, with 1+1 strongly separated setae near caudal margin (Fig. 5Q).

Ventral flaps behind gonopod aperture on ♂ segment 7 rather well distinguishable as low swellings forming a bare transverse ridge.

Legs rather short, on midbody segments about $3/4$ length of segment height (Figs 5A, L, O, 7F). Claw at base with a strong accessory spine about $1/3$ – $1/4$ length of main claw. Tarsi and tarsal setae very delicately fringed (Fig. 7F).

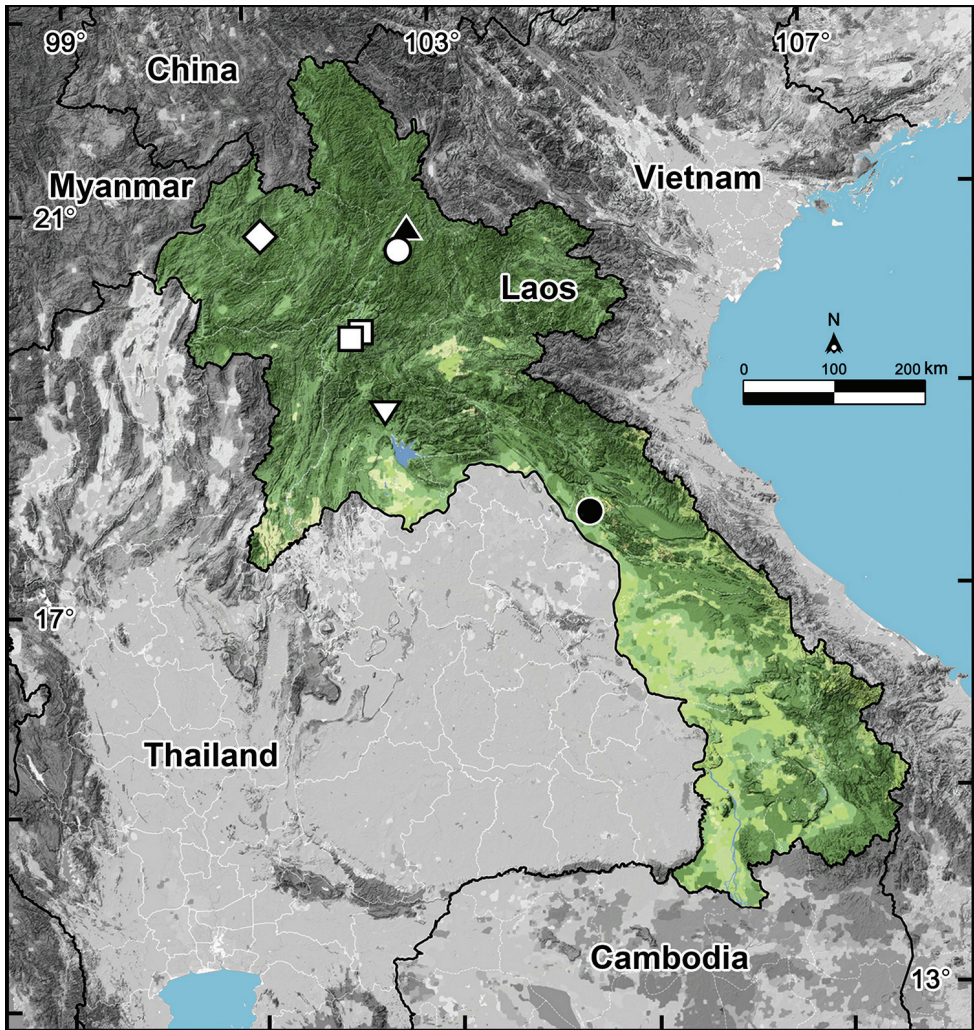


Figure 8. Distribution of *Glyphiulus* species in Laos (6 species): Open diamond: *Glyphiulus semicostulifer* sp. n. Open circle: *Glyphiulus bedosae* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007. Filled triangle: *Glyphiulus costulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007. Open square: *Glyphiulus subbedosae* sp. n. Inverted open triangle: *Glyphiulus subcostulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007. Filled circle: *Glyphiulus percostulifer* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2007.

♂ legs 1 highly characteristic (Figs 6A, 7C) in showing nearly fully developed, 4-segmented telopodites and a pair of large, subdigitiform, medially contiguous, but apically diverging coxal processes with a groups of long and strong setae at base.

♂ legs 2 nearly normal, only claw and, anteriorly, coxa somewhat reduced, and femur abbreviated on frontal face; penes broad, rounded, each with 4–5 strong setae distolaterally (Figs 6B, C, 7D).

♂ legs 3 modified in having coxa especially slender and elongate (Figs 6D, E, 7E).

Anterior *gonopods* (Figs 6F–J, 7G) with a typical shield-like coxosternum, this being rather densely microsetose on caudal face (Fig. 6G, I, J), with a high, digitiform, apicomeral process (d). Telopodite typical, slender, movable, 1-segmented, lateral in position, with 3–5 strong apical setae and a field of microsetae at base (Fig. 6H).

Posterior *gonopods* (Figs 6K–O, 7H, I) highly compact, both contiguous basally until about midheight; two densely and strongly setose lobes (l) paramedially (Fig. 6O); each half with two higher central pieces with a seminal groove between, frontal piece (a) elongate; long, distally micropilumose flagella (f) (Fig. 6K–M); caudal piece (b) subquadrate, membranous, micropapillate frontolaterally, with an apical field of coniform microsetae laterally (Fig. 6L, N).

Remark. The *javanicus*-group is currently comprised of 23 species, including this new species, a fourth in this group to be reported from Laos.

Key to *Glyphiulus* species known from Laos, chiefly based on male characters

- 1 ♂ leg 1 very strongly reduced, completely lacking any median structures (Figs 3A, B, 4C).....2
- ♂ leg 1 either normal or reduced in size, but then with a pair of paramedian coxal processes (Figs 6A, 7C)3
- 2 Paraprocts with a row of several strong setae near median marginal ridge (Fig. 2Q); posterior gonopods broadly subquadrate, each half with a plumose apical flagellum (f) (Fig. 3I, J)..... *G. subbedosae* sp. n.
- Paraprocts with a bare marginal ridge devoid of setae; posterior gonopods narrowly subrectangular..... *G. bedosae*
- 3 Carinotaxy formula of midbody segments 2+I/i+3/3+I/i+2.....4
- Carinotaxy formula of midbody segments 2/2+I/i+3/3+I/i+2/25
- 4 Carinotaxy formula of collum, I–VI+7a+pc+ma+pc+7a+VI–I, texture of both lateralmost crests unusually micropunctate; ♂ leg 1 with two low, paramedian, contiguous cones; each posterior gonopod with a long and bare flagellum..... *G. costulifer*
- Carinotaxy formula of collum, I+2c+III–VI+5c+6a+pc+ma+pc+6a+5c+VI–III+2c+I, both lateralmost crests as usual, smooth (Fig. 5A–C); ♂ leg 1 with medially contiguous, apically diverging cones (Figs 6A, 7C); each posterior gonopod with a long, distally plumose flagellum *G. semicostulifer* sp. n.
- 5 Coloration entirely pallid, ocelli invisible; adult body up to about 1.0 mm wide; ♂ leg 1 telopodites normal, 5-segmented; apicomeral outgrowths of anterior gonopodal coxosternum especially high and large, telopodite smaller than these apicomeral outgrowths *G. percostulifer*
- Coloration usually darker, ocelli always dark and well-discernible; adult body up to about 1.3 mm wide; ♂ leg 1 telopodites reduced in sized, but still 5-segmented; apicomeral outgrowths of anterior gonopodal coxosternum less conspicuous, telopodite as high as these apicomeral outgrowths *G. subcostulifer*

Conclusions

Most *Glyphiulus* species in Laos come from caves or surrounding areas, except for *G. subbedosae* sp. n. found epigeically near waterfalls. Several of the cave species show troglomorphic traits such as an unpigmented tegument and ocellaria (if any), combined with elongated antennae and legs (Golovatch et al. 2011a). The above two new species, however, are pigmented and have short antennae and legs, while the epigean *G. subbedosae* sp. n. presents a distinct colour pattern. Such characters are rather evidence of the cave-dweller *G. semicostulifer* sp. n. being only a troglophile likely to occur also outside caves. Usually only a single cambalopsid species is found per cave. The single exception known so far concerns two *Plusioglyphiulus* species, *P. bedosae* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2009 and *P. pallidior* Golovatch, Geoffroy, Mauriès & VandenSpiegel, 2009, coexisting in the same cave in Kalimantan, Borneo, Indonesia, but both these species differ so strikingly in body size that this alone strongly suggests niche segregation (Golovatch et al. 2009).

The diplopods of Laos are still poorly known, with only a small fraction of their diversity being assessed. There is little doubt that, with further progress in the study of the millipede fauna of Laos, both epigean and cavernicolous, many more novelties are to be expected. As regards the Cambalopsidae alone, we seem to have only touched the tip of the iceberg (Golovatch et al. 2007a).

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A new species of *Echinolaophonte* and record of *E. armiger* (Gurney, 1927) (Crustacea, Copepoda, Harpacticoida, Laophontidae) from the Caribbean with a key to species

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Abstract

A new species of the harpacticoid copepod genus *Echinolaophonte* is described here from specimens obtained during a biological survey of Rodadero Bay, a coastal system in the Colombian Caribbean. This species has been previously recorded as *E. armiger* Gurney, 1927 in different geographic areas (Indian and Pacific Oceans). The Colombian specimens recognized as *E. villabonae* sp. n. and true *E. armiger* are deemed as distinct species based on differences in several features of which the shape of the rostrum and the dorsal spinous process on the prosome are among the most distinctive. These and other characters are shared by specimens recorded as *E. armiger* from Caroline Islands and Australia that are now incorporated to the new species. The finding of the true *E. armiger*, previously known only from Egypt, the Texan coast, Brazil, and possibly Bermuda, constitutes the first record of this species in the western Caribbean and a regional range extension. A key to the identification of the 13 known species of the genus is also provided.

Keywords

Benthic copepods, harpacticoids, littoral, taxonomy

Introduction

The harpacticoid copepod genus *Echinolaophonte* Nicholls, 1941, belonging to the family Laophontidae, was erected to contain several species previously assigned to *Laophonte*. Members of this genus are cosmopolitan, benthic forms (Pesce 2016) that inhabit different marine habitats. *Echinolaophonte* is one of the most diverse genera in the subfamily Laophontinae; it is known to contain 12 valid species (Walter and Huys 2017): *E. armiger* (Gurney, 1927), *E. brevispinosa* (G.O. Sars, 1908), *E. gladiator* (Vervoort, 1964), *E. horrida* (Norman, 1876), *E. hystrix* (Brian, 1928), *E. longantennata* Apostolov, 1990, *E. minuta* Cottarelli & Forniz, 1991, *E. mirabilis* (Gurney, 1927), *E. oshoroensis* Itô, 1969, *E. tetracheir* Mielke, 1981, *E. tropica* Ummerkutty, 1970, and *E. veniliae* Cottarelli, Forniz & Bascherini, 1992. Of these, *E. armiger* has been reported to show a certain degree of variability in the armature of P3-P4EXP and in the urosome ornamentation (Nicholls 1945; Lang 1965; Pesta 1959; Vervoort 1964), therefore, some records have been considered as *species inquirendae* (Wells 2007).

During a survey of the zooplankton community of Rodadero Bay, a shallow coastal system in the Colombian Caribbean, several male and female specimens of harpacticoid copepods of the genus *Echinolaophonte* were obtained. The taxonomic examination of these specimens revealed that some of them were assignable to the strict form of *E. armiger* (Gurney, 1927). Another group of individuals resemble closely *E. armiger sensu* Vervoort (1964) and following the opinion by Lee et al. (2006), it was realized that they represent an undescribed species of *Echinolaophonte*. The aim of this paper is to review the status of the records related to *E. armiger sensu* Vervoort (1964) and propose a species rank to this taxon by comparing it with its closest congeners based on Colombian specimens. A key to the species currently contained in the genus *Echinolaophonte* is also provided.

Materials and methods

Biological samples of littoral habitats were obtained from Rodadero Bay, Magdalena, northern Colombia (11°14'10"N, 74°12'06"W) during fieldwork carried out from August 2015 to March 2016, mainly at the inshore areas covered by vegetation (mangrove) and with a bank of oysters. Water salinity, pH, temperature were measured with a multiparameter WTW 350i equipment. Water samples were collected manually using a 25-l bucket at both littoral and limnetic habitats. Samples were then filtered with a plankton net (mesh size = 45 µm) and preserved in 70% ethanol. Copepods were sorted from all the samples and then processed for taxonomical identification including the examination of the whole specimen and dissection of selected appendages. Dissected appendages were mounted on slides with glycerin and sealed with Canada balsam. The specimens were measured in ventral position, from the anterior end of the rostral area to the posterior margin of the caudal rami. Drawings were made with the aid of a camera lucida mounted on an Olympus BX51 compound

microscope equipped with Nomarski DIC. Some specimens were prepared for SEM examination with a JEOL LV 5900 microscope at the University of Aguascalientes, Mexico. The process included dehydration of specimens in progressively higher ethanol solutions (60, 70, 80, 96, 100 %), critical point drying, and gold coating following standard methods. The specimens examined were deposited at the Museo de Colecciones Biológicas de la Universidad del Atlántico, Barranquilla-Atlántico, Colombia (**UARC**) and in the Centro de Colecciones Biológicas of the Universidad del Magdalena-Colombia (**CBUMAG**) where they are available for consultation and/or further examination. Morphological terminology follows Huys and Boxshall (1991). The following abbreviations are used in the description: **P1–P6** = first to sixth legs, **EXP** = exopod, **ENP** = endopod.

Results

Order Harpacticoida G.O. Sars, 1903

Family Laophontidae T. Scott, 1904

Genus *Echinolaophonte* Nicholls, 1941

***Echinolaophonte villabonae* sp. n.**

<http://zoobank.org/9AA12838-05D6-48FA-88EF-AEDE388D6D8E>

Figs 1–6A, B

Syn.: *Echinolaophonte armiger* Nicholls, 1945; *Echinolaophonte armiger* Vervoort, 1964.

Material examined. Adult female holotype (UARC290M), male allotype (UARC291M), Rodadero Bay, Magdalena, Colombia, coll. J. Fuentes-Reinés, August–June 2016. Paratypes: five females (UARC292M) and two males (UARC293M) from same locality, coll. Juan M. Fuentes-Reinés. Two adult females, two adult males from same locality, date, and collector; specimens dissected, semi-permanent slides (UARC302M–UARC315M). Non-type specimens: two adult females, one adult male in collection of first author (JMFR), one female prepared for SEM analysis, same collection data.

Type locality. Rodadero Bay, Magdalena, northern Colombia (11°14'10"N, 74°12'06"W).

Diagnosis. Body cylindrical, rostrum wide, subrectangular, medially flat, posterior margin of cephalic shield with strong dorsal spiniform which possess two notches. Female antennule six-segmented; male antennule subchirocer, seven-segmented. Antenna three-segmented, EXP one-segmented with four strong setae, inner longest. Mandible ENP and EXP reduced, with three and one short pinnate setae, respectively. Maxillule with well-developed arthrite and eight distal elements; EXP one-segmented, with two apical setae. Maxilliped three-segmented, endopodal claw with single seta. P1–P4ENP and EXP being two and three-segmented, respectively, but P1EXP two-segmented. P1ENP 7.5 times as long as wide. Female and male P5 with long setophore and apical

seta, female P5 EXP and ENP with three and four setae, respectively, male P5EXP with three setae. Female and male caudal rami with seven setae.

Description. *Female.* Habitus as in Figure 1A. Body cylindrical in dorsal view, prosome gradually tapering anteriorly. Total body length measured from anterior margin of rostrum to posterior margin of caudal rami ranging from 560 to 616 μm (average = 586.7 μm , $n = 11$; holotype: 588 μm). Strong dorsal spiniform process present at median posterior margin of cephalic shield (Figs 1A, 5A) and reaching middle of second pedigerous somite. Process with two distinctive notches on posterior margin, distal end represented by curved point (Figs 1B–C, 5B).

Cephalothorax with smooth posterior margin; lateral posterior corners of cephalic shield produced into triangular expansions (Fig. 1D) and intricate cuticular ornamentation (Fig. 5B, C). Urosome five-segmented, in lateral view urosomites 3–5 with strong expansion, cuticular surface ornamented with minute denticles, posterior margins spinulate (Figs 1A, 5D). Genital double-somite (Fig. 1G, H) with transverse, shallow suture on ventral surface, indicating original intersomite segmentation; dorsal surface with ornamentation as in figure 1E, including a field of minute spinules on proximal dorsal surface (arrowed). Genital pore inconspicuous, located medially on anteriormost end of somite (Fig. 1H). Some specimens carrying single egg sac ventrally; egg mass set close to ventral surface of genital and postgenital somites (Fig. 1A). Postgenital somite relatively narrow, with large dorsal spiniform process in lateral view (Fig. 5G); with medial expansions visible in dorsal view (Fig. 1F); surface with cuticular reticulation. Posterior margin ornamented with row of short setules and ventral rows of spinules (Fig. 5G). Succeeding preanal somite lacking large dorsal spiniform process but with posterodorsal expansions visible in dorsal view (Fig. 1E); distal margin of somite and posterolateral surface furnished with spinules and reticulate cuticular surface (Figs 1E, 5G). Anal somite tapering posteriorly, with row of minute spinules on posterior margins (Fig. 5G).

Caudal rami 1.4–1.9 times longer than wide; each ramus with seven setae: setae I–III bare, first one shortest, setae IV and V pinnate, fused at base, seta VI approximately half-length of seta IV, seta VII articulated (Fig. 2I, arrow in Fig. 5G). Rostrum wide, subrectangular, medially flat (Fig. 2B), with rounded protuberance on each end of distal margin (arrows in Fig. 2B), and pair of sensilla. Antennule (Fig. 6A) and antenna (Figs 2A, C, D, 5E, F) as in *E. armiger sensu* Vervoort (1964) (Lee et al. 2016).

Mandible (Fig. 2E) gnathal blade with several multicuspid teeth plus pinnate dorsal seta, dorsal margin with subdistal rounded protuberance. Palp with small basal seta; endopod and exopod reduced, represented by expansions armed with three and one short pinnate setae, respectively.

Maxillule (Fig. 2G). Precoxal arthrite with eight distal spines/setae. Subdistal row of small spinules on inner margin of arthrite. Coxa with cylindrical endite bearing stout smooth seta and curved, distally uniserially pinnate spine. Basal endite cylindrical, armed with two naked setae and pinnate spine. Endopod incorporated in basis, forming small peduncle with two naked slender setae. Exopod one-segmented, with two apical setae.

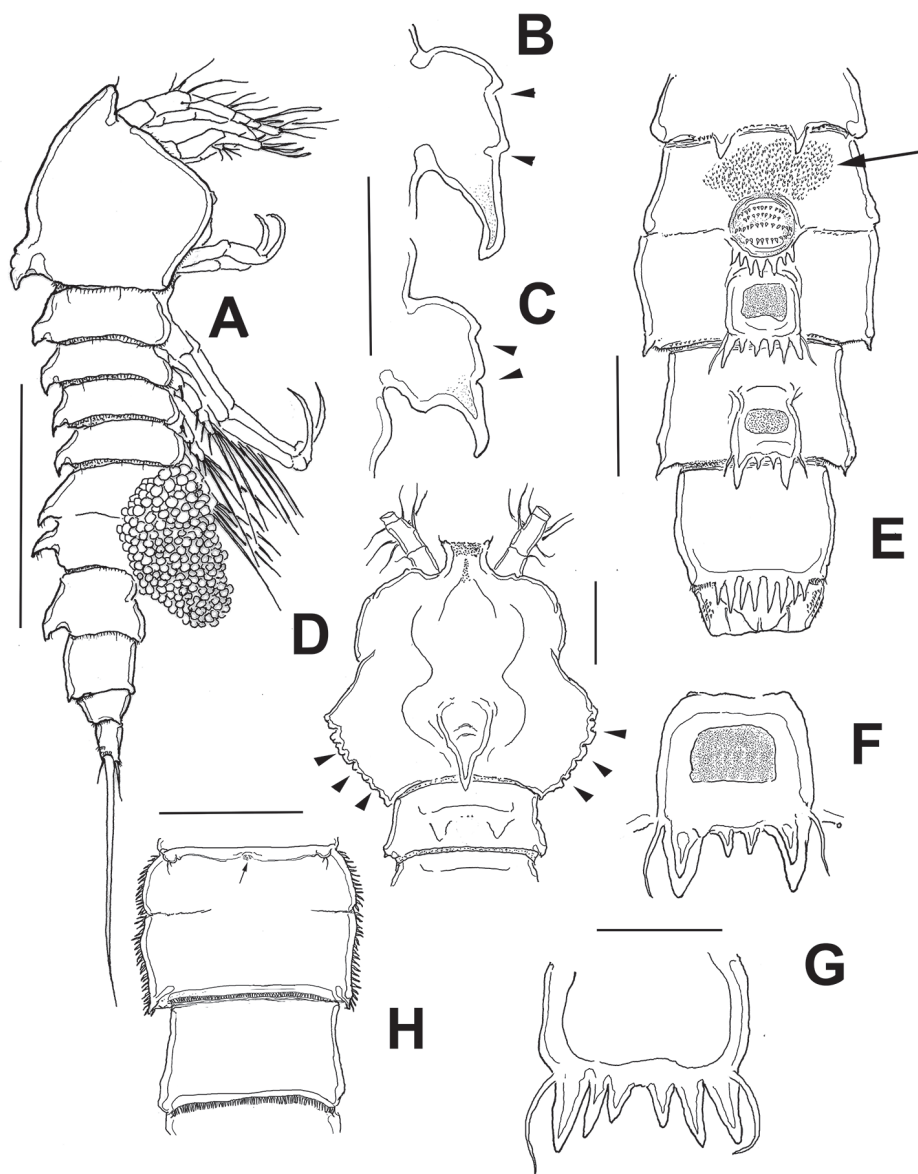


Figure 1. *Echinolaophonte villabonae* sp. n. , adult holotype female from Colombia. **A** habitus, lateral view **B** cephalosoma dorsal process, lateral view, arrows indicate notches **C** same, another specimen **D** cephalosoma showing cuticular indentations on posterolateral margin (arrows), dorsal view **E** genital double, post-genital and preanal somites, dorsal view **F** detail of dorsal process on post-genital double-somite **G** detail of dorsal process, posterior genital double-somite **H** genital double-somite, ventral view showing sixth legs and genital pore (arrowed) on medial anterior margin. Scale bars: 200 µm (**A**); 5 µm (**B–G**).

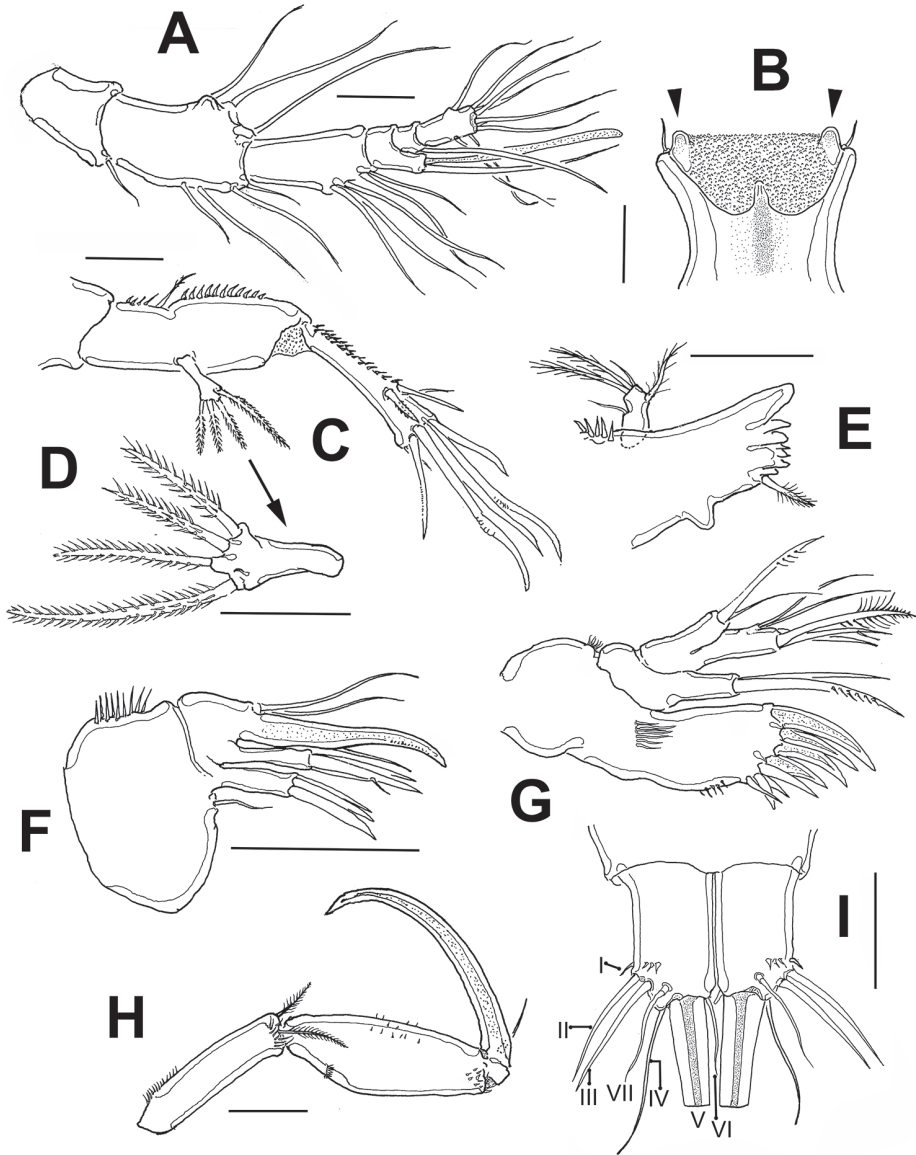


Figure 2. *Echinolaophonte villabonae* sp. n., adult holotype female from Colombia. **A** antennule **B** rostrum showing surface ornamentation and marginal rounded protuberances (arrowed) **C** antenna **D** antennary exopod, detail **E** mandible **F** maxillule **G** maxilla **H** maxilliped **I** caudal rami showing setae I–VII, dorsal view. Scale bars: 25 µm.

Maxilla (Fig. 2F) comprising syncoxa with two endites furnished with spinules along outer margin plus short inner distal seta. Coxal endites each with three pinnate spines. Allobasis transformed into strong, slightly curved, distally pinnate claw. Endopod represented by two setae.

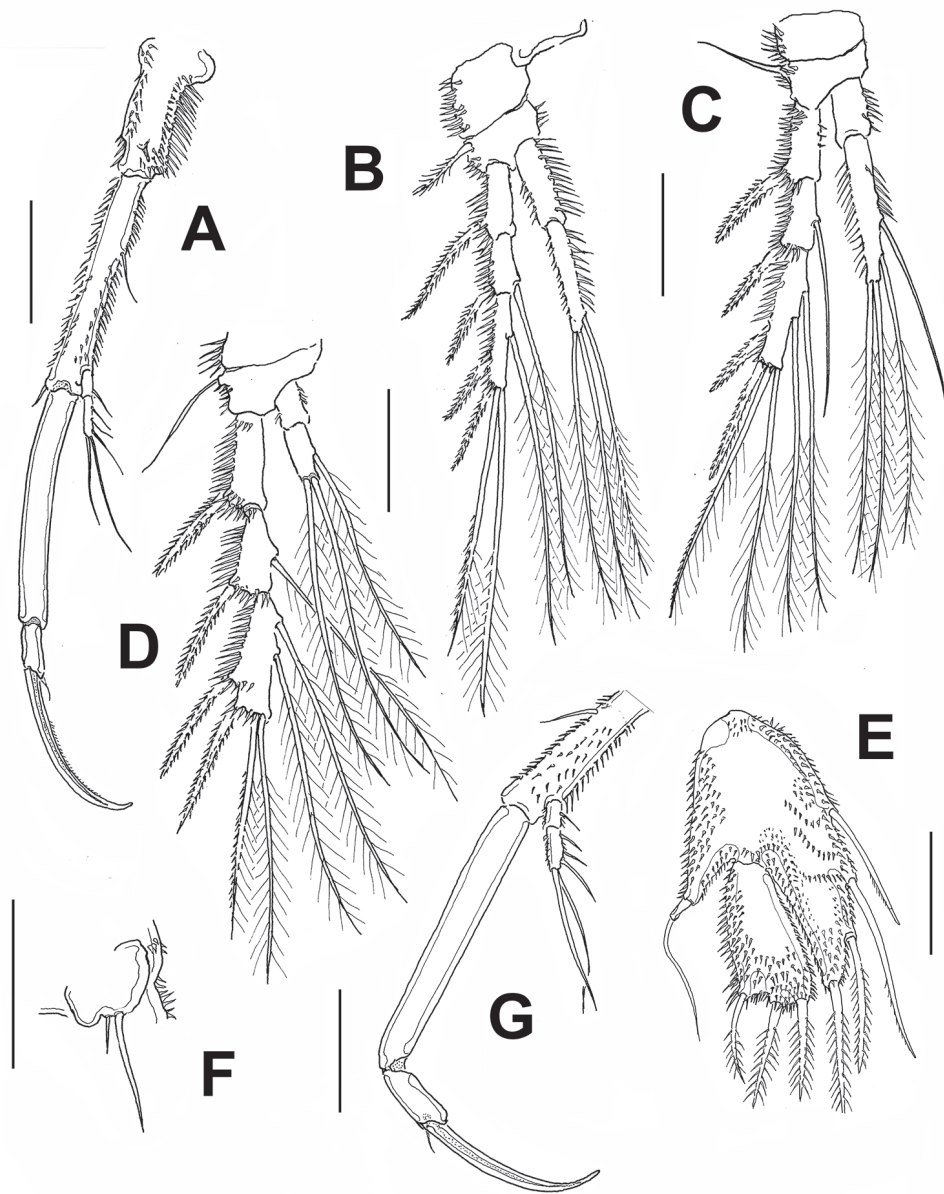


Figure 3. *Echinolaophonte villabonae* sp. n., adult holotype female from Colombia. **A** leg 1 **B** leg 2 **C** leg 3 **D** leg 4 **E** leg 5 **F** leg 6 **G** leg 1, paratype specimen. Scale bars: 50 μ m (**A–E**, **G**); 25 μ m (**F**).

Maxilliped (Figs 2H, 6B) represented by cylindrical syncoxa armed with two distal plumose setae with rows of slender hair-like elements at insertion of setae. Basis nearly twice as thick as syncoxa, widest at midlength, ornamented with comb of spinules on proximal 1/3 (arrowed in Fig. 6B), medial field of scattered spinules, and distal rows of slender setae. Endopod forming long curved claw with short setulated seta at base.

P1 (Fig. 3A, G). Coxa ornamented with rows of spinules on inner and outer margins, as figured. Protuberant tube pore on subdistal medial position. Basis with single slender seta on proximal 1/3 of segment, segment furnished with spinules on inner and outer margins. EXP short, two-segmented, EXP1 with one outer seta, EXP2 with five setae, two apical. ENP1 7.5 times as long as wide, ENP2 short, 2.1 long as wide with strong, denticulate apical claw and small, naked seta at base. EXP short, ¼ the length of ENP1.

P2 (Fig. 3B). Coxa and basis ornamented as figured. Basis with stout outer basipodal seta. EXP three-segmented, longer than endopod; EXP1 lacking inner seta, EXP 2 with inner seta. ENP1 lacking inner seta, ENP2 four times as long as wide with one inner and two apical elements. ENP reaching halflength of EXP3.

P3 (Fig. 3C). Coxa and basis ornamented as figured. Basis with outer basal seta. EXP three-segmented. EXP1 without inner seta, EXP2 with inner seta. ENP two-segmented, ENP1 lacking inner seta, second segment almost five times as long as wide with two inner and two apical elements. ENP barely reaching beyond distal margin of EXP2.

P4 (Fig. 3D) Coxa and basis ornamented as figured. Basis with outer basipodal seta. Exopodal ramus three-segmented. EXP1 without inner seta, EXP2 with inner seta. ENP two-segmented, ENP1 lacking inner seta, ENP2 segment almost four times as long as wide with one inner and two apical elements. ENP short, not reaching distal margin of EXP1. Spine/ setal formula of P2–P4 as follows:

	Basis	Exopod	Endopod
P2	1-0	I-0;I-1;II,2,2	0-0;2,1
P3	1-0	I-0;I-1;I,I-2,2	0-0;2,2
P4	1-0	I-0;I-1;I,I-2,2	0-0;2,1

P5 (Fig. 3E). EXP and baseoendopod covered with small spinules as figured. Baseoendopod with long outer setophore armed with single apical seta. Endopodal lobe not reaching distal margin of exopod, with one apical and three lateral, pinnate setae. EXP elongate, twice as long as wide, with three pinnate setae.

P6 (Fig. 3F). Represented by two setae, a short inner one, and a longer outer one.

Male. Habitus resembling that of female but somewhat smaller. Total body length measured from anterior margin of rostrum to posterior margin of caudal rami ranging from 476 to 508 µm (average = 478 µm, $n = 7$; holotype: 476 µm). Cephalosome with strong dorsal spiniform at median posterior margin of cephalic shield as in female (Fig. 4B). Antennule (Fig. 4A) subchirocer, seven-segmented, geniculation between fourth and fifth segments. First segment with row of spinules, second segment with small subdistal knob. Fourth segment swollen; fifth segment with spiniform processes. Seventh segment with triangular expansion on distal half.

Antenna, mandible, maxillule, and maxilla as in female. Maxilliped as in female (Fig. 4C) except for narrower basis and relatively longer claw. P1 and P2 as in female (not illustrated). P3 (Fig. 4D) as in female except for outer spines on EXP1-3, slightly stronger than in female.

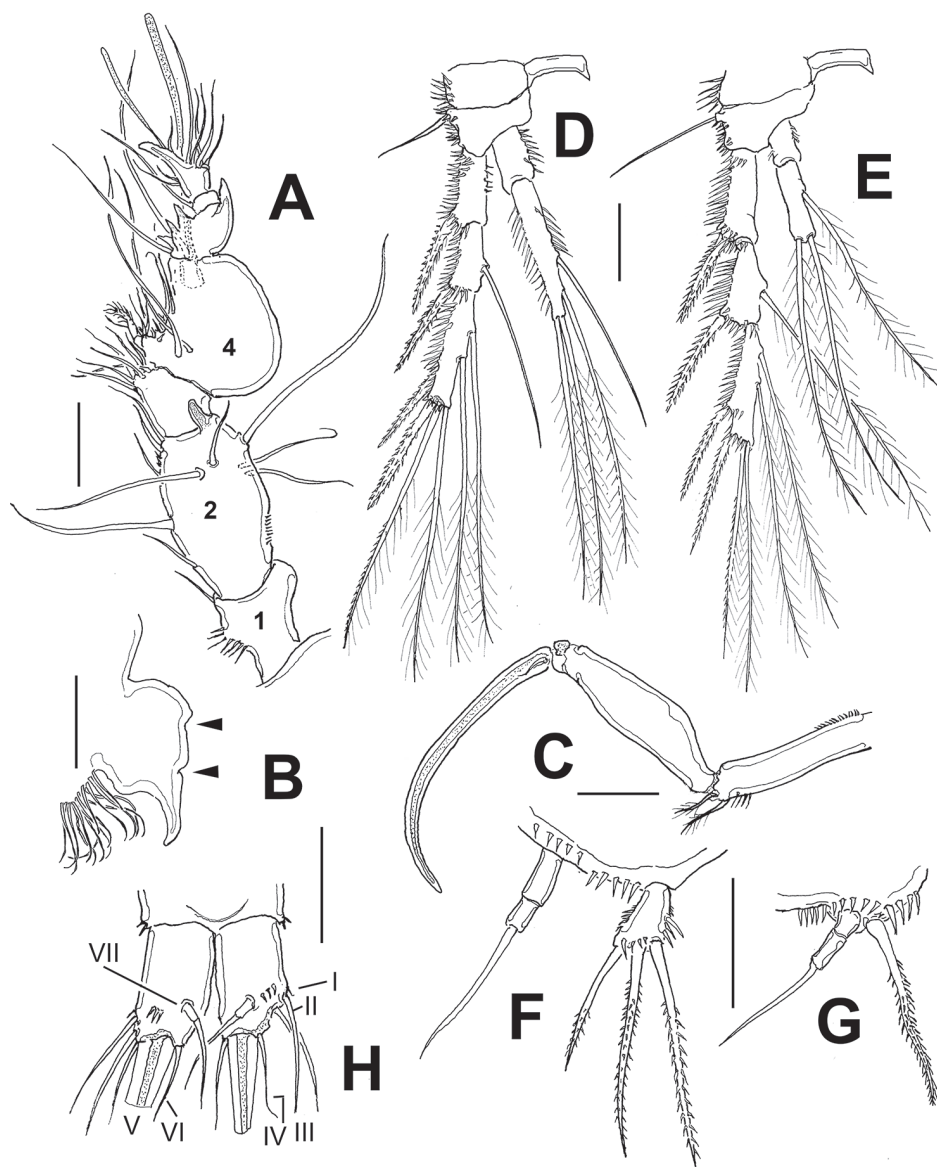


Figure 4. *Echinolaophonte villabonae* sp. n., allotype male from Colombia. **A** antennule **B** cephalosome dorsal process, lateral view, arrows indicate notches **C** maxilliped **D** leg 3 **E** leg 4 **F** leg 5 **G** leg 6 **H** caudal rami showing setae I-VII, dorsal view. Scale bars: 25 µm (**A-G**), 50 µm (**H**).

P4 (Fig. 4E) as in female except for EXP3 and outer spine on EXP1-2, narrower and slightly stronger, respectively, than in female.

P5 (Fig. 4F) clearly separated at base. Baseoendopod with long setophore bearing apical seta. Exopod slightly longer than maximum width, with three pinnate setae and row of spinules on anterior surface.

P6 (Fig. 4G) represented by one bipinnate inner and one naked outer seta. Outer seta arising from setophore.

Caudal rami 1.5–1.6 times as long as wide (Fig. 4H).

Etymology. The species is named after Dr. Silvia Lucía Villabona-González, for her intense research on the zooplankton communities of Colombia and for her legacy and leadership of new generations of planktologists in this country.

Remarks. The genus *Echinolaophonte* was divided by Lang (1965) into two lineages, the first one is characterized by its possession of 3, 3, 2 outer spines on P2–P4 EXP3, respectively, and the male P3ENP is transformed, with an apophysis in the second segment. The second lineage shows 2, 3, 2 outer spines on P2–P4 EXP3, respectively, and the male P3ENP is not modified; it lacks an apophysis on the second segment, as in the female. Most species can be accommodated in these two lineages but *E. minuta* has a mixture of such characters and could fit in both groups (spinal formula 2, 3, 2, and male P3ENP2 with apophysis); a similar situation is true for *E. tetracheir* Mielke, 1981. Two species do not match the characters of any of these lineages: *E. gladiator* (Vervoort, 1964) and *E. mirabilis* (Gurney, 1927). They have an outer spine formula of 2, 2, 2 and 3, 3, 3, respectively; males of both species remain unknown. The new species, *E. villabonae* shares the same set of lineage characters with *E. gladiator*; therefore, this division should be reevaluated or expanded.

The redescription of *E. armiger* based on type material from the Suez Canal, Egypt supported the notion that only a few of the previous records of *E. armiger sensu* Gurney (1927) actually correspond to this species (Lee et al. 2006). One of these uncertain records of *E. armiger* is that provided by Vervoort (1964); these specimens differ from the “true *E. armiger* (Gurney, 1927)” in several characters as previously outlined by Lee et al. (2006) who suggested that Vervoort’s (1964) specimens represent an undescribed species. They also recognized that Nicholl’s (1945) Australian record of *E. armiger* is assignable to *E. armiger sensu* Vervoort (1964). However, the specific identity of these two groups of specimens was not established because of the difficulty to observe and confirm key characters in the preserved specimens and by the low number of individuals available for examination. The recent finding of a large number of specimens of *E. cf. armiger* in plankton samples from Rodadero Bay, Colombia, which are almost identical to those reported as *E. armiger sensu* Vervoort, 1964 from Port Denison (Australia) (Nicholls 1945) and Caroline Islands (Vervoort 1964), motivated a wider analysis of this problem in order to determine and establish the true identity of these specimens. As a result, a new species of *Echinolaophonte* is erected based on the Colombian specimens after comparing them with Gurney’s true *E. armiger* (Gurney, 1927).

The new species, *Echinolaophonte villabonae* sp. n. can be distinguished from *E. armiger* Gurney, 1927 by several characters: 1) the rostrum has two protuberances in its anterior margin in *E. villabonae* (Fig. 2B) whereas it is flat in *E. armiger* (Fig. 7B, Lee et al. 2006, fig. 1A) 2) the maxilla bears a small inner coxal seta in *E. villabonae* (Fig. 2F) whereas this seta is absent in *E. armiger* from the type locality (Lee et al. 2006, fig. 2F), but it was observed in the Colombian material (arrow in Fig. 7H; 3) the maxillipedal base has a spinule comb in the proximal 1/3 in *E. villabonae* (Fig. 2H) whereas this

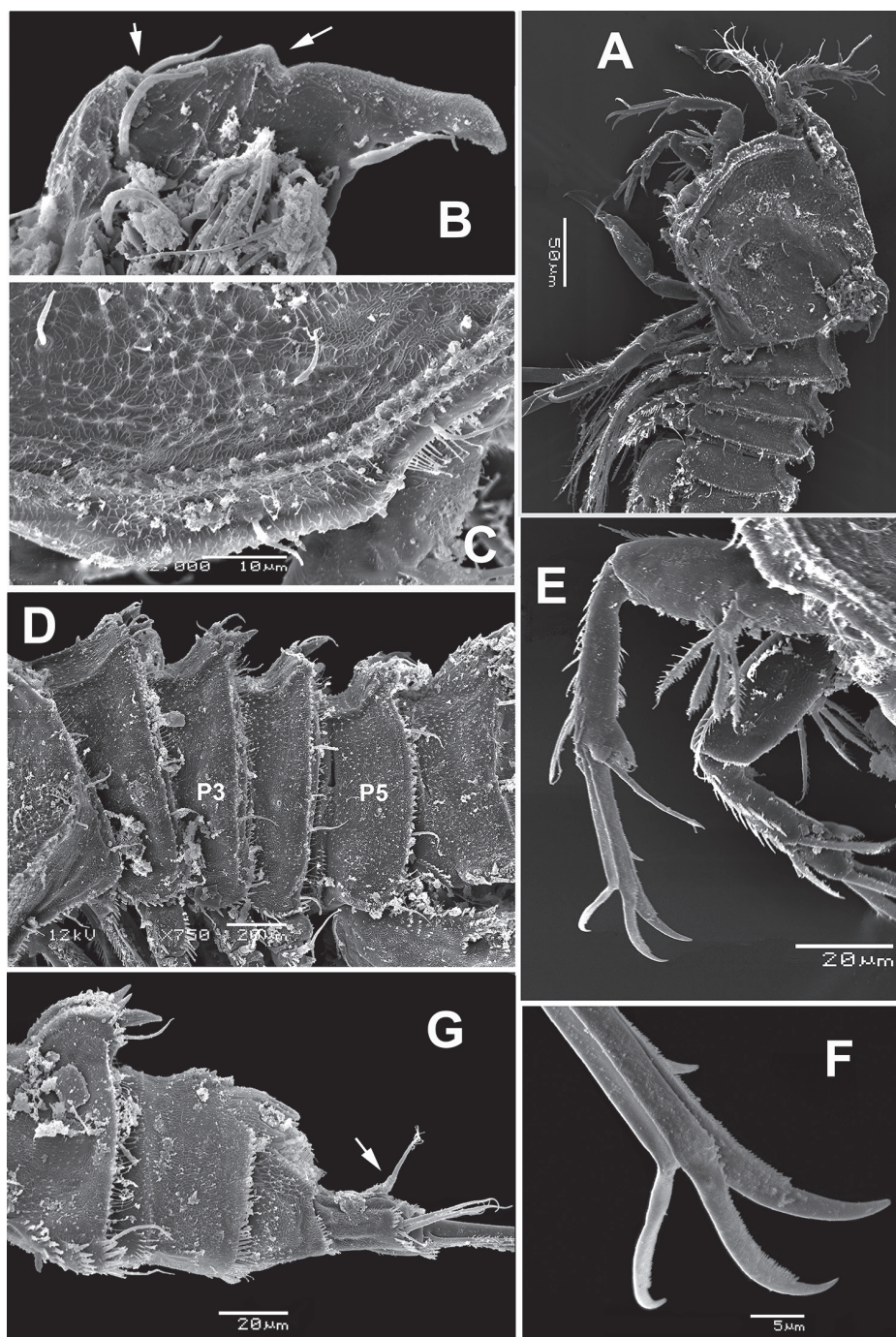


Figure 5. *Echinolaophonte villabonae* sp. n., female from Colombia, SEM-prepared specimen. **A** cephalothorax, lateral view **B** dorsal process on cephalic shield showing distinctive notches (arrowed) **C** detail of cephalic shield marginal ornamentation **D** pedigerous somites 2–5, lateral view **E** antenna **F** detail of distal elements of antenna **G** urosome and caudal rami, lateral view, caudal seta VII arrowed.

comb is medial or subdistal in *E. armiger* (Fig. 6C, Lee et al. 2006, fig. 2C); in both species male maxillipeds are slenderer than in the female (Figs 4C, 6D); 4) the shape of the dorsal spinous process has two distinctive notches on the dorsal margin in *E. villabonae* (visible in lateral view, Figs 1B, C, 5B) whereas in *E. armiger* the same structure is smooth (Fig. 7A, C, Lee et al. 2006, fig. 1B); 5) the length/width ratio of P1ENP1 is 7–7.5 in *E. villabonae* (Vervoort, 1964, fig. 143a, as *Onychocamptus armiger*, Fig. 3A, G) vs. 5.6–5.8 in *E. armiger* (fig. 7I, Lee et al. 2006, fig. 3A); 6) the length/width ratio of P2–P4ENP2 is 6.25, 6.0, and 2.5, respectively in *E. villabonae* sp. n. vs. 3.9, 5.8, and 3.8 in *E. armiger*; 7) in *E. armiger* the distal margin of P4ENP reaches beyond the point of insertion of the outer spine of the elongate P4EXP1 (Lee et al. 2006, fig. 4B) whereas in *E. villabonae* the endopod is clearly shorter and does not reach this level (Fig. 3D); 8) the number of setal elements on P3EXP3 also differs between these two species: it has 6 in *E. villabonae* (Vervoort 1964, fig. 143C, as *O. armiger*, Fig. 3C) vs. 7 in *E. armiger* (Lee et al. 2006, fig. 4A); 9) the setophore of the P5 outer basal seta is relatively longer in *E. villabonae* (Fig. 3E) than in *E. armiger* (Lee et al. 2006, fig. 3C); 10) the dorsal ornamentation of the urosome is clearly stronger in *E. villabonae* (Figs 1E–G, 5G) than in *E. armiger* (Lee et al. 2006, figs 1B, 5B). The male of *E. villabonae* sp. n. shows some additional differences with respect to *E. armiger*: 1) the antennule is 7-segmented in *E. villabonae* (Fig. 4A) vs. 8-segmented in *E. armiger* (Lee et al. 2006, fig. 6B); 2) the caudal rami ratio is 1.5–1.6 in *E. villabonae* (Fig. 4H) vs. 1.4 in *E. armiger* (Lee et al. 2006, fig. 6A). The erection of this new taxon and the comparisons with the other related records of this species allows us to allocate all previous records of *Echinolaophonte armiger sensu* Vervoort (1964) in the Indian and Pacific Ocean as belonging to the new species, *E. villabonae*.

The new species most closely resembles *E. gladiator* Vervoort, 1964 and *E. tropica* Ummerkutty, 1970. They share an identical armature formula of P1–P4. The female fifth leg armature, with 3 and 4 setal elements on the fifth leg EXP and ENP, respectively also resembles the pattern found in *E. gladiator* (Vervoort 1964, fig. 145e), and *E. tropica* (Ummerkutty 1970, fig. 3O; Wells and Rao 1987, fig. 145a). However, *E. villabonae* can be separated from these species when comparing the length/width ratio of P1ENP which is 4.4 in *E. tropica* (Wells and Rao 1987, fig. 144c), 5.8 in *E. gladiator* (Vervoort 1964, fig. 145a) and 7.5 in *E. villabonae* (Fig. 3A). Also, the length of P4ENP with respect to the elongate P4EXP1 is different in these species: in *E. tropica* (Wells and Rao 1987: fig. 144f) and *E. gladiator* (Vervoort 1964, fig. 145d), the endopod reaches the point of insertion of the outer spine of the first exopodal segment, whereas in *E. villabonae* the endopod is clearly shorter and does not reach this level (Fig. 4E). The structure of the dorsal spinous process reveals additional differences: in *E. villabonae* (Figs 1B, C, 5B; Vervoort 1964: fig. 142b) and *E. gladiator* (Vervoort 1964: fig. 144c) a conspicuous process is present, being much longer and with two notches in the former whereas in *E. gladiator* the structure is clearly smaller and lacks such processes; this process is absent in *E. tropica* (Ummerkutty 1970: fig. 3B; Wells and Rao 1987: fig. 142d). We consider that the evidence presented justifies the separation of a new species of *Echinolaophonte*; it comprises previous records of *E. armiger* by Nicholls (1945) and Vervoort (1964) and raises the number of known nominal species to 13.

Distribution and habitat. This species is known to be associated mainly with coral reef areas. It has been reported (as *E. armiger*) from the reef area at Port Denison, Australia (Nicholls 1945) and also from the Ifaluk Atoll, Caroline Islands in the Pacific (Vervoort 1964). In Colombia this species was found in the littoral zone of the Rodadero Bay in an area covered by mangrove with a small adjacent bank of oysters at a depth of 0.70 m and a water temperature ranging between 30 and 32 °C, salinity 36.1 psu, pH 8.3. Its finding in the Northwestern Atlantic Ocean suggests that it is widely distributed in tropical latitudes.

***Echinolaophonte armiger* (Gurney, 1927)**

Figs 6C–D, 7

Syn. *Laophonte armiger* Gurney, 1927: 554–556, fig. 159; Willey 1930: 108–109, figs 65–67; Carvalho 1952: 159–160, Pl. II, figs 68–71. *Onychocamptus armiger* Lang, 1948: 1423–1424, Abb. 571(12), 580.

Material examined. One dissected adult female (CBUMAG:MEI:0003), two adult males and four adult females, ethanol-preserved, vial (CBUMAG:MEI:0002; CBUMAG:MEI:0001); Colombia, Magdalena, Rodadero Bay, 11°14'N, 74°12'W, August, 2016; coll. J.M. Fuentes-Reinés. One male, one female prepared for SEM analysis.

Description. *Female.* Habitus as in Figure 7A. Body cylindrical in dorsal view, prosome gradually tapering anteriorly. Total body length measured from anterior margin of rostrum to posterior margin of caudal rami ranging from 616 to 644 µm (average = 624.4 µm, $n = 5$). Rostrum conical in lateral view, trapezoid with flat anterior margin in dorsal view (Fig. 7B). Strong, dorsal spinous process present at median posterior margin of cephalosome reaching midlength of second pedigerous somite; process smooth in lateral view (arrow in Fig. 7A, C). Cephalosome with lateral posterior corners produced into triangular expansions (arrows in Fig. 7G) with weak cuticular incisions.

Antennule (Fig. 7D) 6-segmented, with long aesthetasc on fourth segment. Antenna (Fig. 7E, F) three-segmented, comprising coxa, allobasis, one-segmented endopod and one-segmented exopod, antennal exopod one-segmented with four well developed, pinnate setae (two lateral, two apical).

Mandible, maxillule, maxilla, and maxilliped (Fig. 6C) as in syntype specimens of *E. armiger* (Lee et al., 2006), except for seta on maxillary coxa (arrow in Fig. 7H).

P1 (Fig. 7I) with ENP and EXP two-segmented, ENP1 length/width ratio = 5.6, ENP2 ratio = 2.8, with denticulate claw and small, naked seta at base. EXP short. EXP1 with unipinnate spine. EXP2 with three unipinnate spines and two geniculate setae. P2–P4 as described by Lee et al. (2006).

P5 (Fig. 7J) with EXP and baseoendopod separate; each covered with spinules. Baseoendopod with short setophore bearing basal seta. Endopodal lobe armed with four setae, exopodal lobe with three. P6 represented by one inner small and one outer longer seta. Caudal rami length/width ratio = 1.4.

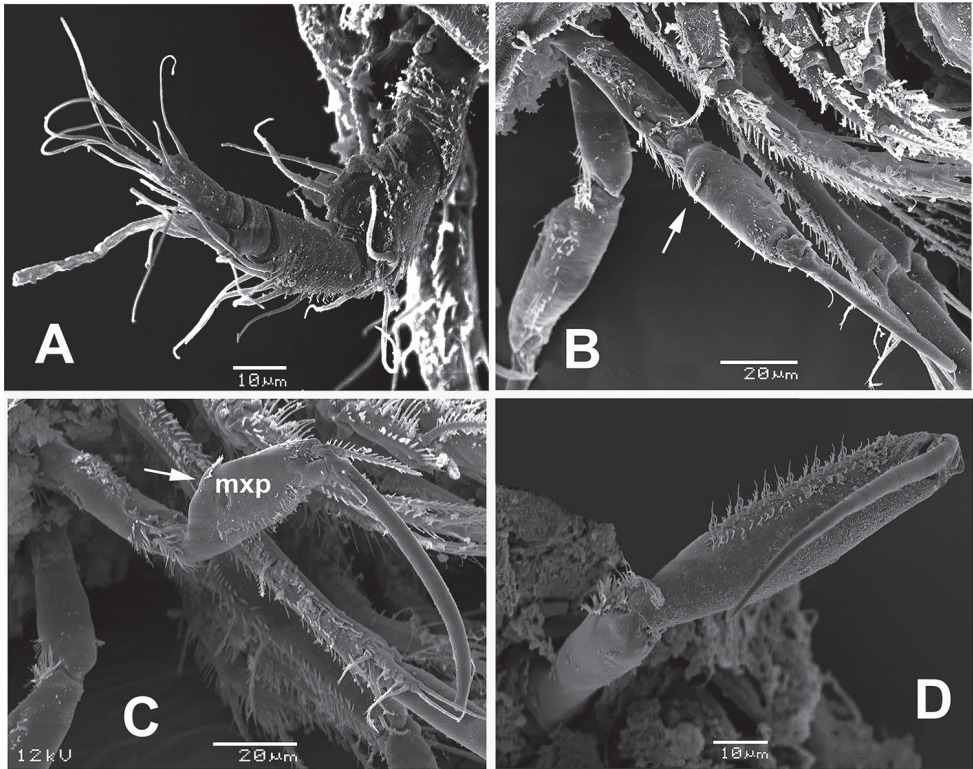


Figure 6. *Echinolaophonte villabonae* sp. n., female from Colombia, SEM-prepared specimen. **A** antennule **B** maxilliped showing proximal position of spinule comb (arrow); *E. armiger* female from Colombia **C** maxilliped showing medial position of spinule comb **D** male maxilliped.

Male. Habitus resembling that of female (Fig. 7K). Total body length ranging from 532 to 588 μm (average = 560 μm , $n = 3$). Cephalosome with strong dorsal spiniform medial process as in female (arrowed in Fig. 6K). Antennule (Fig. 7L) subchirocer, eight-segmented, with geniculation between segments 5 and 6. First segment with row of spinules, second segment with small subdistal knob. Segment 5 swollen, segment 6 with spiniform processes. Maxilliped with relatively narrower basis and longer terminal claw than in female (Fig. 6D).

P1 (Fig. 7M) and P2 as in female; P3–P4 as in female, except for outer and distal spines of exopod which are slightly thicker than in female. P5 (Fig. 7N) fused medially, defined at base. Baseoendopod with short setophore bearing long outer basal seta, endopodal lobe obsolete. Exopod narrow, armed with three pinnate setae and spinules on anterior surface. P6 (Fig. 7O) represented by subquadrate plate armed with bipinnate inner and naked outer seta. Caudal rami length/width ratio = 1.4.

Variability. One male was observed to have three setal elements on the antennal exopod instead of the usual pattern of four.

Remarks. The present record, from the Caribbean coast of Colombia, is the fifth of *E. armiger sensu* Gurney, 1927 worldwide. In the surveyed area this species coexists

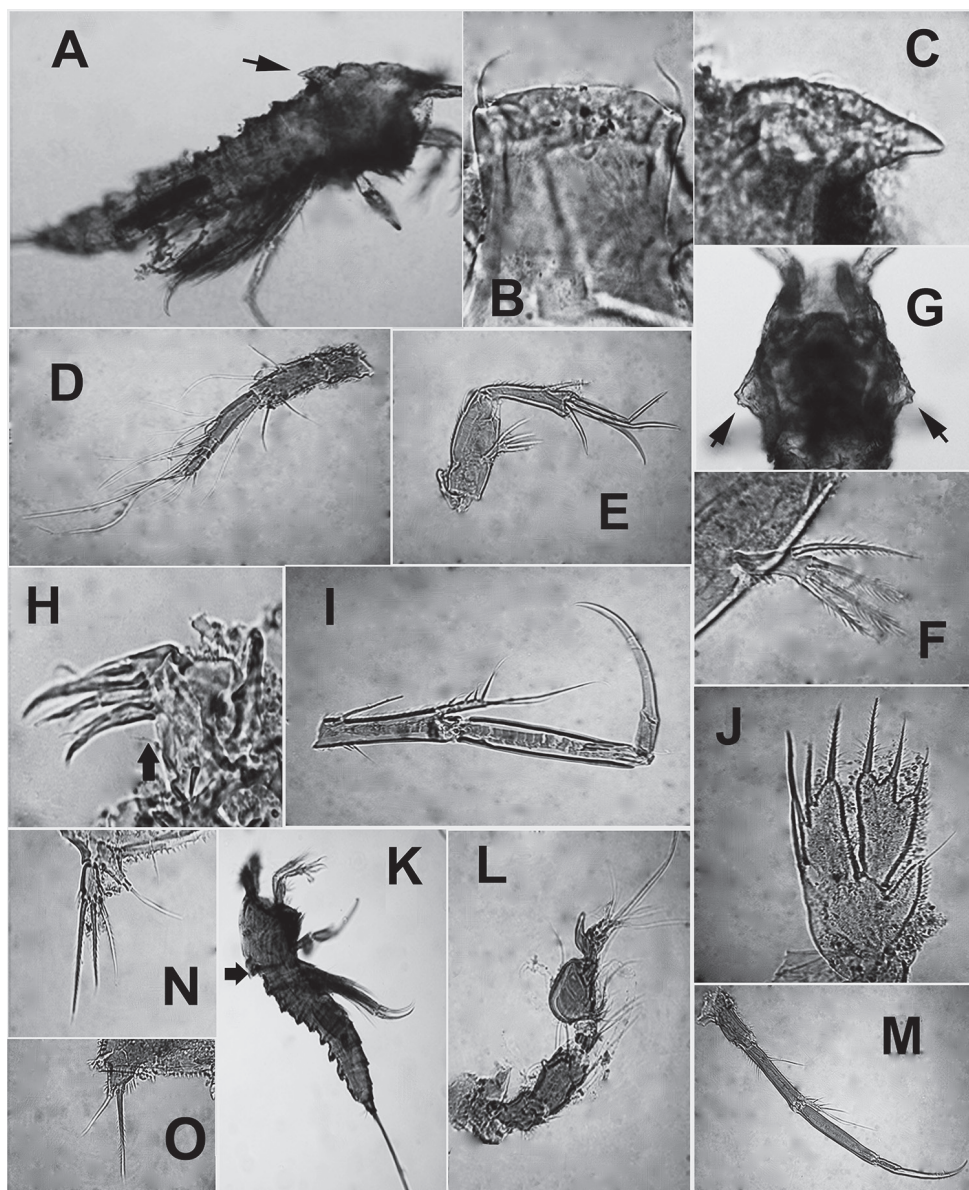


Figure 7. A–O *Echinolaophonte armiger* (Gurney) from Colombia, unscaled digital micrographs. Adult female (body length = 644 μm). **A** habitus, lateral view showing dorsal process on cephalic shield (arrow) **B** rostrum showing flat anterior surface and depressed distal margins **C** process on cephalic shield, lateral view **D** antennule **E** antenna **F** detail of antennary exopod **G** cephalosome showing weak development of posterolateral margins (arrows), dorsal view **H** maxillule showing slender inner seta on syncoxa (arrowed) **I** leg 1 **J** leg 5; adult male (body length 560 μm) **K** habitus, lateral view showing smooth dorsal process on cephalosome **L** antennule **M** leg 1 **N** leg 5 **O** leg 6.

with the closely related *E. villabonae*, which is locally more abundant. Lee et al. (2006) redescribed *E. armiger* from syntypic specimens from the Suez Canal and complemented their report with specimens from the Gulf of Mexico (Texan Coast, USA); the species is characterized by: 1) the smooth apical margin of the rostrum, 2) the simple dorsal spinous process on the cephalosome, 3) the armature formula of the swimming legs, 4) the short ENP2 of P2-P4, 5) the unmodified P3 endopod in male, 6) the slightly modified exopods of P3 and P4 in male, 7) the short setophore of the P5 outer basal seta, 8) short caudal ramus (only 1.4 times longer than wide), 9) the shape of dorsal spiny processes in the prosome and urosome and 10) the shape of pseudoperculum. Most of these distinctive traits were observed in the Colombian specimens. However, subtle differences were detected in our specimens from Colombia, thus allowing an expansion of the morphological range of this species: 1) a maxillary coxal seta is present in the Colombian specimens (Fig. 7H) whereas it is absent in the Texan material (Lee et al. 2006: fig. 2F), 2) the P1ENP1 length/width ratio. It is 5.6 in the Colombian specimen (Fig. 7I) whereas in the Texas specimens the figure is slightly higher: 5.8 (Lee et al. 2006: fig. 3A).

Distribution. Suez Canal, Egypt (type locality), the Texan coast (USA) (Lee et al. 2006), Brazil (Carvalho 1952), northern Colombia (present data), and possibly Bermuda (Willey 1930).

Key to the known species of *Echinolaophonte*

- 1 Spinal formula of outer spines on P2-P4 EXP3 = 332 or 232 5
- Spinal formula of outer spines on P2-P4 EXP 3 = 222 or 333 2
- 2 Spinal formula of outer spines on P2-P4 EXP 3 = 222..... 3
- Spinal formula of outer spines on P2-P4 EXP 3 = 333.....
..... *E. mirabilis* (Gurney, 1927)
- 3 Dorsal spiniform process present on cephalic shield, P2ENP reaching half-length of EXP3, length/width ratio of P1 ENP between 4.5 and 5.8 4
- Dorsal spiniform process on cephalothorax absent, P2ENP reaching inner seta of P2EXP2, length/width ratio of P1 ENP = 4.4..... *E. tropica* Ummerkuty, 1970
- 4 Dorsal spiniform process with two distinctive notches on posterior margin, second segment of antennule without particular features, length width ratio of P1 ENP = 7.5. *E. villabonae* sp.n.
- Dorsal spiniform process smooth, lacking notches on posterior margin, second segment of antennule with strong, outwardly directed hook, length/width ratio of P1 ENP = 5.8..... *E. gladiator* (Vervoort, 1964)
- 5 Spinal formula of P2-P4 = 232, male P3 ENP with or without apophysis... 6
- Spinal formula of P2-P4= 332, male P3 ENP with or without apophysis.... 8
- 6 Baseoendopod of female P5 with 2 inner setae; EXP3 P2 as long as segments 1-2 combined. EXP2-3 P2 lacking inner setae
..... *E. minuta* Cottarelli & Forniz, 1991
- Baseoendopod of female P5 with single inner seta; EXP1-3 P2 subequal in length. EXP2-3 P2 with inner setae 7

- 7 P4 ENP shorter than EXP1, rostrum reverse trapezoid, small, body size 580 μm (female), 490 μm (male) *E. hystrix* (Brian, 1928)
- P4 ENP longer than EXP1, rostrum rectangular, body size 618–650 μm (female), 565 μm (male) *E. armiger* (Gurney, 1927)
- 8 Female P5ENP with four setae, maxillule with endopod 9
- Female P5ENP with two setae, maxillule lacking endopod
..... *E. veniliae* Cottarelli, Forniz & Bascherin, 1992
- 9 Caudal rami length/width ratio 4 times as long as wide, male P3 ENP lacking apophysis *E. tetracheir* Mielke, 1981
- Caudal rami length/width ratio between 3.1 and 3.4 times as long as wide, EXP2 P2 with two setal elements, inner seta and outer spine; EXP3 P2 with inner seta 10
- Caudal rami length/width ratio ranging between 2.0 and 2.2 times as long as wide, EXP2 P2 with one setal element, inner seta absent, EXP3 P2 lacking inner seta 11
- 10 P1 EXP reaching half length of ENP1, P2ENP1 not reaching distal end of EXP1, rostrum bilobed at tip, male P3EXP2–3 inner setae long
..... *E. brevispinosa* Sars, 1908
- P1 EXP relatively short, reaching $\frac{1}{4}$ the length ENP1, P2ENP1 reaching distal end of EXP1, rostrum rounded at tip, male P3EXP2–3 inner setae short ...
..... *E. horrida* (Norman, 1876)
- 11 P2 ENP2 with medial distal seta spiniform, clearly shorter than adjacent two distal setae, half the length of bearing segment. P1 ENP1 lacking inner seta.
..... *E. longantennata* Apostolov, 1990
- P2 ENP2 with medial distal seta setiform, as long as adjacent 2 setae. P1 ENP1 with inner seta *E. oshoroensis* Itô, 1969

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An illustrated key to the genera and subgenera of the Alysiini (Hymenoptera, Braconidae, Alysiinae), with three genera new for China

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Abstract

An illustrated key to the genera and subgenera of the Alysiini (Hymenoptera, Braconidae, Alysiinae) from China is presented. Three genera new for China are reported: *Adeluroloa* Strand, 1924, *Anisocyrtia* Foerster, 1863, and *Pentapleura* Foerster, 1863. The total for China is 26 genera of Alysiini and an additional seven subgenera (excluding the nominal subgenera, which are included in the total of genera). The known Chinese species are listed under each genus and the biology is summarised. *Separatatus sinicus* (Zheng, Chen & Yang, 2012) and *Grammospila euryx* (Chen & Wu, 1994) are new combinations. *Regetus* Papp, 1999, and *Adelphenaldis* Fischer, 2003, are new synonyms of *Eusynaldis* Zaykov & Fischer, 1982. In addition, *Eusynaldis* Zaykov & Fischer and *Synaldis* Foerster, 1863, are treated as subgenera of *Aspilota* Foerster, 1863, and *Dinotrema* Foerster, 1863, respectively. An aberrant species of *Separatatus* Chen & Wu, 1994, *S. parallelus* sp. n., is described from Yunnan and Hainan.

Keywords

Alysiinae, Alysiini, Braconidae, China, Hymenoptera, key to genera, new record, Oriental, Palaearctic

Introduction

The subfamily Alysiinae Leach, 1815 (Hymenoptera: Braconidae) contains small to medium-sized koinobiont endoparasitoids of cyclorrhaphous dipterous larvae (Wharton 1984; Shaw and Huddleston 1991; van Achterberg 1993). Alysiinae is characterized among the Braconidae by having exodont mandibles, a feature occurring almost exclusively in this subfamily. The mandibles do not touch each other, even when they are closed (van Achterberg 1993; Belokobylskij and Kostromina 2011). Specimens of Alysiinae are often common, especially when decaying organic material is abundant (Peris-Filipo and Jimenez-Peydro 2011; pers. obs.).

Keys to the genera of Alysiinae of the Old World are found in Fischer (1976a) (including all known genera up to 1975), Chen and Wu (1994) (key to genera of China) and Wharton (2002) (key to genera of the Australian region). All of these keys are useful, but are not illustrated and do not include all the genera found during our study. Therefore, an illustrated key to all genera and subgenera of the Alysiini known from China is presented in this paper.

Chen and Wu (1994) reported 19 genera and *Heterolexis* Foerster as a subgenus, but the report of *Adeluroloa* Strand is not accepted because the included species belongs to *Grammospila* Foerster. Wu et al. (1995a) and Yao (2015b) reported *Cratospila* Foerster, and *Trachyusa* Ruthe, respectively. Zheng et al. (2012) added *Bobekoides* van Achterberg, but the reported species is here transferred to *Separatatus* Chen & Wu. Chen and Wu (1994) indirectly reported *Grammospila* (because of the reported species) and the subgenera *Eusynaldis* Zaykov & Fischer and *Synaldis* Foerster. These subgenera are recognised for convenience, because their recognition likely renders the genera *Aspilota* Foerster and *Dinotrema* Foerster paraphyletic. Recently, the total number of genera for China reached 23 by the publication of *Dacnulyisia* Zhu, van Achterberg & Chen by Zhu et al. (2017).

In this paper three genera are listed as new for China: *Adeluroloa* Strand, *Anisocyrta* Foerster and *Pentapleura* Foerster. The total for China is 26 genera of Alysiini and seven subgenera (without the nominal subgenera; they are included in the total of genera), comprising 132 species.

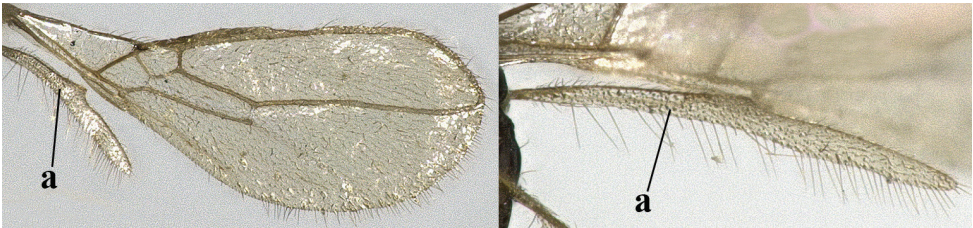
Materials and methods

The collection specimens were hand net collected and glued on card points. They were sorted from the Braconidae collection present in the Institute of Insect Sciences of the Zhejiang University (ZJUH). The terminology and measurements used follow van Achterberg (1979, 1988a). The following abbreviations are used: **POL** – postocellar line; **OOL** – ocular-ocellar line, measured from ocellus directly to eye; **OD** – maximum diameter of lateral ocellus; medial length of the first tergite is measured from the apex of the adductor to the apex of tergite. Descriptions and measurements were made under a Leica M125 stereomicroscope. Photographs were made with a Keyence

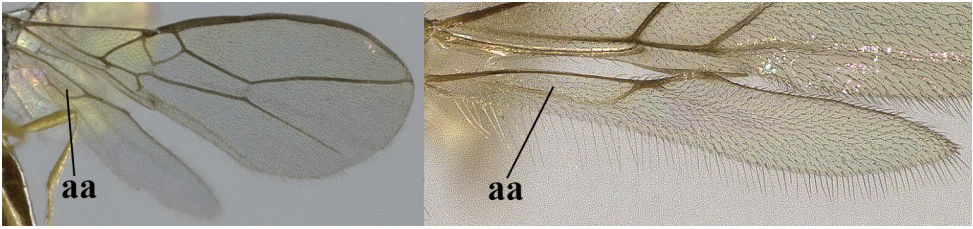
VHX-2000 digital microscope and the photos were slightly processed (mainly cropped and backgrounds modified) in Photoshop CC. The drawings are from van Achterberg (1988b). The literature on Chinese Alysiini and the original publications of the genera are referenced; for additional references, see Yu et al. (2016).

Key to genera of Chinese Alysiini

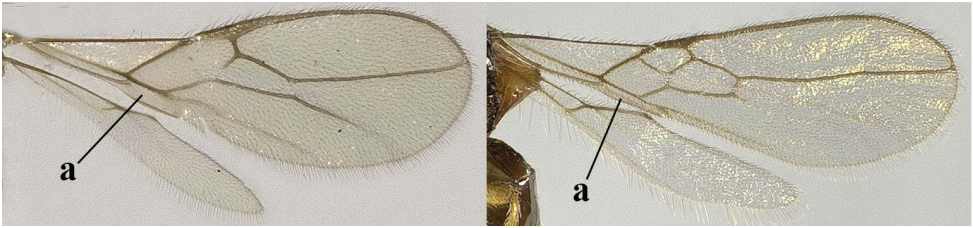
- 1 Hind wing without closed cells and very narrow (a); [few aberrant spp.].....
..... *Dinotrema* Foerster, 1863 p.p.



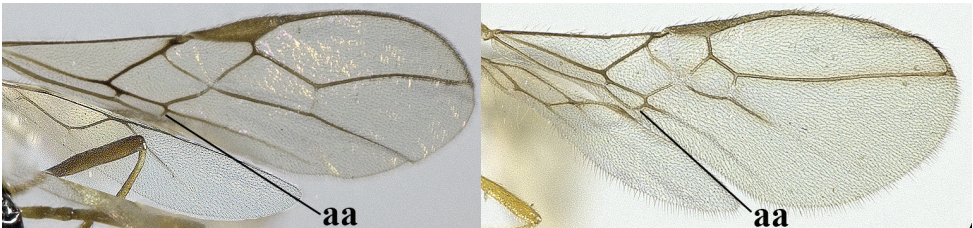
- Hind wing with 1–2 closed cells and usually wider (aa)2



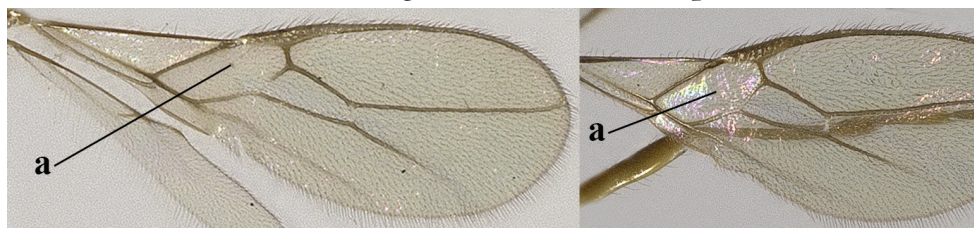
- 2 Veins 2-1A and CU1b of fore wing absent, resulting in an open first subdiscal cell apico-posteriorly (a).....3



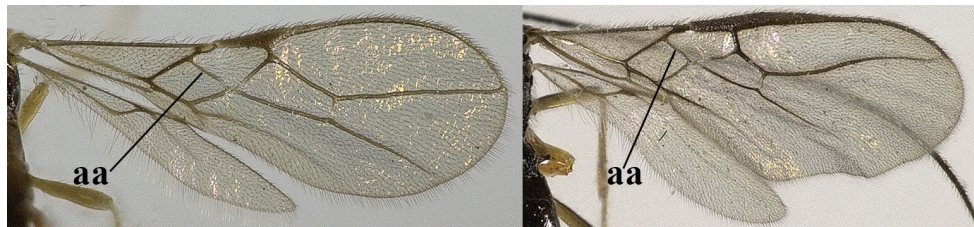
- Veins 2-1A and CU1b of fore wing present, resulting in a closed first subdiscal cell apico-posteriorly (aa), rarely CU1b absent (*Alysia* spp.)7



- 3 Vein 1-SR+M of fore wing absent (a) *Aphaereta* Foerster, 1863



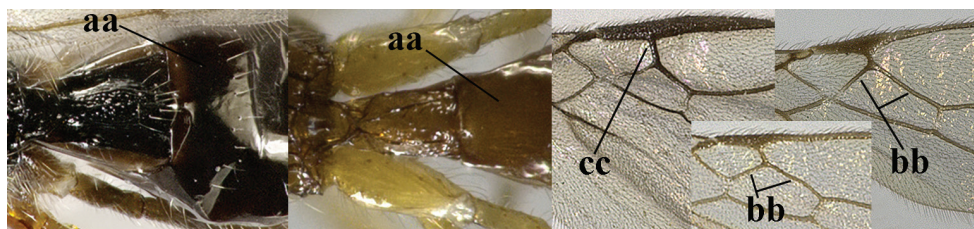
- Vein 1-SR+M of fore wing present (aa) 4



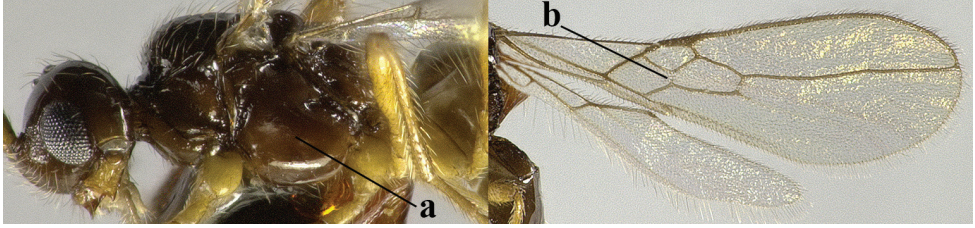
- 4 Second metasomal tergite granulate (a); vein 2-SR of fore wing at most about as long as vein 3-SR (b) **and** vein r of fore wing emitted near middle of pterostigma (c) *Trachyusa* Ruthe, 1854



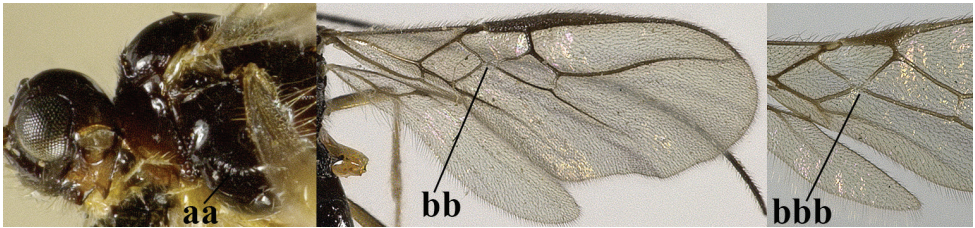
- Second tergite smooth (aa); vein 2-SR of fore wing shorter than vein 3-SR (bb) **or** vein r of fore wing emitted near basal third of pterostigma (cc) 5



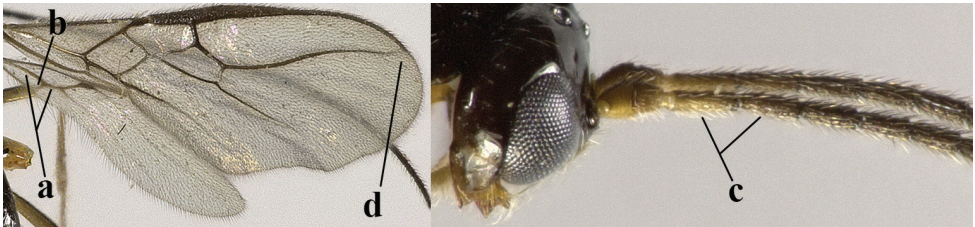
- 5 Precoxal sulcus absent (a), at most shallowly impressed and with some micro-sculpture; vein m-cu of fore wing (just) postfurcal (b) ***Pentapleura* Foerster, 1863**



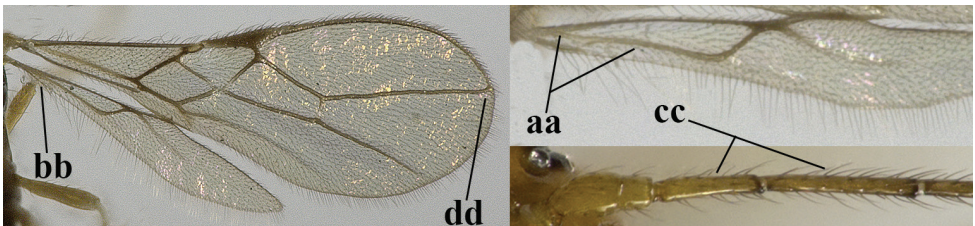
- Precoxal sulcus at least medially distinctly impressed and with some (micro-) crenulae (aa); vein m-cu of fore wing antefurcal (bb) or interstitial (bbb) **6**



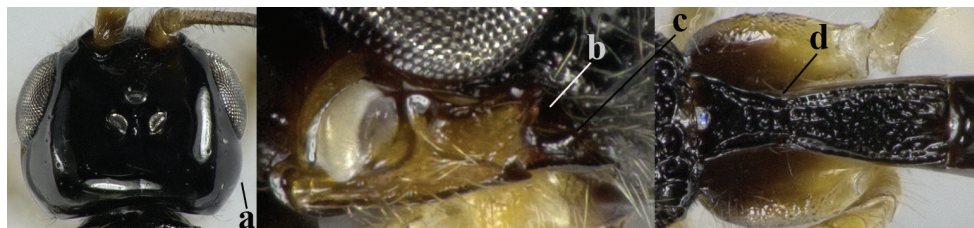
- 6 Vein M+CU of hind wing at least somewhat longer than vein 1-M (a) and vein cu-a present (b); third antennal segment slightly longer than fourth segment (c) or of equal length; marginal cell of fore wing remaining distinctly removed from apex of wing (d) ***Heterolexis* Foerster, 1863**



- Vein M+CU of hind wing distinctly shorter than vein 1-M (aa) or vein cu-a absent (bb); third antennal segment usually shorter than fourth segment (cc); marginal cell of fore wing reaching wing apex (dd)..... ***Asobara* Foerster, 1863**



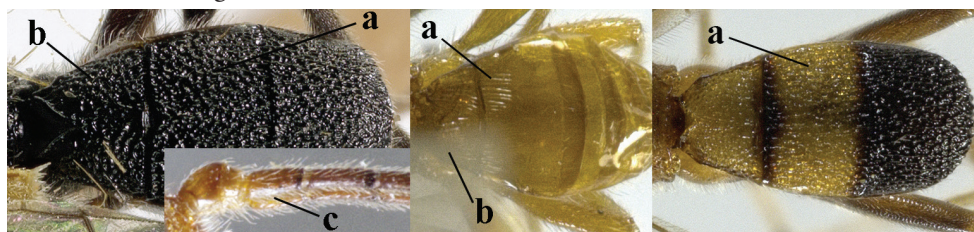
- 7 Head nearly square in dorsal view (a); mandible with wide gap between first and second tooth (b) and second tooth with dorsal tooth (c); first metasomal tergite (compared to base of tergite) distinctly constricted near basal third (d); [metasoma of ♀ compressed; first tergite without dorsope, except elongate shallow depression (d)]*Dacnulysia* Zhu, van Achterberg & Chen, 2017



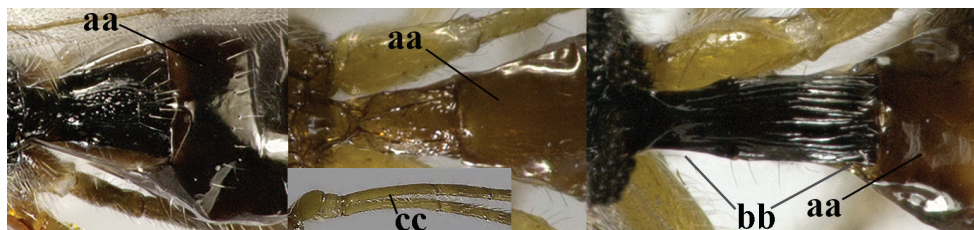
- Head transverse and at least 1.7 times as wide as long in dorsal view (aa); **if** rarely about as long as wide or longer than wide then first tergite with normal dorsope (dd); mandible at most with narrow gap between first and second tooth (bb), and second tooth without distinct dorsal tooth (cc); first tergite (compared to base of tergite) at most weakly constricted near basal third (dd) 8



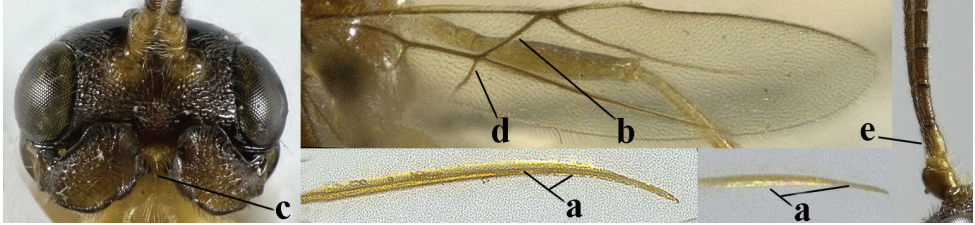
- 8 Second metasomal tergite striate, rugose or reticulate basally (a); first tergite robust (b); third antennal segment short to medium-sized compared to fourth segment (c) 9



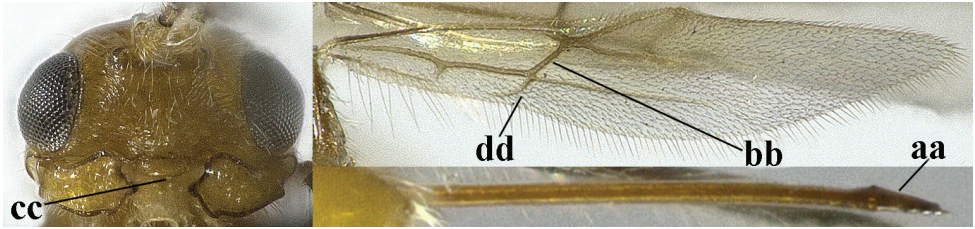
- Second tergite smooth basally (aa), if rarely with some striae basally, then first tergite slender (bb), and third antennal segment long compared to fourth segment (cc); cf. couplet 20 (*Cratospila* Foerster) 10



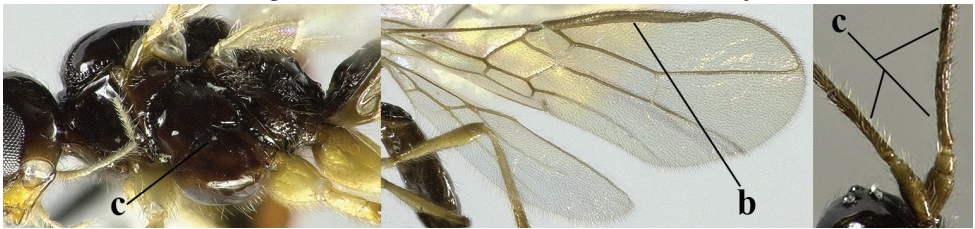
- 9 Upper valve of ovipositor enlarged and enclosing small lower valve (a); vein 1r-m of hind wing long compared to vein 1-M (b); clypeus acutely protruding (c); vein m-cu of hind wing nearly straight (d); [third antennal segment often distinctly widened, 1.5–2.0 times wider than fourth segment (e), but slender in few spp.] *Hylcalosia* Fischer, 1967



- Ovipositor valves normal (aa); vein 1r-m of hind wing medium-sized compared to vein 1-M (bb); clypeus obtusely protruding (cc); vein m-cu of hind wing curved (dd) or absent; [apex of hind wing acute; if rounded, pterostigma nearly parallel-sided with vein r subbasally emitted, and clypeus triangular, cf. *Senwot* Wharton, 1983] *Separatatus* Chen & Wu, 1994



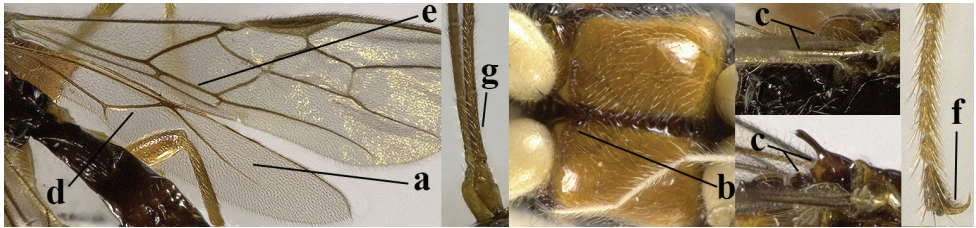
- 10 Precoxal sulcus absent (a) and pterostigma linear or slightly widened basally, about 10 times longer than wide (b); third antennal segment much longer than fourth segment (c) *Anisocyrta* Foerster, 1863



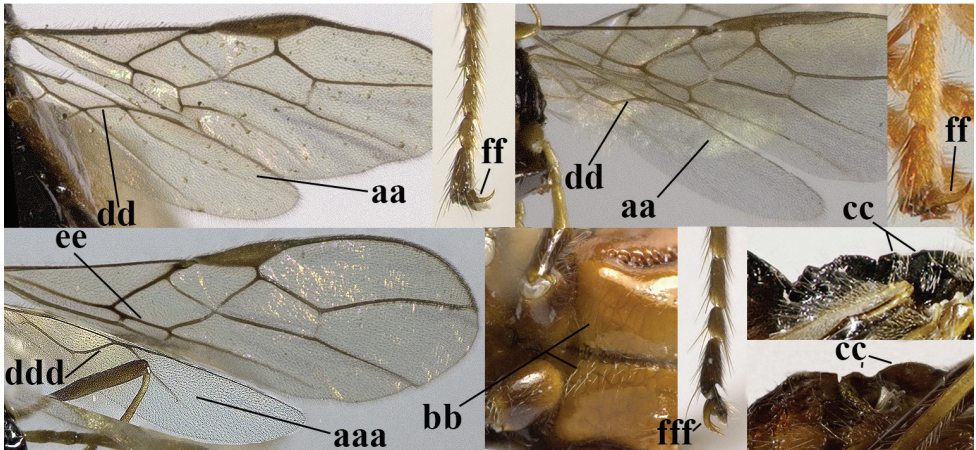
- Precoxal sulcus present (aa); if absent then pterostigma wide elliptical (bb); length of third antennal segment variable, often somewhat longer than fourth segment (cc) to distinctly shorter (ccc) 11



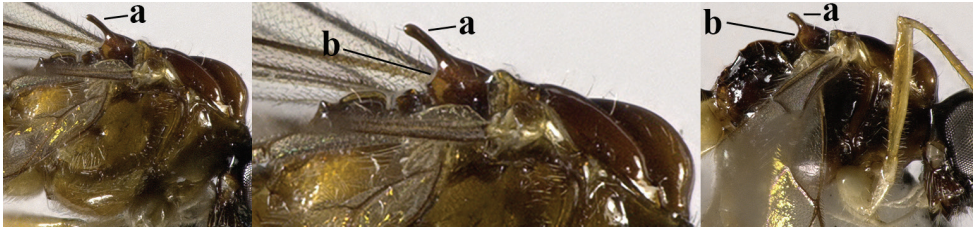
- 11 Marginal cell of hind wing strongly widened (a) **and** postpectal carina present medio-ventrally (b); scutellum medio-posteriorly distinctly protruding above level of metanotum in lateral view (c); vein 1r-m of hind wing long, longer than half width of hind wing (d); first subdiscal cell of fore wing narrow and long compared to vein cu-a (e); basal half of tarsal claws narrow and subparallel-sided (f); [metanotal tooth absent; antenna of ♀ at least twice as long as body, third segment very slender (f) and with a short white band; hind coxa ventrally angulate subbasally; Chinese spp. often with medium-sized to large occipital tubercle]; *Heratemis* Walker, 1860..... 12



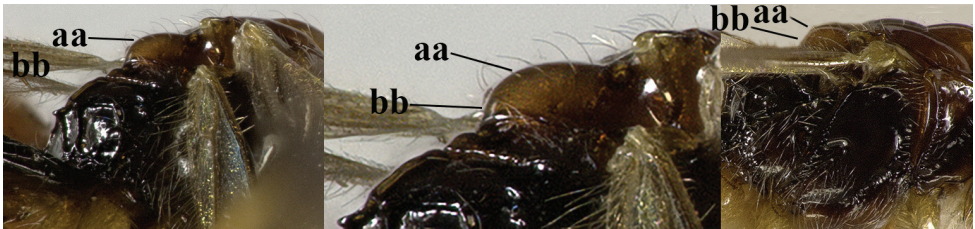
- Marginal cell of hind wing slightly widened to narrowed (aa); **if** distinctly widened (aaa) then postpectal carina absent medio-ventrally (bb) and scutellum medio-posteriorly slightly or not protruding above level of metanotum in lateral view (cc); vein 1r-m of hind wing medium-sized, shorter than half width of hind wing (dd), **if** rarely longer (ddd) then first subdiscal cell of fore wing wider and shorter compared to vein cu-a (ee) and basal half of tarsal claws distinctly widened, subtriangular (ff), but sometimes parallel-sided (fff)..... 14



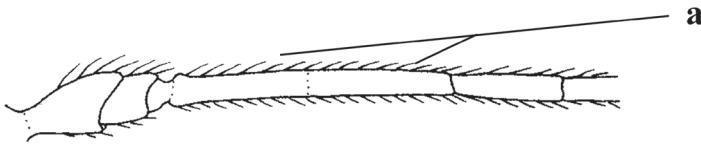
- 12 Scutellum of ♀ with distinct apical spine posteriorly (a), but sometimes less developed in ♂; scutellum steep medio-posteriorly in lateral view (b)
subgenus *Heratemis* Walker, 1860



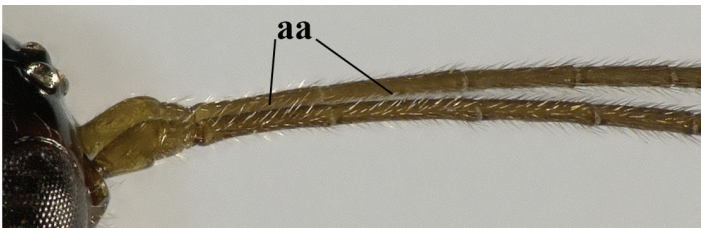
- Scutellum of ♀ only distinctly convex posteriorly and without trace of a spine (aa); scutellum medio-posteriorly gradually lowered in lateral view (bb).... 13



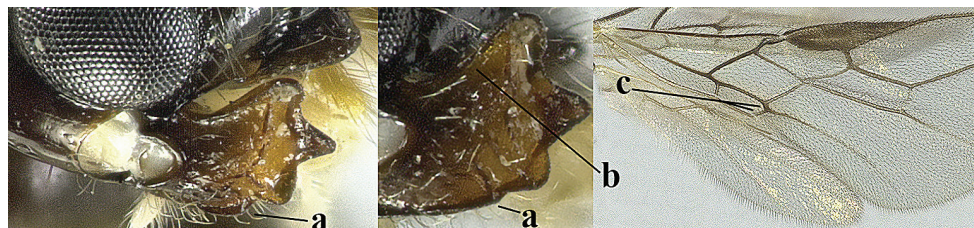
- 13 “Third” (actually joined third and fourth segments, sometimes vaguely separated) antennal segment 2.1–2.9 times as long as following segment and 9–11 times as long as wide (a).....subgenus *Kritscherysia* Fischer, 1993



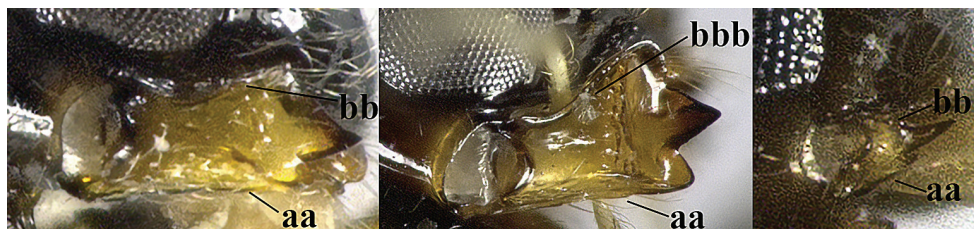
- Third antennal segment 0.8–1.2 times following (= real fourth) segment and 4–7 times as long as wide (aa), **if** rarely third segment only partly separated from fourth segment, then its separation remains visible in lateral view
 subgenus *Conalysia* Papp, 1969



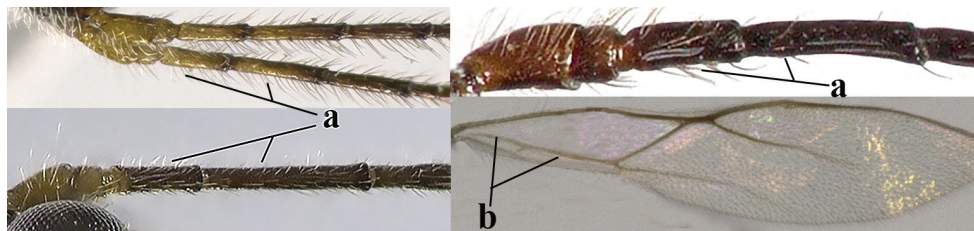
- 14 Mandible with a fourth small lamelliform protuberance ventrally (a) and abruptly widened dorsally (b); [vein CU1b of fore wing longer than vein 3-CU1 (c)].....*Adeluroloa* Strand, 1928



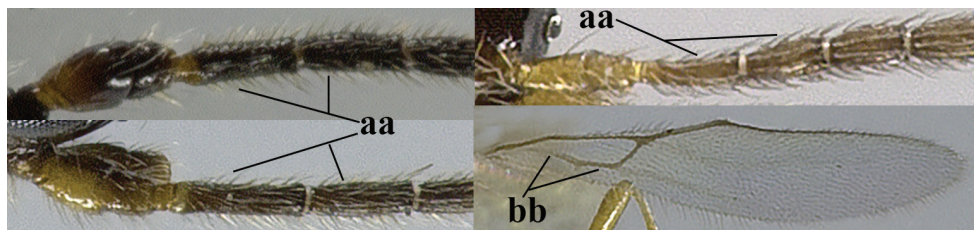
- Mandible without fourth protuberance ventrally (aa), at most with a small protuberance between first and second tooth and not or moderately widened dorsally (bb), but sometimes strongly so (bbb).....15



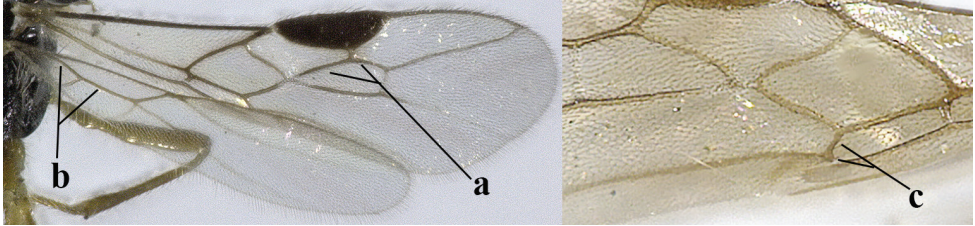
- 15 Third antennal segment distinctly shorter than fourth segment (a); **if** subequal or slightly longer than vein M+CU of hind wing distinctly shorter than vein 1-M (b).....16



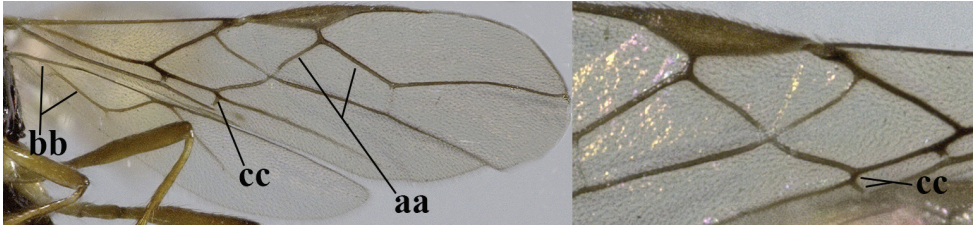
- Third antennal segment subequal to or longer than fourth segment (aa); **if** subequal then vein M+CU of hind wing longer than vein 1-M (bb)20



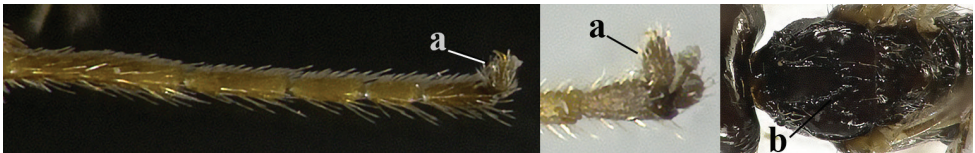
- 16 Vein 3-SR of fore wing as long as vein 2-SR or shorter (a) **and** vein M+CU of hind wing longer than vein 1-M or subequal (b); vein CU1b of fore wing shorter than or subequal to vein 3-CU1 (c)..... ***Idiasta* Foerster, 1863**



- Vein 3-SR of fore wing longer than vein 2-SR (aa); **if** subequal then vein M+CU of hind wing distinctly shorter than vein 1-M (bb); vein CU1b of fore wing longer than vein 3-CU1 (cc); ***Phaenocarpa* Foerster, 1863** **17**



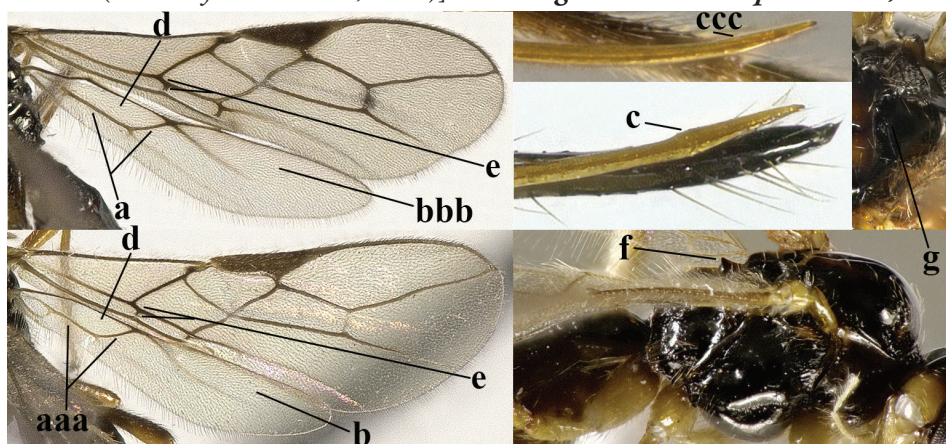
- 17 Tarsal claws distinctly widened medially and densely setose (especially swollen in ♀ and with apical tooth indistinct or small (a); but tarsal claws in ♂ slenderer and with distinct apical tooth, but still wider and more setose than in other groups) and pulvillus of ♀ strongly swollen; notauli complete, deep and crenulate (b)..... **subgenus *Discphaenocarpa* Belokobylskij, 1998**



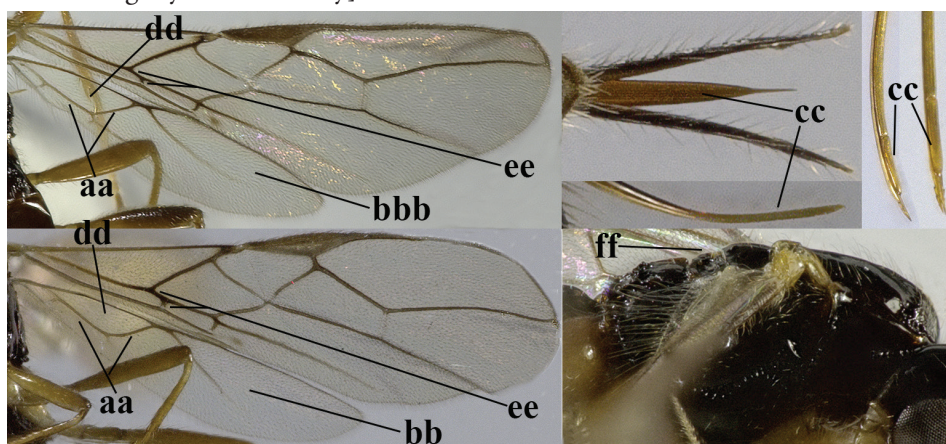
- Tarsal claws flattened and with large apical tooth (aa) and pulvillus of ♀ not swollen; notauli often absent or smooth and shallow posteriorly (bb) **18**



- 18 Vein 1r-m of hind wing 0.2–0.7 times as long as vein 1-M (a); **if** 0.6–0.7 times (aaa) then metanotum tooth-shaped protruding dorsally in lateral view (f); marginal cell of hind wing medium-sized (bbb) or small (b); upper valve of ovipositor cylindrical and more or less widened subapically in lateral view (c), but in *P. ruficeps* group of equal width (ccc); apical half of basal cell of hind wing at most weakly widened (d); vein 1-CU1 of fore wing usually about as long as vein cu-a or shorter (e); [vein 1-SR+M of fore wing straight or slightly sinuate basally; vein 1-R1 of fore wing at least 1.6 times as long as pterostigma; metanotum tooth-shaped protruding in lateral view, vein 1r-m of hind wing 0.6–0.7 times as long as vein 1-M (0.2–0.5 times in other spp.) and the scutellar sulcus more or less narrowed medially in the *P. ruficeps* group (= *Holcalysia* Cameron, 1905)]..... **subgenus *Phaenocarpa* Foerster, 1863**



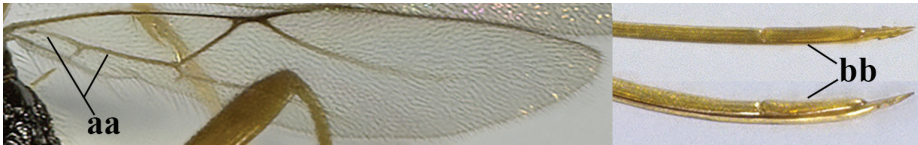
- Vein 1r-m of hind wing 0.8–0.9 times as long as vein 1-M (aa); marginal cell of hind wing large (bb) or medium-sized (bbb); upper valve of ovipositor depressed subapically (cc); apical half of basal cell of hind wing distinctly widened (dd); vein 1-CU1 of fore wing longer than vein cu-a (ee); metanotum obtuse dorsally in lateral view (ff); [vein 1-SR+M of fore wing regularly slightly curved basally] **19**



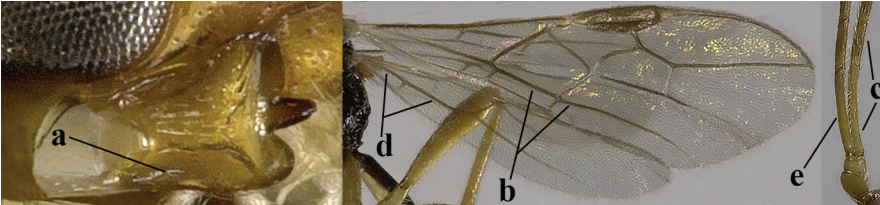
- 19 Vein 1-M of hind wing 0.8–1.2 times longer than vein M+CU (a); apically upper valve of ovipositor enclosed by much wider lower valve (b)
 **subgenus *Clistalsia* Zhu, van Achterberg & Chen, 2017**



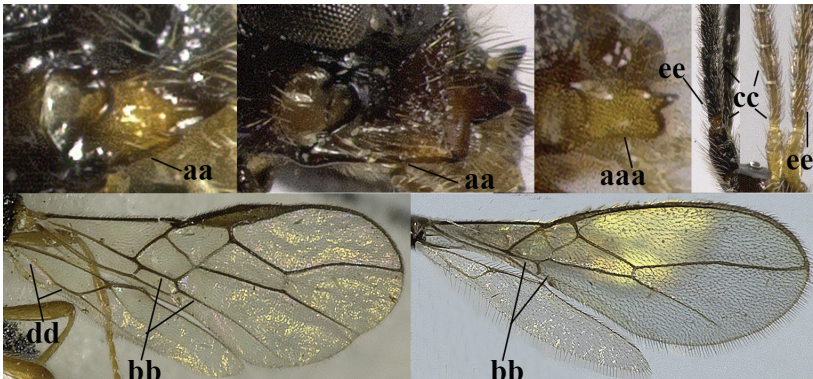
- Vein 1-M of hind wing 1.4–1.9 times as long as vein M+CU (aa); apically upper valve of ovipositor free from lower valve (bb); [antenna about twice as long as fore wing; ovipositor of type species of *Neophaenocarpa* strongly depressed, ribbon-shaped; often vein 1r-m of hind wing rather curved]
***Neophaenocarpa* Belokobylskij, 1999**



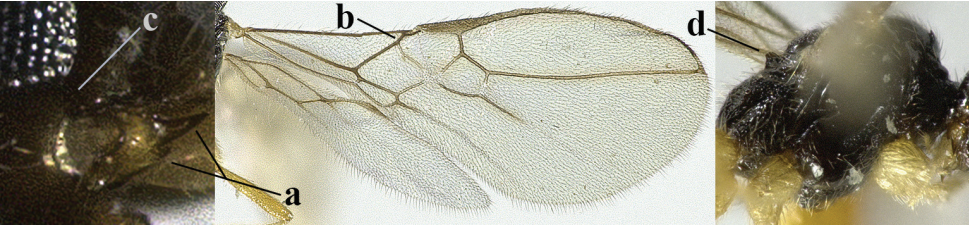
- 20 Mandible with a wide medio-ventral lamella (a); vein CU1a of fore wing near level of 2-CU1 (b); third antennal segment 1.5–1.7 times as long as fourth segment (c); vein M+CU of hind wing somewhat shorter than vein 1-M (d); third antennal segment 6–7 times as long as wide (e); [second tergite sometimes partly finely striate] ***Cratospila* Foerster, 1863**



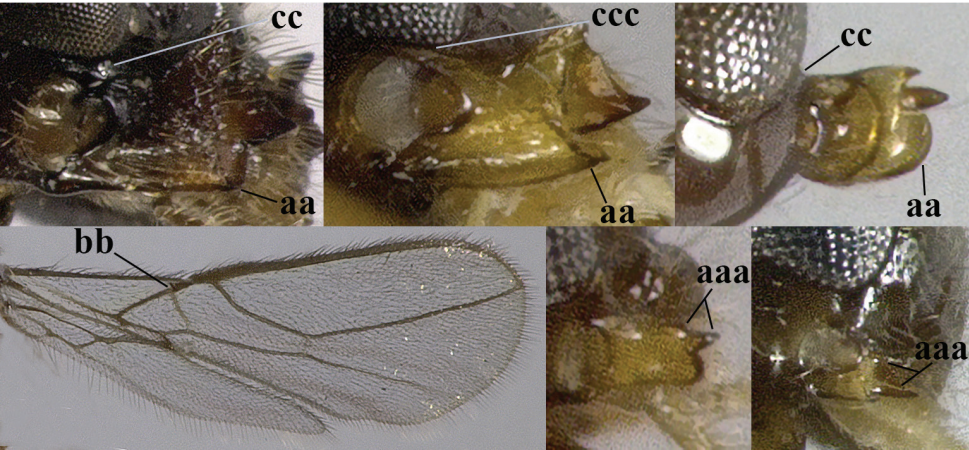
- Mandible at most with a medium-sized ventral lamella (aa) or absent (aaa); vein CU1a of fore wing distinctly below level of 2-CU1 (bb); third antennal segment about as long as fourth segment or somewhat longer (cc); **if** 1.3–1.7 times then vein M+CU of hind wing distinctly longer than vein 1-M (dd) and third segment less than 5 times as long as wide (ee) **21**



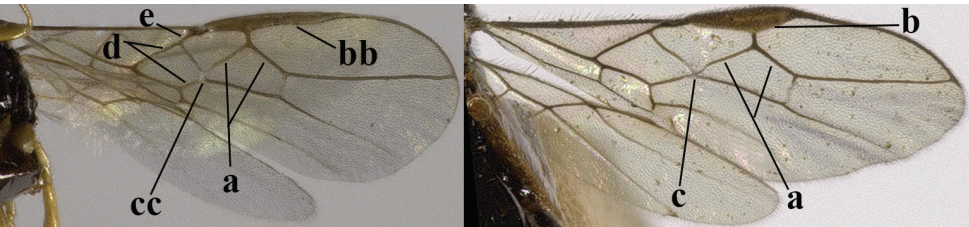
- 21 Lateral teeth of mandible small, acute and much shorter than elongate middle tooth (a), vein 1-SR of fore wing distinct (b) **and** in lateral view metanotum with acute or truncate protuberance medio-dorsally (d); malar suture often rather long and deep (c); [brachypterous specimens can be recognised by the combination of both last characters].....*Alloea* Haliday, 1833



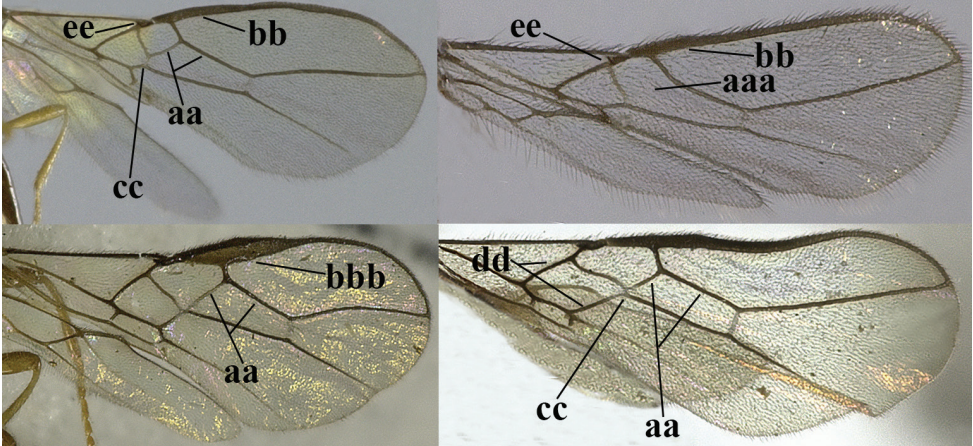
- Lateral teeth or lobes of mandible medium-sized to large, about as long middle tooth (aa); **if** minute and acute (aaa) then vein 1-SR very short or absent (bb) or metanotum weakly convex in lateral view; malar suture shorter (cc) or absent (ccc).....22



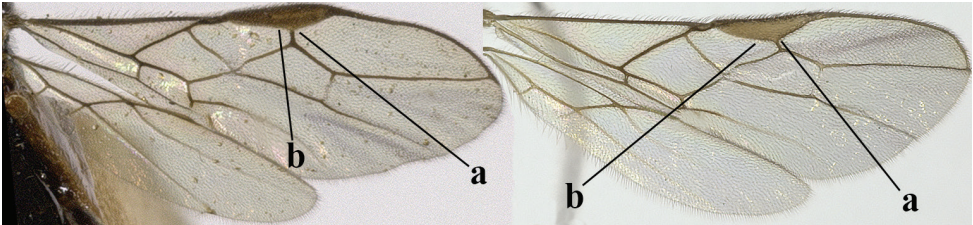
- 22 Length of vein 3-SR of fore wing 1.2 times vein 2-SR or less and vein 2-SR present (a); pterostigma triangular or elliptical (b), but sometimes sublinear (bb); vein m-cu of fore wing usually antefurcal or interstitial (c); **if** postfurcal (cc) then vein m-cu of fore wing distinctly shorter than vein 1-M (d) **and** vein 1-SR distinctly longer than wide (e).....23



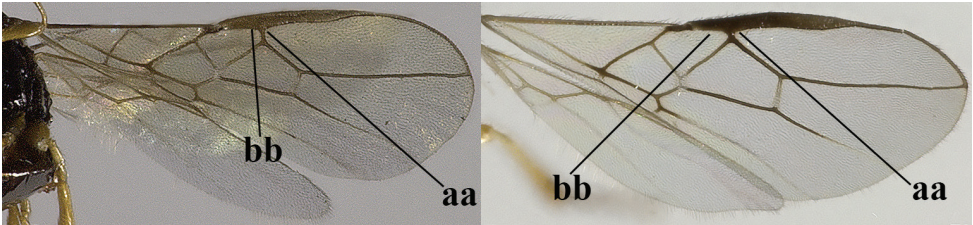
- Length of vein 3-SR of fore wing more than 1.2 times vein 2-SR (aa) or vein 2-SR absent (aaa); pterostigma usually linear (bb), but sometimes widened (bbb); vein m-cu of fore wing often postfurcal (cc) and either vein m-cu nearly as long as vein 1-M (dd) **or** vein 1-SR absent or about as long as wide (ee)25



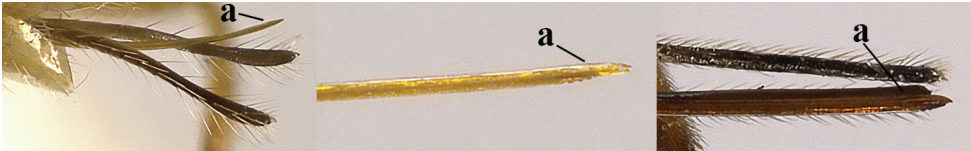
- 23 Vein r issued from middle or between middle and apex of pterostigma (a); pterostigma rather robust (b); *Alysia* Latreille, 180424



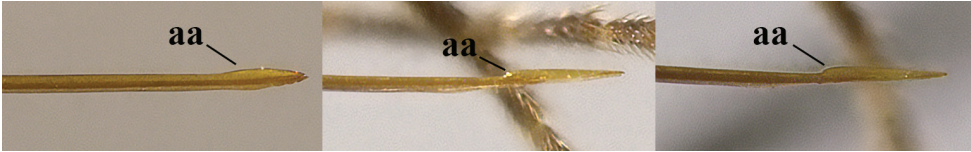
- Vein r issued between basal third and middle of pterostigma (aa); pterostigma usually slender (bb); [temple posteriorly setose; tarsal claws often very slender submedially; second–fourth tarsal segments with long spines apically; apex of hind tibia with distinct whitish comb at inner side, but rarely absent; vein m-cu of fore wing about half as long as vein 1-M] *Tanycarpa* Foerster, 1863



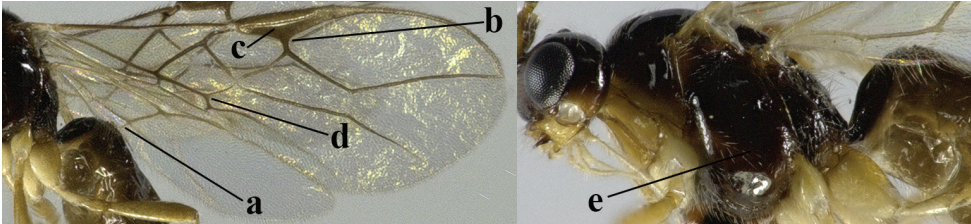
- 24 Upper valve of ovipositor flat dorsally in lateral view (a)
..... **subgenus *Anarcha* Foerster, 1863**



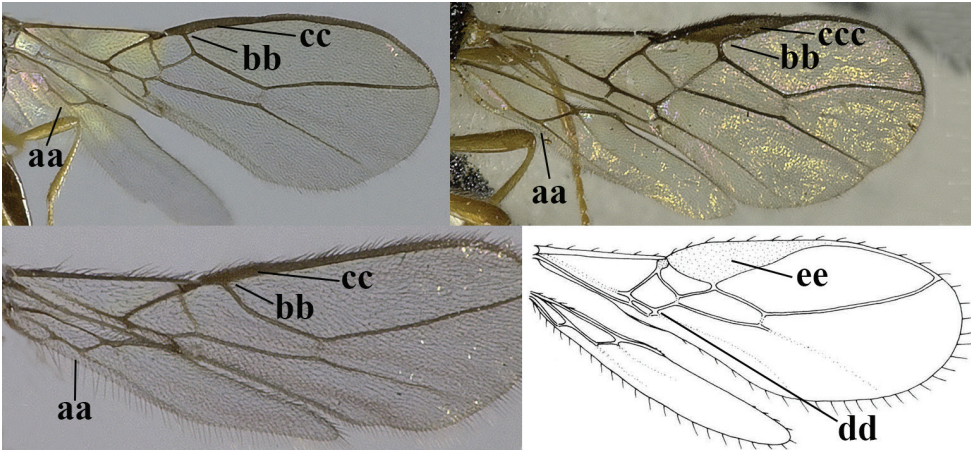
- Upper valve of ovipositor with dorsal convex area (aa), sometimes preceded by a notch..... **subgenus *Alysia* Latreille, 1804**



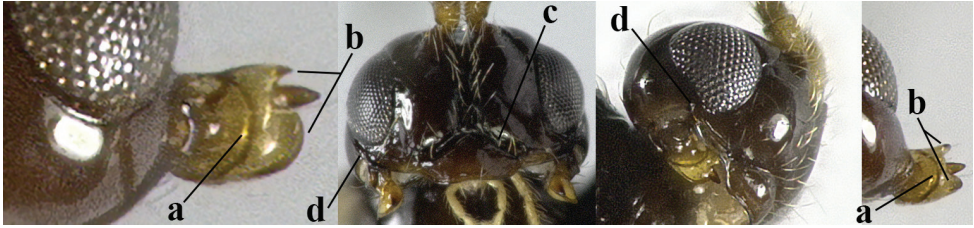
- 25 Vein m-cu of hind wing present (a); vein r of fore wing emerging submedially from elliptical part of pterostigma (b); pterostigma largely wide elliptical or narrow triangular (c); vein 3-CU1 of fore wing slender and longer than vein CU1b (d); [precoxal sulcus absent in typical spp. (e) and metasoma of ♀ compressed] ***Mesocrina* Foerster, 1863**



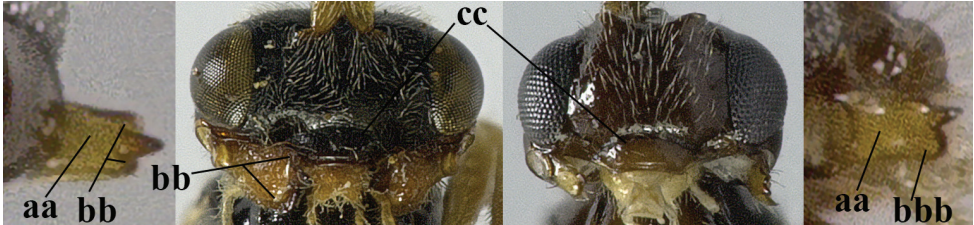
- Vein m-cu of hind wing absent (aa); vein r of fore wing emerging between base and middle of pterostigma (bb); pterostigma (sub)linear (cc) or narrow elliptical (ccc); **if** wide elliptical (ee) then vein 3-CU1 of fore wing widened and about as long as vein CU1b (dd) **26**



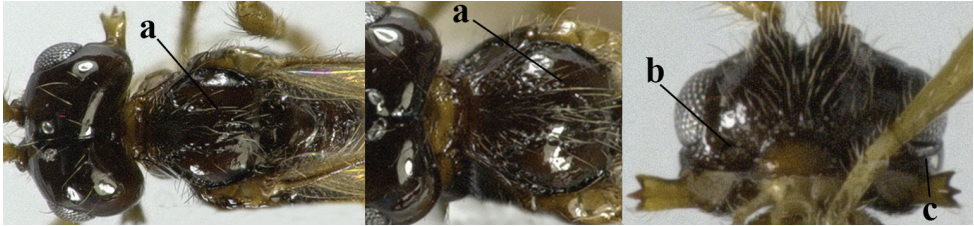
- 26 Mandible with a complete transverse curved carina or basal depression (a); third tooth of mandible wider than first [= dorsal] tooth (b); clypeus often wide (c); [malar suture subvertical or oblique (d); anterior tentorial pits remain far removed from eyes]..... *Orthostigma* Ratzeburg, 1844



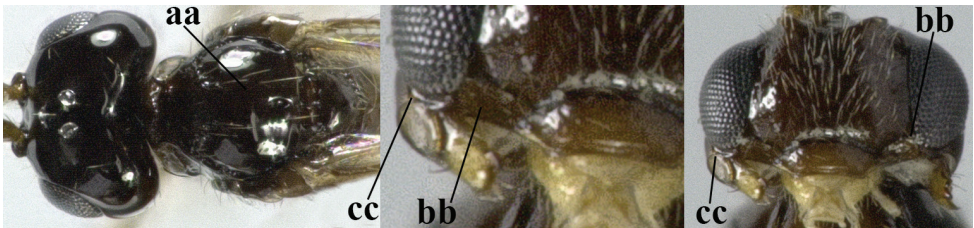
- Mandible at most with an oblique carina, without a complete transverse curved carina or depression (aa); third tooth of mandible often smaller or similar to first tooth (bb), but sometimes wider (bbb); clypeus narrower (cc) 27



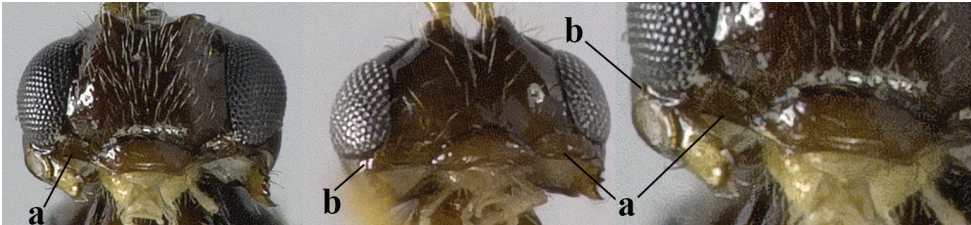
- 27 Notauli present posteriorly, complete (a); anterior tentorial pit enlarged (at least half as long as distance between clypeus and eye) and flat (b), combined with an oblique subocular depression (c)..... *Carinthilota* Fischer, 1975



- Notauli absent posteriorly, at most anterior half impressed (aa); anterior tentorial pit variable, **if** enlarged and flat (bb) then without an oblique subocular depression (cc) 28



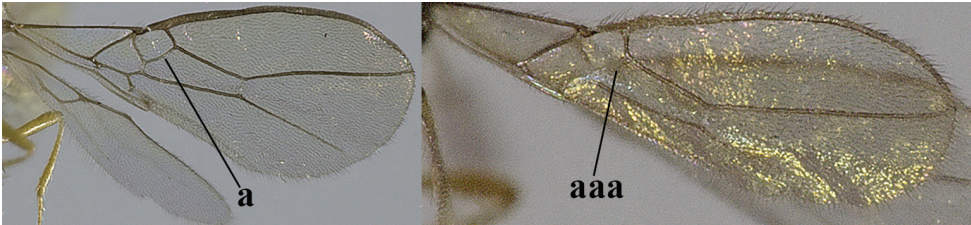
- 28 Anterior tentorial pits modified into a flat area up to eyes or nearly so and with curved outer border (a); malar suture smooth and subvertical (b), but rarely absent; *Aspilota* Foerster, 1863.....29



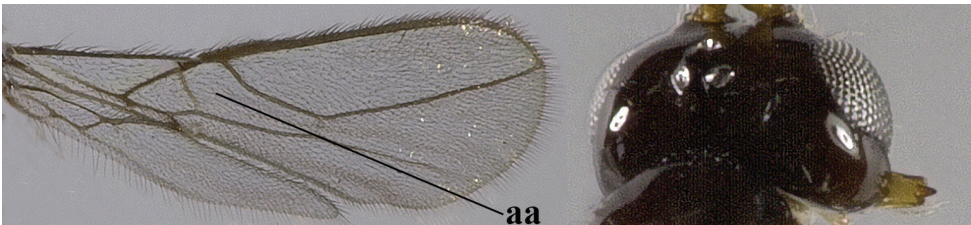
- Anterior tentorial pits concave, pit-shaped, and remaining removed from eyes (aa); malar suture (nearly) absent (bb) or with oblique subocular depression (bbb)30



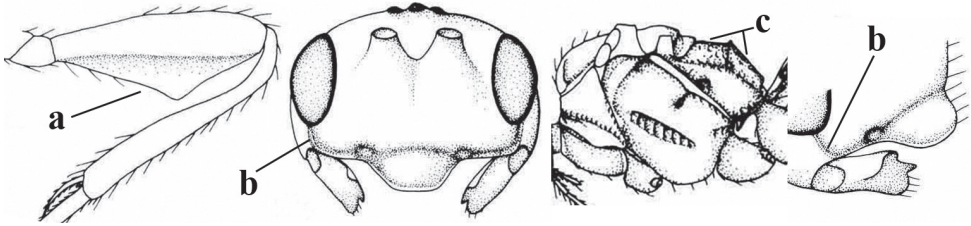
- 29 Vein 2-SR of fore wing present (a), but sometimes hardly sclerotized (aaa) ...
 subgenus *Aspilota* Foerster, 1863



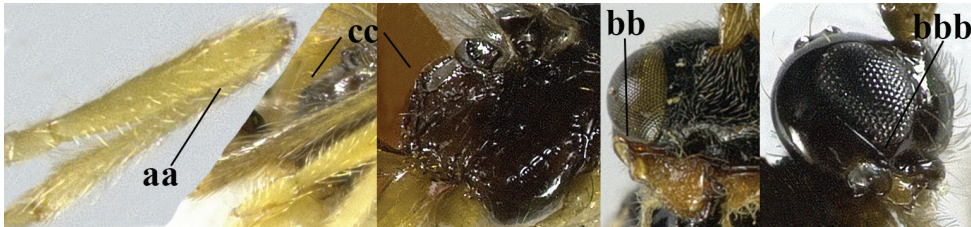
- Vein 2-SR of fore wing absent (aa).....
 subgenus *Eusynaldis* Zaykov & Fischer, 1982



- 30 Fore femur with large obtuse tooth (flange) ventrally (a) or with row of minute teeth; malar suture subvertical (b); anterior part of propodeum differentiated and nearly as long as posterior part (c).....***Leptotrema* van Achterberg, 1988**



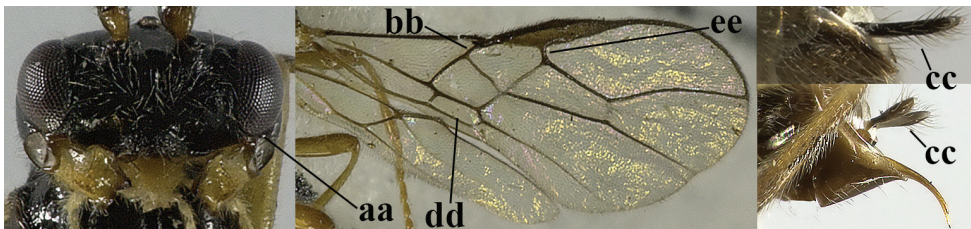
- Fore femur without ventral tooth or flange (aa); malar suture (nearly) absent (bb) or with long oblique subocular depression (bbb); anterior part of propodeum comparatively short or hardly differentiated (cc)31



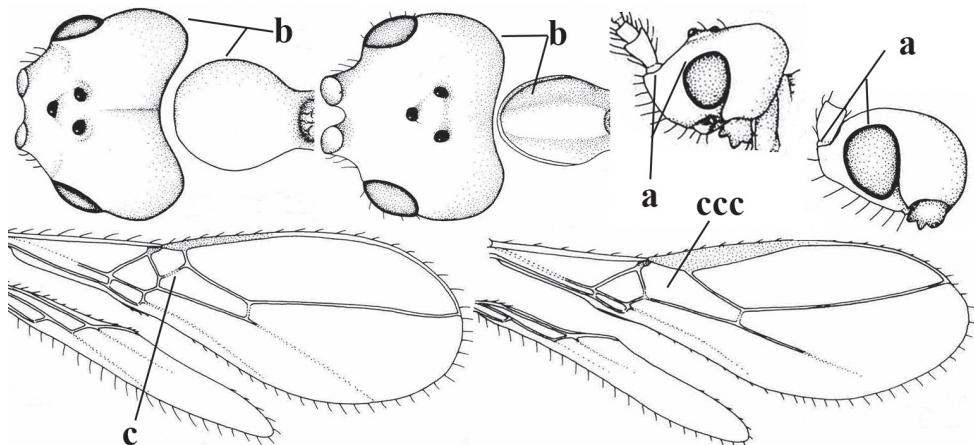
- 31 Between mandibular base and ventro-posterior margin of eye with an oblique subocular depression (a); **if** absent then vein 1-SR of fore wing almost absent, resulting in a (sub)sessile first discal cell (b); ovipositor sheath with few sub-apical setae (c); first subdiscal cell of fore wing often widened distally (d); vein r of fore wing emitted distinctly before middle of fore wing (e).....32



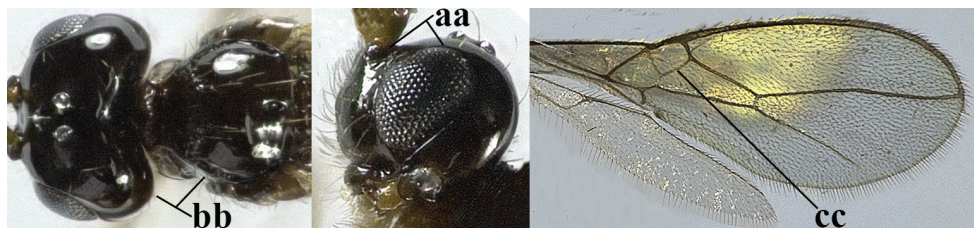
- Between mandibular base and ventro-posterior margin of eye convex or flat, without oblique depression (aa) **and** vein 1-SR of fore wing distinct, resulting in a petiolate first discal cell (bb); apical third of ovipositor sheath more evenly setose (cc); first subdiscal cell of fore wing parallel-sided or nearly so (dd); vein r of fore wing emitted near middle of fore wing (ee)34



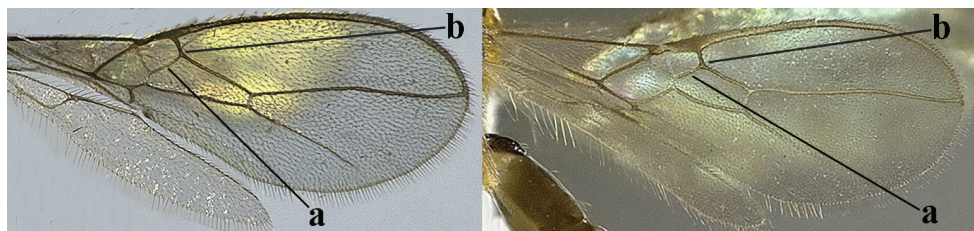
- 32 Antennal sockets near upper level of eye (a); maximum width of head in dorsal view 1.6–2.4 times width of mesoscutum (b); vein 2-SR of fore wing partly obsolescent (c) or completely absent (ccc); [oblique subocular depression usually present (d)] *Eudinostigma* Tobias, 1986



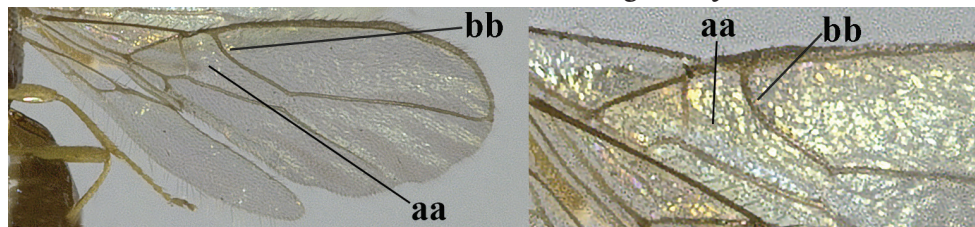
- Antennal sockets below upper level of eye (aa); maximum width of head in dorsal view 1.8 times width of mesoscutum or less (bb); vein 2-SR of fore wing usually present (cc); *Dinotrema* Foerster, 1863.....33



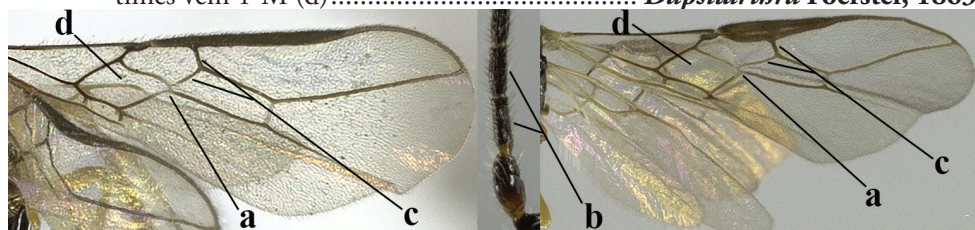
- 33 Vein 2-SR of fore wing present (a), if sometimes weakly sclerotised then vein r distinctly angled with vein 3-SR (b) subgenus *Dinotrema* Foerster, 1863



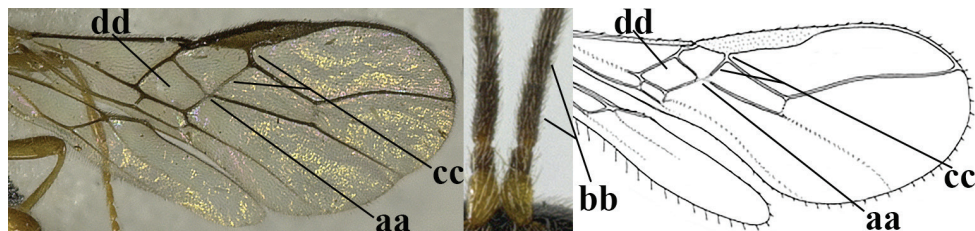
- Vein 2-SR of fore wing absent (aa); vein r gradually merging with vein 3-SR (bb) subgenus *Synaldis* Foerster, 1863



- 34 Vein m-cu of fore wing just postfurcal (a); third antennal segment 0.9–1.1 times as long as fourth segment (b); length of vein r of fore wing 0.4–0.6 times vein 2-SR (c); diagonal width of first discal cell of fore wing 1.8–1.9 times vein 1-M (d) *Dapsilarthra* Foerster, 1863



- Vein m-cu of fore wing just antefurcal (aa); third antennal segment 1.2–1.5 times as long as fourth segment in Palearctic spp. (bb); length of vein r of fore wing 0.2–0.3 times vein 2-SR (cc); diagonal width of first discal cell of fore wing often 1.4–1.6 times vein 1-M (dd) *Grammospila* Foerster, 1863



List of genera and species of Chinese Alysiini

Adeluroloa Strand, 1928

Adeluroloa Strand, 1928: 51 (nom. n. for *Adelura* Foerster, 1863); Shenefelt 1974: 986–987. Type species: *Alysia florimela* Haliday, 1838 (monobasic)

Synonym. *Adelura* Foerster, 1863, not Bonaparte, 1854; *Neocarpa* Fischer, 1966.

Biology. Small genus, containing parasitoids of Tephritidae and Anthomyiidae.

Species. *Adeluroloa florimela* Haliday, 1838.

Notes. *Adeluroloa euryis* Chen & Wu, 1994, belongs to *Grammospila* (comb. n.); it was transferred to *Dapsilarthra* Foerster by Peris-Filipo et al. (2016) because *Dapsilarthra* was used in a wider sense including *Grammospila* Foerster.

***Alloea* Haliday, 1833**

Alloea Haliday, 1833: 265; Shenefelt 1974: 939; Chen and Wu 1994: 20; Belokobylskij 1998: 287. Type species: *Alysia contracta* Haliday, 1833.

Synonym. *Diaspasta* Foerster, 1863; *Lamadatha* Cameron, 1900.

Biology. Small genus, containing parasitoids of Lonchopteridae.

Species. *Alloea ampla* Wharton & Chou, 1985; Chen and Wu 1994

Alloea artus Chen & Wu, 1994

Alloea lineata Wharton & Chou, 1985; Chen and Wu 1994

Alloea lonchopterae Fischer, 1966; Chen and Wu 1994

Alloea mesostenos Chen & Wu, 1994

Alloea sparsa Wharton & Chou, 1985; Chen and Wu 1994

Alloea striata Wharton & Chou, 1985; Chen and Wu 1994

***Alysia* Latreille, 1804**

Alysia Latreille, 1804: 173; Shenefelt 1974: 939; Wharton 1980a: 458; Chen and Wu 1994: 28; Belokobylskij 1998: 170. Type species: *Ichneumon manducator* Panzer, 1799.

Synonym. *Cechenus* Illiger, 1807; *Anarcha* Foerster, 1863 (subgenus); *Goniarcha* Foerster, 1863; *Strophaea* Foerster, 1863.

Biology. Large genus, containing parasitoids of Calliphoridae, Sarcophagidae, Tephritidae, Anthomyiidae, Agromyzidae and Mycetophylidae.

Notes. Typical species have vein m-cu of fore wing long (approx. 0.8 times 1-M) and 1-SR of fore wing linear with 1-M.

Species. *Alysia (Alysia) frigida* Haliday, 1838 (Chen and Wu 1994)

Alysia (Alysia) macrops Wharton, 1986 (Chen and Wu 1994)

Alysia (Alysia) manducator (Panzer, 1799) (Chen and Wu 1994)

Alysia (Anarcha) masneri Wharton, 1988 (Chen and Wu 1994)

Alysia (Alysia) nigratarsis Thomson, 1895 (Chen and Wu 1994)

***Aphaereta* Foerster, 1863**

Aphaereta Foerster, 1863: 264; Shenefelt 1974: 956; Wharton 1980: 74; Chen and Wu 1994: 37; Belokobylskij 1998: 273; van Achterberg 2012: 2. Type species: *Alysia cephalotes* Haliday, 1833.

Biology. Rather small genus containing parasitoids of Agromyzidae, Anthomyiidae, Aulacigastridae, Calliphoridae, Chloropidae, Coelopidae, Fannidae, Muscidae, Otidae, Sarcophagidae, Sciomyzidae, Tachinidae and Tephritidae.

Species. *Aphaereta major* (Thomson, 1895) (Chen and Wu 1994)

Aphaereta rubicunda Tobias, 1962 (Chen and Wu 1994)

Aphaereta scaptomyzae Fischer, 1966a (He and Chen 2004)

Aphaereta tricolor Papp, 1994 (He and Chen 2004)

Asobara Foerster, 1863

Asobara Foerster, 1863: 267; Shenefelt 1974: 964; Wharton 1980: 31; Chen and Wu 1994: 39; Belokobylskij 1998: 268; Wharton 2002: 28. Type species: *Alysia tabida* Nees von Esenbeck, 1834.

Synonym. *Spanista* Foerster, 1863.

Biology. Rather large genus, contains parasitoids of Drosophilidae and Sepsidae in decaying organic matter, especially fruits and leaves. The group with widened ovipositor sheath contains parasitoids of Tephritidae in fruits.

Species. *Asobara aurea* (Papp, 1967) (Papp 1967; Chou 1981; Chen and Wu 1994)

Asobara bactrocerae (Gahan, 1925) (Chen and Wu 1994)

Asobara elongata van Achterberg & Guerrieri, 2016 (Guerrieri et al. 2016)

Asobara formosae (Ashmead, 1906) (Fischer 1973a; Chou 1981; Ashmead 1906)

Asobara fungicola (Ashmead, 1894) (Chen and Wu 1994)

Asobara leveri (Nixon, 1939) (Chen and Wu 1994)

Asobara mesocauda van Achterberg & Guerrieri, 2016 (Guerrieri et al. 2016)

Asobara obliqua (Papp, 1969) (Chen and Wu 1994)

Asobara pleuralis (Ashmead, 1905) (Papp 1967; Guerrieri et al. 2016)

Asobara triangulata van Achterberg & Guerrieri, 2016 (Guerrieri et al. 2016)

Asobara tabida (Nees, 1834) (Chen and Wu 1994)

Asobara tabidula (Tobias, 1962) (Chen and Wu 1994)

Asobara unicolorata van Achterberg & Guerrieri, 2016 (Guerrieri et al. 2016)

Aspilota Foerster, 1863 s. s.

Aspilota Foerster, 1863: 268; Shenefelt 1974: 966; Wharton 1980: 84; van Achterberg 1988b: 9; Chen and Wu 1994: 49; Belokobylskij 1998: 218; Wharton 2002: 34. Type species: *Alysia ruficornis* Nees von Esenbeck, 1834 (monobasic).

Synonym. *Dipiesta* Foerster, 1863; *Eusynaldis* Zaykov & Fischer, 1982 (retained as subgenus with *Regetus* Papp, 1999 (syn. n.) and *Adelphenaldis* Fischer, 2003 (syn. n.) and *Synaldis* auctt. p.p. as synonyms).

Biology. Large genus, containing parasitoids of Phoridae and Platypezidae (in mushrooms). The host records of Anthomyiidae and Drosophilidae are probably erroneous.

Species. *Aspilota (Eusynaldis) acutidentata* (Fischer, 1970a) (Chen and Wu 1994)
Aspilota (Aspilota) elongata Chen & Wu, 1994 (Chen and Wu 1994)
Aspilota (Eusynaldis) globipes (Fischer, 1962) (Chen and Wu 1994)
Aspilota (Aspilota) intermedia Fischer, 1975 (Chen and Wu 1994)
Aspilota (Aspilota) louiseae van Achterberg, 1988 (Chen and Wu 1994)
Aspilota (Aspilota) nasica Belokobylskij, 2005 (Belokobylskij 2005; Belokobylskij and Tobias 2007)
Aspilota (Eusynaldis) parvicornis (Thomson, 1895) (Chen and Wu 1994)
Aspilota (Aspilota) schrenki Belokobylskij, 2007 (Belokobylskij and Tobias 2007)
Aspilota (Aspilota) tianmushanica Belokobylskij, 2005 (Belokobylskij 2005; Belokobylskij and Tobias 2007)
Aspilota (Aspilota) xuexini Belokobylskij, 2007 (Belokobylskij and Tobias 2007)

Notes. The genera *Regetus* Papp and *Adelphenaldis* Fischer share with *Eusynaldis* Zaykov & Fischer the derived character of the reduced vein 1-SR+M of the fore wing. The only difference between *Eusynaldis* and both other taxa is the shortened vein r-m of fore wing, a feature often variable within species of *Aspilota* Foerster and not suitable for separation of genera; the same applies to the enlarged propodeal spiracle of *Regetus* Papp. *Eusynaldis* Zaykov & Fischer is recognised as subgenus for convenience, because the recognition as genus likely renders the genus *Aspilota* Foerster paraphyletic, and the loss of vein 1-SR+M occurred probably more than once in the genus.

***Carinthilota* Fischer, 1975**

Carinthilota Fischer, 1975: 311; van Achterberg 1988b: 17; Chen and Wu 1994: 59; Belokobylskij 1998: 221. Type species: *Carinthilota parapsidalis* Fischer, 1975.

Biology. Unknown, but related genera have been reared from Phoridae and Platypezidae.

Species. *Carinthilota parapsidalis* Fischer, 1975 (Chen and Wu 1994)

***Cratospila* Foerster, 1863**

Cratospila Foerster, 1863: 265; Shenefelt 1974: 985; Wharton 1980: 84; Tobias 1990; Belokobylskij 1998: 287; Yao 2016: 1. Type species: *Alysia circe* Haliday, 1838.

Synonym. *Hedylus* Marshall, 1894 (not Foerster 1868).

Biology. Rather small genus, of which the biology is unknown.

Species. *Cratospila circe* (Haliday, 1838) (Wu and Chen 1995a)

***Dacnulysia* Zhu, van Achterberg & Chen, 2017**

Dacnulysia Zhu, van Achterberg & Chen, 2017: 361.

Biology. Unknown.

Species. *Dacnulysia chaenomastax* Zhu, van Achterberg & Chen, 2017

***Dapsilarthra* Foerster, 1863**

Dapsilarthra Foerster, 1863: 267. Shenefelt 1974: 986–991; Marsh 1979: 222; Wharton 1980: 37–38; van Achterberg 1983a: 6–14; Chen and Wu 1994: 61; Belokobylskij 1998: 208–209. Type species: *Alysia apii* Curtis, 1826 (monobasic).

Biology. Small genus, containing parasitoids of Agromyzidae.

Species. *Dapsilarthra apii* (Curtis, 1826) (Chen and Wu 1994)

Dapsilarthra sylvia (Haliday, 1839) (Chen and Wu 1994)

***Dinotrema* Foerster, 1863**

Dinotrema Foerster, 1863: 268; Shenefelt 1974: 966; Wharton 1980: 84; van Achterberg and Bin 1981: 104; Chen and Wu 1994: 69; Wharton 2002: 56; Tobias 2003: 138. Type species: *Dinotrema erythroga* Foerster, 1863 (monobasic).

Synonym. *Spanomeris* Foerster, 1863; *Coloboma* Foerster, 1863; *Prosapha* Foerster, 1863; *Synaldis* Foerster, 1863 (subgenus); *Synaldotrema* Belokobylskij & Tobias, 2007 (subgenus); *Aspilota* auctt. p. p.

Biology. Very large genus, containing parasitoids of Phoridae.

Species. *Dinotrema (Dinotrema) amoenidens* (Fischer, 1973b) (Chen and Wu 1994)

Dinotrema (Dinotrema) cato Tobias, 2007 (Belokobylskij and Tobias 2007)

Dinotrema (Dinotrema) conjunctum Tobias, 2007 (Belokobylskij and Tobias 2007)

Dinotrema (Synaldis) distractum (Nees, 1834) (Chen and Wu 1994)

Dinotrema (Dinotrema) hodisense (Fischer, 1976) (Chen and Wu 1994)

Dinotrema (Dinotrema) kempei (Hedqvist, 1973) (Chen and Wu 1994)

Dinotrema (Dinotrema) longus (Wu & Chen, 1998) (Wu and Chen 1998a)

Dinotrema (Synaldis) mandibulatum (Fischer, 1970) (Chen and Wu 1994)

Dinotrema (Dinotrema) mesocaudatum van Achterberg, 1988 (Chen and Wu 1994)

Dinotrema (Dinotrema) monstrconnexum Tobias, 2007 (Belokobylskij and Tobias 2007)

Dinotrema (Dinotrema) multiarticulatum van Achterberg, 1988 (Chen and Wu 1994)

Dinotrema (Dinotrema) nitidula (Masi, 1933) (Chen and Wu 1994)

Dinotrema (Dinotrema) occipitale (Fischer, 1973) (Chen and Wu 1994)

Dinotrema (Dinotrema) pratense van Achterberg, 1988 (Chen and Wu 1994)

Dinotrema (Dinotrema) pulvinatum (Stelfox & Graham, 1949) (Chen and Wu 1994)

Dinotrema (Dinotrema) tauricum (Telenga, 1935) (Chen and Wu 1994)

Dinotrema (Dinotrema) tuberculatum van Achterberg, 1988 (Chen and Wu 1994)

Notes. A diverse genus including several spp. without oblique subocular depression for which the names *Prosapha* Foerster, 1863, *Panerema* Foerster, 1863, and *Pterusa* Fischer, 1958, are available. An extensive worldwide phylogenetic study of the genus *Dinotrema* is necessary before a well-based decision can be made on a possible recognition as subgenus or genus. *Synaldis* Foerster is recognised as subgenus for convenience, because the recognition as genus likely renders the genus *Dinotrema* Foerster paraphyletic, and the loss of vein 1-SR+M occurred probably more than once in the genus.

***Eudinostigma* Tobias, 1986**

Eudinostigma Tobias, 1986: 244; Chen and Wu 1994: 78; Belokobylskij 1998: 219.

Type species: *Eudinostigma fischeri* Tobias, 1986.

Synonym. According to Wharton (2002) a synonym of *Dinotrema* Foerster, 1863.

Biology. Small genus, of which the biology is unknown, but related species are parasitoids of Phoridae.

Species. *Eudinostigma alox* van Achterberg, 1988 (Chen and Wu 1994)

Eudinostigma latistigma (Fischer, 1962) (Wu and Chen 1998b)

Eudinostigma latus Chen & Wu, 1994. (Chen and Wu 1994)

***Grammospila* Foerster, 1863**

Grammospila Foerster, 1863: 269; Shenefelt 1974: 987; van Achterberg 1983a: 7. Type species: *Alysia isabella* Haliday, 1838 (monobasic).

Synonym. *Paraorthostigma* Königsman, 1972.

Biology. Small genus, containing parasitoids of Agromyzidae and Scathophagidae.

Species. *Grammospila eurys* (Chen & Wu, 1994), comb. n.

Grammospila isabella (Haliday, 1838) (Chen and Wu 1994)

Grammospila rufiventris (Nees, 1812) (Chen and Wu 1994)

Notes. *Grammospila eurys* (Chen & Wu, 1994), comb. n. has the third antennal segment 1.4–1.5 times as long as fourth segment; vein m-cu of fore wing antefurcal (not postfurcal as mentioned in original (Chinese) description); body with many long setae (includ-

ing mesoscutum); vein r of fore wing widened, hardly longer than wide; base of pterostigma slender and posteriorly concave and pterostigma up to level of vein r-m of fore wing.

***Heratemis* Walker, 1860**

Heratemis Walker, 1860: 310; Fischer 1966b: 177; Shenefelt 1974: 992; Chen and Wu 1994: 82; Belokobylskij 1998: 268; Wharton 2002: 75; Yaakop et al. 2009: 1. Type species: *Heratemis filosa* Walker, 1860 (monobasic).

Synonym. *Conalysia* Papp, 1969 (subgenus); *Kritscherysia* Fischer, 1993 (subgenus).

Biology. Medium-sized genus, of which the biology is unknown, possibly parasitoids of Tephritidae.

Species. *Heratemis (Conalysia) devriesi* van Achterberg & Yaakop, 2009 (Yaakop et al. 2009)

Heratemis (Kritscherysia) enodis Wu & Chen, 1994 (Chen and Wu 1994)

Heratemis (Heratemis) filosa Walker, 1860 (Chen and Wu 1994; Yaakop et al. 2009)

Heratemis (Conalysia) laticeps (Papp, 1969) (Chen and Wu 1994; Yaakop et al. 2009)

Heratemis (Conalysia) ustulata Wu & Chen, 1996 (Wu and Chen 1996)

Notes. Morphologically *Heratemis* spp. are very similar to species of the subgenus *Neophaenocarpa* Belokobylskij of the genus *Phaenocarpa* Foerster. The presence of the postpectal carina and the posteriorly steep scutellum of *Heratemis* allow a clear separation.

***Heterolexis* Foerster, 1863**

Heterolexis Foerster, 1863: 268; Shenefelt 1974: 992; van Achterberg 1983a: 7. Type species: *Heterolexis subtilis* Foerster, 1863.

Biology. Small genus, containing parasitoids of Agromyzidae and Anthomyiidae.

Species. *Heterolexis subtilis* Foerster, 1863 (Chen and Wu 1994)

***Hylcalosia* Fischer, 1967**

Hylcalosia Fischer, 1967: 125; Shenefelt 1974: 993; Chen and Wu 1994: 85; Belokobylskij 1998: 297; Zheng et al. 2012: 454. Type species: *Holcalysia testaceipes* Cameron, 1910.

Synonym. *Holcalysia* Cameron, 1910, not Cameron 1905.

Biology. Small genus, of which the biology is unknown.

Species. *Hylcalosia complexa* Chen & Wu, 1994 (Chen and Wu 1994; Zheng et al. 2012)

Hylcalosia ventisulcata Zheng, Chen & Yang, 2012 (Zheng et al. 2012)

***Idiasta* Foerster, 1863**

Idiasta Foerster, 1863, 265; Shenefelt 1974: 993; Chen and Wu 1994: 87; Belokobylskij 1998: 277. Type species: *Alysia maritima* Haliday, 1838.

Synonym. *Euphaenocarpa* Tobias, 1975.

Biology. Medium-sized genus, containing parasitoids of Muscidae.

Species. *Idiasta annulicornis* (Thomson, 1895) (Chen and Wu 1994)

Idiasta brevicauda Telenga, 1935 (Chen and Wu 1994)

Idiasta dichrocera Königsmann, 1960 (Chen and Wu 1994)

Idiasta paramaritima Königsmann, 1960 (Chen and Wu 1994)

Idiasta picticornis (Ruthe, 1854) (Chen and Wu 1994)

Idiasta subannellata (Thomson, 1895) (Chen and Wu 1994)

***Leptotrema* van Achterberg, 1988**

Leptotrema van Achterberg, 1988a: 42; Chen and Wu 1994: 94; Belokobylskij 1998: 219. Type species: *Aspilota dentifemur* Stelfox, 1943.

Synonym. According to Wharton (2002) this is a synonym of *Dinotrema* Foerster, 1863. However, the vertical malar suture excludes it from *Dinotrema* Foerster. A future DNA-analysis is needed to find its position within the *Aspilota*-group.

Biology. Small genus of which the biology is unknown, but belongs to the *Aspilota*-group containing parasitoids of Phoridae.

Species. *Leptotrema dentifemur* (Stelfox, 1943) (Chen and Wu 1994)

***Mesocrina* Foerster, 1863**

Mesocrina Foerster, 1863: 266; Shenefelt 1974: 996; Chen and Wu 1994: 95; Belokobylskij 1998: 191. Type species: *Mesocrina indagatrix* Foerster, 1863.

Synonym. *Pseudomesocrina* Königsmann, 1959.

Biology. Small genus, containing parasitoids of Anthomyiidae and Scathophagidae, the type species is associated with hosts in mushrooms.

Species. *Mesocrina dalhousiensis* (Sharma, 1978) (Chen and Wu 1994)

Mesocrina indagatrix Foerster, 1863 (Chen and Wu 1994)

Mesocrina lichō Belokobylskij, 1998 (new to China)

***Mesocrina lichō* Belokobylskij, 1998**

Figs 1–14

Material. ♀ (ZJUH), “[N. China:], Hebei, Mt. Xioawutai, 23.viii.2005, Shi Min, No. 200608887”; 2 ♂♂ (ZJUH), id., but Zhang Hongying, No. 200609036, 200609050; 2 ♂♂ (ZJUH), id., but 21.viii.2005, Zhang Hongying, 200608013, 200608045.

Description of ♀ from Mt. Xioawutai. Length of body 3.9 mm, of fore wing 4.6 mm.

Head. Transverse and shiny (Fig. 9), width of head twice its lateral length; antenna incomplete, with 23 remaining segments, segments with bristly setae, third segment 1.4 times longer than fourth segment, length of third and fourth segments 5.0 and 3.8 times their width, respectively (Fig. 7); length of maxillary palp twice height of head; eye in dorsal view 1.4 times as long as temple (Fig. 9); eye in lateral view 1.4 times higher than wide; vertex convex and glabrous (Fig. 11); OOL:diameter of ocellus:POL = 9:5:5; face 1.7 times wider than high, smooth and shiny (Fig. 10), with some long setae next to eye; clypeus medium-sized, rather flat, truncate and slightly convex laterally (Fig. 10); malar space absent; mandible moderately widened dorsally, dorsal teeth large and lobe-shaped (Fig. 12), lateral teeth rather small and lobe-shaped (Fig. 13), middle tooth curved and acute; medial length of mandible 1.5 times its maximum width (Fig. 13).

Mesosoma. Length of mesosoma 1.3 times its height; mesoscutum without lateral carina in front of tegula (Fig. 3); precoxal sulcus absent; mesopleuron smooth and glabrous; pleural sulcus crenulate; episternal scrobe small, connected by a furrow to pleural sulcus; metapleuron smooth except some ventral rugae, with long setae and a round large pit anteriorly (Fig. 3); notauli only anteriorly impressed on disc, narrowly crenulate and medio-posteriorly with deep longitudinal depression; mesoscutum with some setae anteriorly and near notauli; scutellar sulcus deep and narrow, with 4 short longitudinal carinae and 6 times wider than its maximum length; scutellum rather flat and wide (Fig. 4); surface of propodeum with rather long median carina, without areola absent and with some rugae anteriorly (Fig. 5).

Wings (Fig. 2). Pterostigma largely wide elliptical, vein r 0.5 times width of pterostigma; r:3-SR:SR1 = 5:33:67; SR1, 1-SR+M nearly straight and 2-SR slightly curved; cu-a postfurcal, short; 1-CU1:2-CU1 = 2:17; 3-CU1 longer than CU1b; 2-SR:3-SR:r-m = 19:25:8; m-cu postfurcal, slightly converging to 1-M posteriorly; first subdiscal cell 3.3 times as long as wide; M+CU1 largely unsclerotized. Hind wing: M+CU: 1-M:1r-m = 25:23:20; m-cu present.

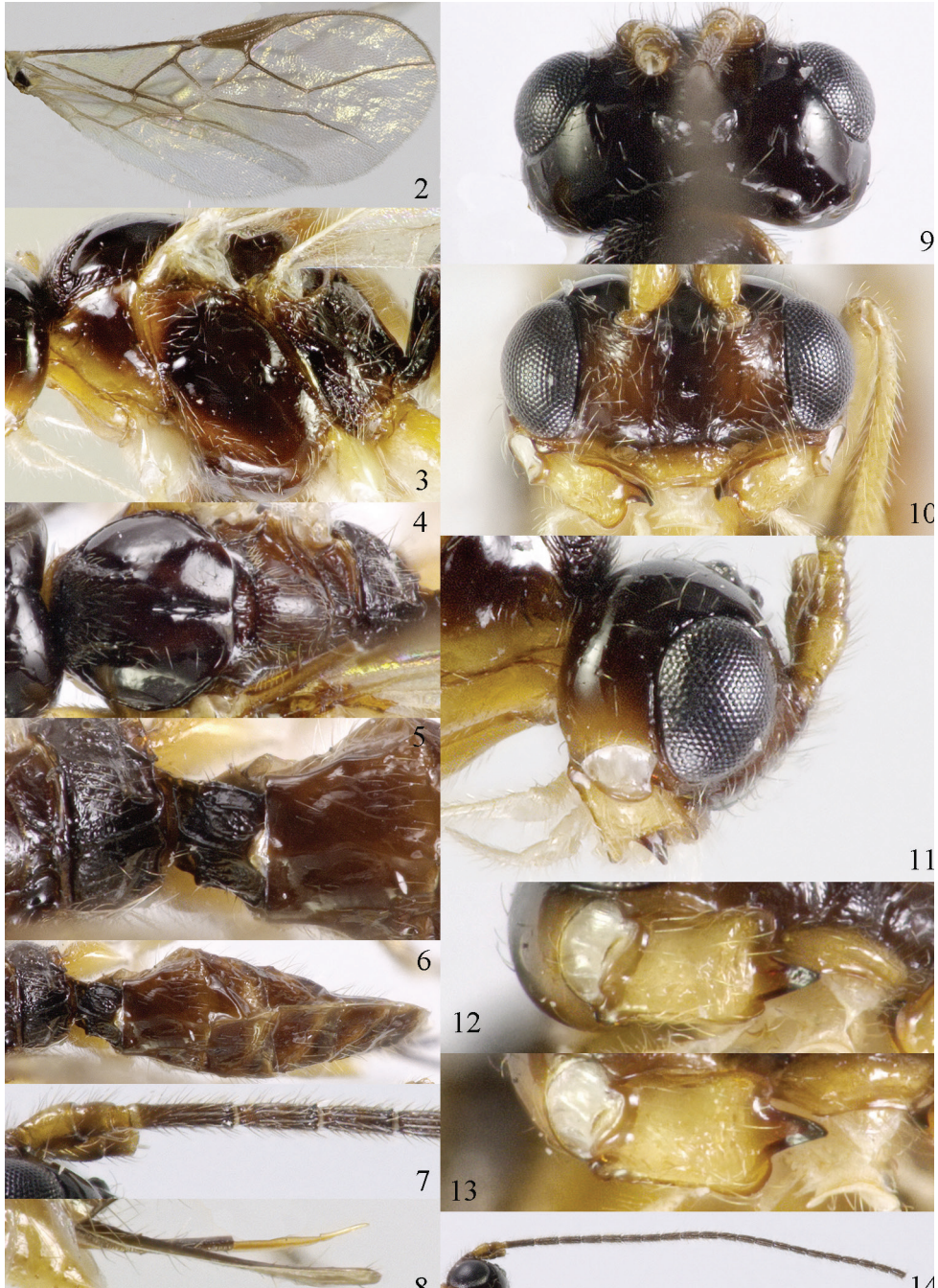


Figure 1. *Mesocrina lichō* Belokobylskij, ♀, China, Mt. Xiaoawutai, habitus lateral.

Legs. Hind coxa smooth; tarsal claws rather robust and longer than arolium (Fig. 1); length of femur, tibia and basitarsus of hind leg 4.3, 10.0 and 6.7 times their width, respectively; apical spiny bristles of first-fourth hind tarsal segments absent (Fig. 1).

Metasoma. Length of first tergite 1.3 times its apical width, its surface with longitudinal striae, its dorsal carinae narrowly connected (Fig. 5); laterope absent; dorsope rather large (Fig. 6); setose part of ovipositor sheath 0.18 times as long as fore wing (total visible sheath 0.19 times), flattened and sparsely setose and 0.6 times as long as hind tibia (Fig. 8).

Colour. Blackish brown (Fig. 1); pronotum ventrally, mandible, tegula, two basal segments of antenna, palpi mainly pale and remainder of legs yellowish; antenna (ex-



Figures 2–14. *Mesocrina licho* Belokobylskij, ♀, China, Mt. Xioawutai. **2** wings **3** mesosoma lateral **4** mesosoma dorsal **5** propodeum, first and second metasomal tergites dorsal **6** propodeum and metasoma dorsal **7** basal segments of antenna lateral **8** ovipositor and sheath lateral **9** head dorsal **10** head anterior **11** head lateral **12** full view of first and second tooth of mandible **13** full view of third tooth of mandible **14** antenna lateral.

cept two basal segments of antenna), head (except ventrally), mesosoma, dorsal spot of hind femur, hind tibia (except basally) and basitarsus, and first tergite of metasoma blackish brown; head ventrally, mesopleuron ventrally and remainder of metasoma brown; pterostigma and veins brown; wing membrane slightly infuscated.

Variation. Males are similar to females, but have 35(1) antennal segments (according to the original description females have 31 or 32 segments); body length of ♂: 3.7–4.2 mm, length of fore wing 4.1–4.7 mm, width of head 1.9–2.0 times its lateral length.

***Orthostigma* Ratzeburg, 1844**

Orthostigma Ratzeburg, 1844: 53; Shenefelt 1974: 997; Wharton 1980: 85; van Achterberg 1988b: 44; Chen and Wu 1994: 99; Belokobylskij 1998: 209. Type species: *Aphidius flavipes* Ratzeburg, 1844.

Synonym. *Delocarpa* Foerster, 1863; *Ischnocarpa* Foerster, 1863; *Afrostitigma* Fischer, 1995 (subgenus); *Patrisaspilota* Fischer, 1995 (subgenus).

Biology. Medium-sized genus, containing parasitoids of Phoridae. The records of Agromyzidae, Cecidomyiidae, and Drosophilidae are probably erroneous.

Species. *Orthostigma cratospilum* (Thomson, 1895) (Chen and Wu 1994)
Orthostigma imperator van Achterberg & Ortega, 1983 (Chen and Wu 1994)
Orthostigma laticeps (Thomson, 1895) (Chen and Wu 1994)
Orthostigma lokei Hedqvist, 1973 (Chen and Wu 1994)
Orthostigma longicorne Königsmann, 1969 (Chen and Wu 1994)
Orthostigma longicubitale Königsmann, 1969 (Chen and Wu 1994)
Orthostigma lucidum Königsmann, 1969 (Chen and Wu 1994)
Orthostigma mandibulare (Tobias, 1962) (Chen and Wu 1994)
Orthostigma pumilum (Nees, 1834) (Chen and Wu 1994)
Orthostigma pusillum (Zetterstedt, 1838) (Chen and Wu 1994)
Orthostigma sculpturatum Tobias, 1962 (Chen and Wu 1994)
Orthostigma sibiricum (Telenga, 1933) (Chen and Wu 1994)
Orthostigma sordipes (Thomson, 1895) (Chen and Wu 1994)

***Phaenocarpa* Foerster, 1863**

Phaenocarpa Foerster, 1863: 267; Papp, 1968: 570; Fischer, 1970b: 409; Shenefelt, 1974: 1003; Wharton, 1980: 96; Chen & Wu, 1994: 114; Belokobylskij, 1998: 233. Type species: *Alysia picinervis* Haliday, 1838.

Synonym. *Homophyla* Foerster, 1863 (subgenus); *Mesothesis* Foerster, 1863; *Sathra* Foerster, 1863; *Idiolexis* Foerster, 1863 (subgenus); *Asynaphes* Provancher, 1886; *Kahlia* Ashmead, 1900 (subgenus); *Stiralysia* Cameron, 1910; *Rhopaloneura* Stelfox, 1941;

Discphaenocarpa Belokobylskij, 1998 (subgenus); *Neophaenocarpa* Belokobylskij, 1998 (subgenus); *Sibphaenocarpa* Belokobylskij, 1998 (subgenus); *Uncphaenocarpa* Belokobylskij, 1998 (subgenus); *Ussurphaenocarpa* Belokobylskij, 1998 (subgenus); *Clistalsia* Zhu, van Achterberg & Chen, 2017 (subgenus).

Biology. Large genus, containing koinobiont endoparasitoids of larvae of cyclorhaphous Diptera in many niches. Known from larvae of Sciomyzidae in Mollusca, of Syrphidae under bark or between leaves of marsh plants, of Anthomyiidae in roots of vegetables, under bark, in cones of conifers, mining in leaves or in dung, of Muscidae and Scathophagidae in dung, of Muscidae and Clusiidae in flood refuse and of Chloropidae and Scathophagidae in grasses and Drosophilidae in crops (e.g. cotton) and slime (Wharton, 1984; van Achterberg, 1998).

Species. *Phaenocarpa* (*Phaenocarpa*) *cameroni* Papp, 1967 (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *carinthiaca* Fischer, 1975 (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *conspurator* (Haliday, 1838) (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *diffusa* Chen & Wu, 1994 (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *eunice* (Haliday, 1838) (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *galatea* (Haliday, 1838) (Wu and Chen 1995b)
Phaenocarpa (*Phaenocarpa*) *impressinotum* Fischer, 1975 (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *ingressor* Marshall, 1896 (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *intermedia* Tobias, 1962 (Wu and Chen 1995b)
Phaenocarpa (*Phaenocarpa*) *laticellula* Papp, 1968 (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *lissogastra* Tobias, 1986 (Belokobylskij 1998)
Phaenocarpa (*Phaenocarpa*) *notabilis* Stelfox, 1944 (Chen and Wu 1994)
Phaenocarpa (*Clistalsia*) *platychora* Zhu, van Achterberg & Chen, 2017
Phaenocarpa (*Phaenocarpa*) *pratellae* (Curtis, 1826) (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *riphaeica* Tobias, 1986 (Wu and Chen 1995b)
Phaenocarpa (*Phaenocarpa*) *ruficeps* (Nees, 1812) (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *seitneri* Fahringer, 1929 (Chen and Wu 1994)
Phaenocarpa (*Phaenocarpa*) *vitata* Chen & Wu, 1994 (Chen and Wu 1994)

Notes. Some species (e.g., *P. stackelbergi* Tobias & Gurasashvili, 1985) are superficially similar to *Idiasta* Foerster, because the ♀ antenna has a white band and the metanotum has an acute tooth in lateral view.

***Separatatus* Chen & Wu, 1994**

Separatatus Chen & Wu, 1994: 132. Type species: *Separatatus carinatus* Chen & Wu, 1994.

Synonym. *Phasmidiasta* sensu Fischer, 2006, not Wharton 1980; *Hovalysia* sensu Wharton, 2002 (p. p.); *Bobekoides* auct. p. p.

Biology. Small genus, of which the biology is unknown.

Species. *Separatatus carinatus* Chen & Wu, 1994

Separatatus sinicus (Zheng, Chen & Yang, 2012), comb. n.

Separatatus parallelus sp. n.



Figure 15. *Separatatus parallelus* sp. n., ♀, holotype, habitus lateral.

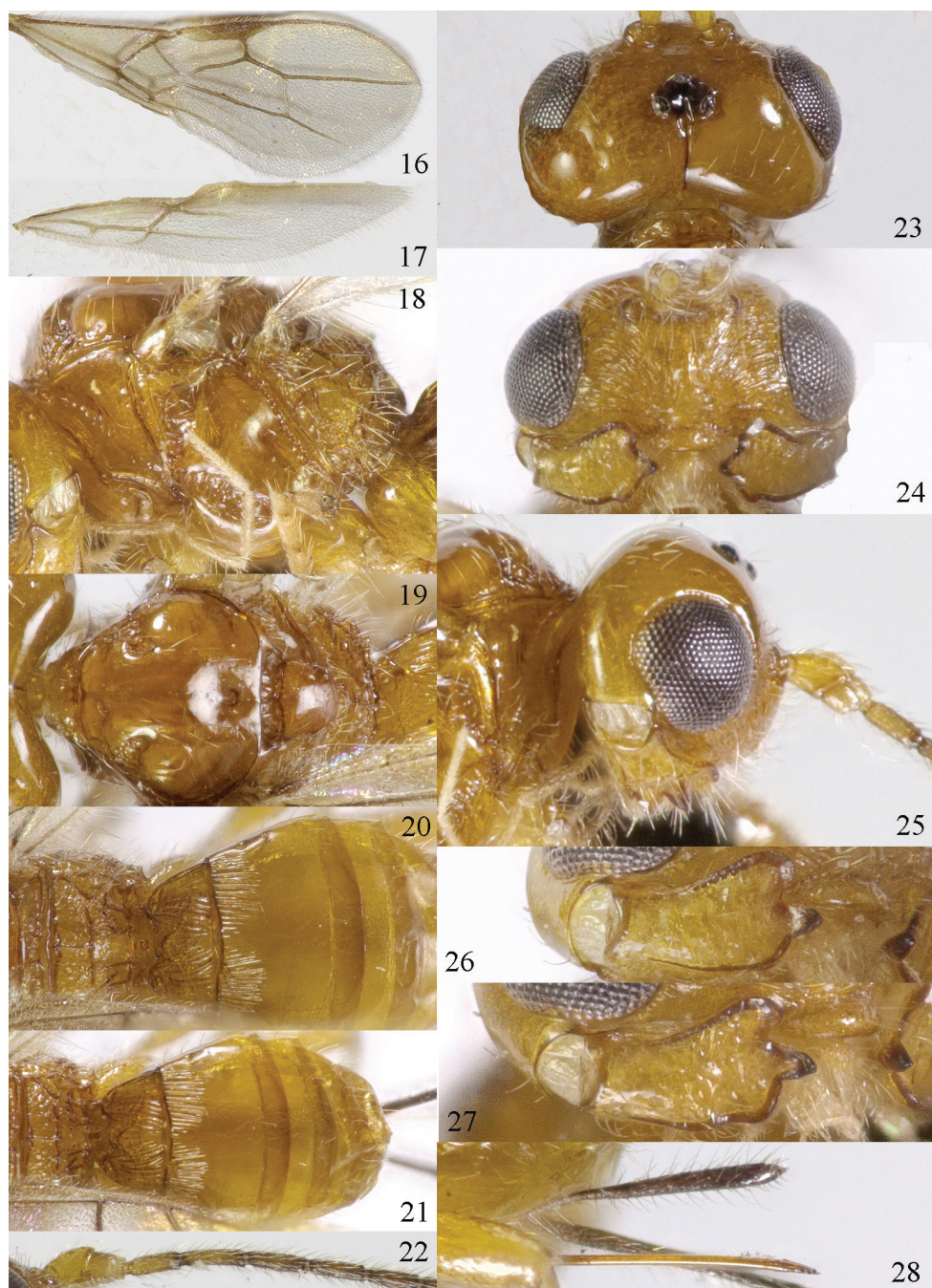
***Separatatus parallelus* sp. n.**

<http://zoobank.org/CB7FCC77-14F8-4080-8899-D23DA5A76D4E>

Figs 15–28

Material. Holotype, ♀ (ZJUH), “[S. China:], Yunnan, green water nuclear power station, 536 m, 23.vii.2003, Xu Zaifu, No. 20055387”. Paratype: 1 ♂ (ZJUH), “Hainan, Yinggeling, 283.v.2007, Weng Liqiong, No. 200804310”.

Description. Holotype, ♀, length of body 2.5 mm, of fore wing 2.6 mm.



Figures 16–28. *Separatatus parallelus* sp. n., ♀, holotype, **16** fore wing **17** hind wing **18**, mesosoma lateral **19** mesosoma dorsal **20** propodeum, first and second metasomal tergites dorsal **21** propodeum and metasoma lateral **22** basal segments of antenna **23** head dorsal **24**, head anterior **25** head lateral **26** mandible full view of first and second tooth mandible **27** mandible full view of third tooth **28** ovipositor and sheath lateral.

Head. Transverse and shiny, concave posteriorly (Fig. 23), width of head 1.8 times its lateral length; antenna incomplete, with 21 remaining segments, segments with bristly setae, third segment 0.7 times longer than fourth segment, length of third and fourth segments 2.5 and 4.7 times their width, respectively (Fig. 22); length of maxillary palp 1.4 times height of head; eye in dorsal view 2.1 times as long as temple (Fig. 23); eye in lateral view nearly as high as wide; vertex convex and glabrous (Fig. 25); OOL:diameter of ocellus:POL= 14:3:5; face 1.8 times wider than high, largely rugose (Fig. 24); clypeus rather small, truncate and slightly convex laterally (Fig. 24); malar space absent; mandible moderately widened dorsally, dorsal teeth large and lobe-shaped (Fig. 26), lateral teeth rather small and lobe-shaped (Fig. 27), middle tooth curved; medial length of mandible 1.6 times its maximum width (Fig. 27).

Mesosoma. Length of mesosoma 1.4 times its height; mesoscutum without lateral carina in front of tegula (Fig. 18); epicnemial area smooth except for a few crenulae; precoxal sulcus wide, with distinct crenulae medially, but anteriorly and posteriorly absent; remainder of mesopleuron smooth and glabrous; pleural sulcus narrowly crenulate; episternal scrobe small, connected by a furrow to pleural sulcus; metapleuron reticulate-rugose but smooth medially, with long setae and a round large pit anteriorly (Fig. 18); notauli wide, only anteriorly impressed on disc, widely crenulate and medio-posteriorly with a shallow, round depression; mesoscutum with some setae along notauli; scutellar sulcus deep and narrow, with one median carina and 2 short longitudinal carinae and 4.0 times wider than its maximum length; scutellum rather flat and wide (Fig. 19); surface of propodeum rugose, with rather distinct median carina on anterior half, areola present but inconspicuous (Fig. 20).

Wings (Figs 16, 17). Pterostigma elliptical, vein r 0.8 times width of pterostigma; r:3-SR:SR1 = 5:14:40; SR1, 1-SR+M nearly straight and 2-SR curved; cu-a postfurcal, short; 1-CU1:2-CU1 = 2:17; 3-CU1 longer than CU1b; 2-SR:3-SR:r-m = 19:25:8; m-cu postfurcal, slightly converging to 1-M posteriorly; first subdiscal cell 3.8 times as long as wide; M+CU1 unsclerotised. Hind wing: M+CU: 1-M:1r-m = 4:3:2; m-cu absent.

Legs. Hind coxa smooth; tarsal claws rather robust and shorter than arolium (Fig. 15); length of femur, tibia and basitarsus of hind leg 2.7, 7.5 and 5.0 times their width, respectively; apical bristles of first-fourth hind tarsal segments absent (Fig. 15).

Metasoma. Length of first tergite 0.7 times its apical width, its surface longitudinally striate, its dorsal carinae widely separate (Fig. 20); second tergite of metasoma with longitudinally striate anteriorly; laterope present; dorsope rather large (Fig. 21); setose part of ovipositor sheath 0.26 times as long as fore wing (total visible sheath 0.35 times), flattened and sparsely setose and 0.8 times as long as hind tibia.

Colour. Yellowish brown (Fig. 15); palpi yellow; 4 basal segments of antenna, pterostigma and veins yellowish brown; wing membrane slightly infuscated.

Variation. Male is similar to female; body length of ♂ 2.3 mm, length of fore wing 2.4 mm, width of head 2.0 times its lateral length.

Notes. The new species can be separated from all known species by the parallel-sided and long basal part of the pterostigma, vein r of fore wing comparatively close to the apex of the pterostigma and vein 3-SR of fore wing about $2.9 \times$ as long as vein r.

***Tanycarpa* Foerster, 1863**

Tanycarpa Foerster, 1863: 26; Chen and Wu 1994: 133; Belokobylskij 1998: 198; Yao 2015a: 170. Type species: *Basus gracilicornis* Nees von Esenbeck, 1812 (monobasic and original designation).

Synonym. *Acrobela* Foerster, 1863; *Epiclista* Foerster, 1863.

Biology. Small genus, containing parasitoids primarily of Drosophilidae and Mycetophilidae in rotting plant or fungal substrates.

Species. *Tanycarpa amplipennis* (Foerster, 1863) (Chen and Wu 1994; Yao 2015a).

Tanycarpa areolata Yao, 2015 (Yao 2015a).

Tanycarpa bicolor (Nees, 1812) (Chen and Wu 1994; Yao 2015a).

Tanycarpa chors Belokobylskij, 1998 (Yao 2015a).

Tanycarpa concreta Chen & Wu, 1994 (Chen and Wu 1994; Yao 2015a).

Tanycarpa gladia Chen & Wu, 1994 (Chen and Wu 1994; Yao 2015a).

Tanycarpa gracilicornis (Nees, 1812) (Chen and Wu 1994; Yao 2015a).

Tanycarpa gymnonotum Yao, 2015 (Yao 2015a).

Tanycarpa lineata Yao, 2015 (Yao 2015a).

Tanycarpa mitis Stelfox, 1941 (Chen and Wu 1994; Yao 2015a).

Tanycarpa punctata van Achterberg, 1976 (Chen and Wu 1994; Yao 2015a).

Tanycarpa rufinotata (Haliday, 1838) (Chen and Wu 1994; Yao 2015a).

Tanycarpa scabrator Chen & Wu, 1994 (Chen and Wu 1994; Yao 2015a).

Tanycarpa similis Yao, 2015 (Yao 2015a)

***Trachyusa* Ruthe, 1854**

Trachyusa Ruthe, 1854: 351; Yao 2015b: 580. Type species: *Trachyusa nigriceps* Ruthe, 1854.

Synonym. *Cosmiocarpa* Foerster, 1863.

Biology. Small genus, of which the biology is unknown. The record of Cimbicidae is erroneous.

Species. *Trachyusa whartoni* Yao, 2015 (Yao 2015b).

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A new species of *Xylotrechus* Chevrolat from China (Coleoptera, Cerambycidae)

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Abstract

Xylotrechus tristisfacies sp. n. (Coleoptera, Cerambycidae, Cerambycinae, Clytini) from China is described and illustrated. Characters distinguishing the new species from its close relatives, which possess an entirely black or dark brown pronotum with a black median stripe on the disc and dense yellowish to gray pubescent elytra with black or brown spots or bands, are presented.

Keywords

Guizhou, Leigongshan Nature Reserve, longhorn beetles, taxonomy

Introduction

Xylotrechus Chevrolat, 1860 is a genus of the tribe Clytini Mulsant, 1839 characterized by one or more vertical or branching carina on the forehead. There are over 210 species and subspecies described worldwide. Among them, 125 species and subspecies are recorded in the Palaearctic region and 70 of them are distributed in China

(Tavakilian and Chevillotte 2016, Danilevsky 2017). Specimens representing a new species of *Xylotrechus* were collected in a survey for the Leigongshan National Nature Reserve within Leishan County, Guizhou Province of China. The type material is preserved in the School of Life Sciences, Guizhou Normal University, Guiyang, China (GZNULS).

Taxonomy

Xylotrechus tristisfacies sp. n.

<http://zoobank.org/E124F1E2-D4D6-499D-9185-CEB6F1B9BF95>

Figure 1

Type material. Holotype ♂: Leigongshan National Nature Reserve, Leishan County, Guizhou Province, CHINA, 2016.VIII.31, 26°22'25"N, 108°11'58"E, leg. S. Yang (GZNULS). Paratypes: two ♀, same data as holotype except 2016.IX.21 (GZNULS); Four ♀, same location as holotype, 2017.X.7, leg. Yaokui Yang and Gugangzu Yang (GZNULS).

Differential diagnosis. Characters of *Xylotrechus tristisfacies* sp. n. place it into the subgenus *Xylotrechus*, especially into the species group whose elytra have black integuments clothed with dense yellow pubescence broken by black markings and the pronotum shows a black median stripe. This species group contains *X. polyzonus* (Fairmaire, 1888), *X. multisignatus* Pic, 1915, *X. incurvatus incurvatus* (Chevrolat, 1863), and *X. incurvatus contortus* Gahan, 1906 (Gressitt 1951, key couplets 25–27 for genus *Xylotrechus*). Though *X. atrolineatus* Pic, 1917 was not included in Gressitt (1951), it is close to *X. incurvatus contortus* and could be included into this group. Subsequently described species, such as *X. vinnulus* Holzschuh, 1993 and *X. securus* Holzschuh, 2009, could also be included into this group.

Similar to the new species, *X. bilyi* (Holzschuh, 2003), *X. savioi* (Pic, 1935), *X. securus* (Holzschuh, 2009), *X. daoi* (Gressitt & Rondon, 1970) and *X. klapperichi* (Gressitt, 1951) also have three black bands on each elytron. However, the new species differs from *X. bilyi*, *X. savioi*, and *X. daoi* in pronotal marking pattern, i.e., one median black ridge and one black round marking on each side of the ridge. In contrast, *X. bilyi* has one triangular marking in the middle and one on each side, *X. savioi* has three round black dots, one in the middle and one on each side, and *X. daoi* has one round black spot on each side and no median ridge.

The new species differs from *X. klapperichi*, which it resembles in general habitus, in the pronotum obviously narrower than elytra (pronotal width subequal to the elytral width in *X. klapperichi*), distinct black humeral markings, short lengthwise post-scutellar black markings (which *X. klapperichi* does not have), post-median elytral stripe more curving towards apex, and rather dense yellow pubescence with a caret shaped black marking on the apical third (not entirely pitch-black on the apical fourth as in *X. klapperichi*).

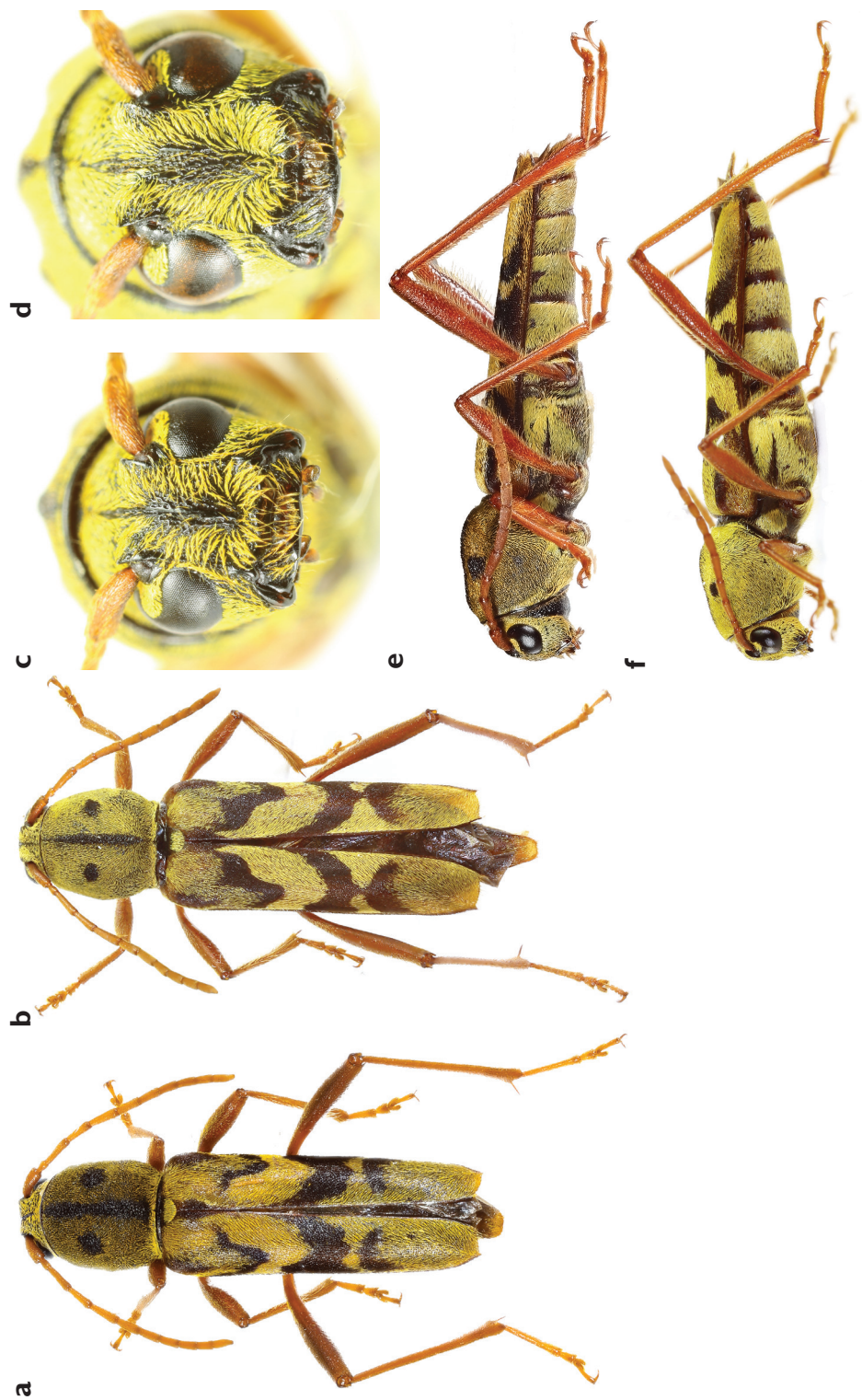


Figure 1. *Xylotrechus tristifacies* sp. n., Male. **a** dorsal view **c** front view **e** lateral view Female. **b** dorsal view **d** front view **f** lateral view.

Xylotrechus securus, which also has one median black ridge and two round markings on the pronotum, was described from Laos (Holzschuh 2009) and it is the closest congener of *X. tristifacies*. The elytral band pattern can differentiate these two species. The sutural end of the first elytral black band, starting from approximately the basal sixth, turns laterally at basal third in *X. tristifacies*. The first elytral band of *X. securus* starts about basal fourth from the sutural end to nearly half of the elytral length to the lateral end. The 2nd elytral band of *X. tristifacies* is wider than that of *X. securus*.

Description. Male (Fig. 1a, c, e): Body cylindrical; integument dark reddish brown to black, clothed with yellow and black pubescence forming black stripes and patches on pronotum and elytra. Length: 13.9 mm. Face and genae clothed with yellow pubescence, striated smooth black stripe, which narrow at bottom and gradually wide towards antennal insertions in the middle of frons; vertex densely punctured, also clothed with yellow pubescence except a narrow median black line. Antennae 11-segmented, short, not reaching hind femurs; 6th antennomere slightly surpassing the humeri; reddish-brown clothed with yellow hairs; these hairs longer on antennomeres I–V, especially on inner side of antennomeres II–V, suberect and forming small hair clusters; 3rd antennomere longer than scape, 4th and other antennomeres; 4th and 6th antennomeres subequal in length and shorter than 5th; 7th antennomere subequal to 6th; 8th through 11th antennomeres subequal and shorter than 7th. Prothorax longer than wide with nearly parallel sides, narrower than elytra; surface of disc densely punctured, clothed with yellow hairs except a median ridge and two round patches on the disc; ridge and patches rugulose and slightly raised. Elytra subparallel-sided, reddish brown, approximately 2.6 times longer than width at humeri; apices obliquely subtruncate with outer angle minutely acute; mostly covered with short, dense yellow pubescence, thinner at basal and apical third; two lengthwise short black stripes at basal of each elytron, one at humerus and one at suture after scutellum; three transverse black bands on each elytron: 1st band V-shaped (outer half of the band shorter), from basal sixth to basal third, sutural apex of the band extending transversely towards suture but not reaching suture; 2nd band wider, curving towards apex to the middle of elytron, narrowing down obliquely forward and reaching suture; 3rd band at apical third, slightly curving forward as a caret character, not reaching suture. Legs reddish brown, thinly clothed with suberect pale yellow hairs, moderately elongated; femora moderately clavate; hind femora nearly reaching but not exceeding elytral apices; first meta-tarsomere longer than total length of remaining tarsomeres and at least twice as long as 2nd and 3rd combined. Sternites finely closely punctate, clothed with yellow pubescence except for the basal margin of the 2nd sternite.

Female (Fig. 1b, d, f): Mostly as the male except for: body somewhat larger on average; 7th antennomere surpassing the humeri; 1st elytral band wider, sutural vertex reaching suture and scutellum stripe for some individuals; 3rd elytral band wider sometimes, reaching suture or connecting to the 2nd marking in some individuals; meta-femora not reaching the elytral apex; yellow hairs not covering the basal margins of the 3rd, 4th and 5th sternite. Length 14.2–17.8 mm.

Etymology. The name of the new species was inspired by the pensive face emoji-like pattern formed by the transverse black stripes on its elytra.

Modified couplets to key by Gressitt (1951) of Chinese *Xylotrechus* species group above to accommodate the new species

24	Pronotum with a distinct median black stripe.....	25
–	Pronotum lacking a distinct median black stripe, but with several indistinct blackish areas on disk.....	<i>savioi</i>
25	Pronotum with lateral discal spots more or less separated, not joined to basal band by curved lateral stripes.....	26
–	Pronotum with median stripe joining a subbasal band that curves forward to join lateral spots of disc.....	<i>polyzonus</i>
26	Frons with a single carina.....	27
–	Frons with a V-shaped carina or striated projected stripe.....	30
27	Four transverse bands on each elytron, the first maybe reduced to a marking in the middle of elytron; the hind two curved toward base, or the third one curved toward base and the last broken into two markings.....	28
–	Three transverse black bands on each elytron, the last covers apical third of elytron.....	<i>klapperichi</i>
28	Second elytral band widely separated from third band	<i>incurvatus incurvatus</i>
–	Second elytral band curving backward on disc nearly to third band.....	29
29	Last elytral band not broken into two markings.....	<i>incurvatus contortus</i>
–	Last elytral band broken into two markings.....	<i>atrolineatus</i>
30	Elytra with ground color entirely black, clothed with yellow pubescence and with a common postsutural spot and each with three longitudinal stripes of black.....	<i>multisignatus</i>
–	Elytra with only two post-scutellum longitudinal short stripes, no other longitudinal stripes.....	<i>tristisfacies</i> sp. n.

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Two new genera and three new species of Epipaschiinae Meyrick from China (Lepidoptera, Pyralidae)

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Abstract

Two new genera of Epipaschiinae are described. The genus *Arcanusa* Wang, Chen & Wu, **gen. n.** is established for *Ar. apexiarcanusa* Wang, Chen & Wu, **sp. n.** and *Ar. sinuosa* (Moore, 1888), **comb. n.**, described in *Scopocera* Moore, 1888 (junior synonym of *Stericta* Lederer, 1863). The female genitalia of *Ar. sinuosa* (Moore, 1888), **comb. n.** are described for the first time. *Androconia* Wang, Chen & Wu, **gen. n.** is erected, including two new species, *An. rallusa* Wang, Chen & Wu, **sp. n.** and *An. morulusa* Wang, Chen & Wu, **sp. n.** Illustrations of all adults and their genitalia, and a key to the two new genera are provided.

Keywords

New genus, new species, Pyraloidea, snout moth, taxonomy

Introduction

The subfamily Epipaschiinae Meyrick, 1884, includes more than 700 species distributed all over the world (Solis 1992), and embodies 93 genera currently (Nuss et al. 2003–2017). The post taxonomic works of Epipachiinae were mainly published from the late 19th century to the early 20th century, while little work was done in the middle to the later 20th century. In recent decades, ten new genera and some new species were reported from the Neotropical, Paleotropical, and Afrotropical regions (Solis 1991, 1993; Shaffer and Solis 1994; Mey 2011). Few works were published from the Pal-

aearctic and Oriental regions, except some new species described by Inoue and Sasaki (1995), Liu et al. (2016), and Wang et al. (2017a, b).

During our work, some species were identified not attributed to any known epipaschiine genus. Thus, two new genera, *Arcanusa* Wang, Chen & Wu, gen. n. and *Androconia* Wang, Chen & Wu, gen. n., are proposed for them here, including two species each.

Materials and methods

The specimens examined and the types of the new species are deposited in the collection of the Institute of Zoology, Chinese Academy of Sciences (IZCAS), Beijing, P. R. China. The specimens were collected by light trap. The photographs of moths and their genitalia were taken with a NIKON D7000 digital camera connected to a NIKON SMZ 1500 stereomicroscope. The images were adjusted by Adobe Photoshop CS5 and Adobe Illustrator CS6 software, and the distribution maps were made by ArcGIS 10.2 software. Methods of dissection, morphometrics, and terminology follow Wang et al. (2003) and Slamka (2006, 2008).

Taxonomy

Arcanusa Wang, Chen & Wu, gen. n.

<http://zoobank.org/0BA9E0CF-030E-4272-B80E-B281568012F9>

Type species. *Arcanusa apexiarcanusa* Wang, Chen & Wu, sp. n.

Diagnosis. *Arcanusa* gen. n. differs from all known Epipaschiinae by the juxta of the male genitalia, which lateral lobes joined distally. The new genus is very similar to *Lista* Walker, 1859 based on the long hair-like scales at the base of the forewing and the similar pattern on both pairs of wings. In the male genitalia, the base of the sacculus is usually expanded and extended into a sclerotized spine or process, which is similar to that found in the genus *Lista*. However, the new genus can be distinguished by its dark scales on both wings while the species of *Lista* are covered with brighter scales. The new genus is also similar to *Coenodomus* Walsingham, 1888 in wing pattern and sclerotized process of the sacculus, but it can be distinguished easily by its filiform antennae in the male. In addition, the two genera have minute differences on the stalked R_{3+5} of the forewing.

Description. Medium sized to Pyralidae (14.5–15.5 mm in forewing length). Head covered with dense scales; labial palpus upturned, third segment slender and obviously pointed; antenna filiform, male with a scape extension covered with dense scales. Forewing with distinct antemedial and postmedial lines. Hindwing with similar pattern as in forewing, but paler than forewing.

Venation (Fig. 22). In forewing, Sc reaching 1/2 of costa; R_1 arising from 1/2 of upper margin of cell; R_2 arising before upper angle of cell; R_{3+5} and M_1 from upper

angle of cell; R_{3+4} stalked with R_5 at mid-length; M_2 and M_3 from lower angle of cell, CuA_1 and CuA_2 nearly parallel; $1A+2A$ anastomosed at base. In hindwing, $Sc+R_1$ and Rs adjacent in middle of $Sc+R_1$; Rs shortly stalked with M_1 ; M_2 and M_3 separated from lower angle of cell; CuA_1 and CuA_2 nearly parallel; three A veins present.

Male genitalia. Uncus expanded. Gnathos pointed apically. Valval costa sclerotized; sacculus expanded at base, with a spine or process in middle. Juxta with two strongly sclerotized lateral lobes joined in apex. Phallus slender, slightly curved, spine-like cornuti present.

Female genitalia. Ovipositor expanded obviously. Apophysis anterioris lightly longer than apophysis posterioris. Antrum lightly sclerotized. Ductus bursae membranous. Corpus bursae rounded, signa consisting of two sclerotized incurved plates.

Distribution. China, India (Fig. 24).

Etymology. The generic name is derived from Latin “*Arcanus*” (= closed), in reference to the lateral lobes of juxta joined distally in male genitalia.

Key to species of *Arcanusa* Wang, Chen & Wu, gen. n.

- 1 Hindwing with black scales on central area, sacculus with a pointed process in middle (Figs 2, 8) *Arcanusa sinuosa* comb. n.
- Hindwing with pale yellow scales on central area, sacculus with a slightly bifurcated process in middle (Figs 1, 7) *Arcanusa apexiarcanusa* Wang, Chen & Wu, sp. n.

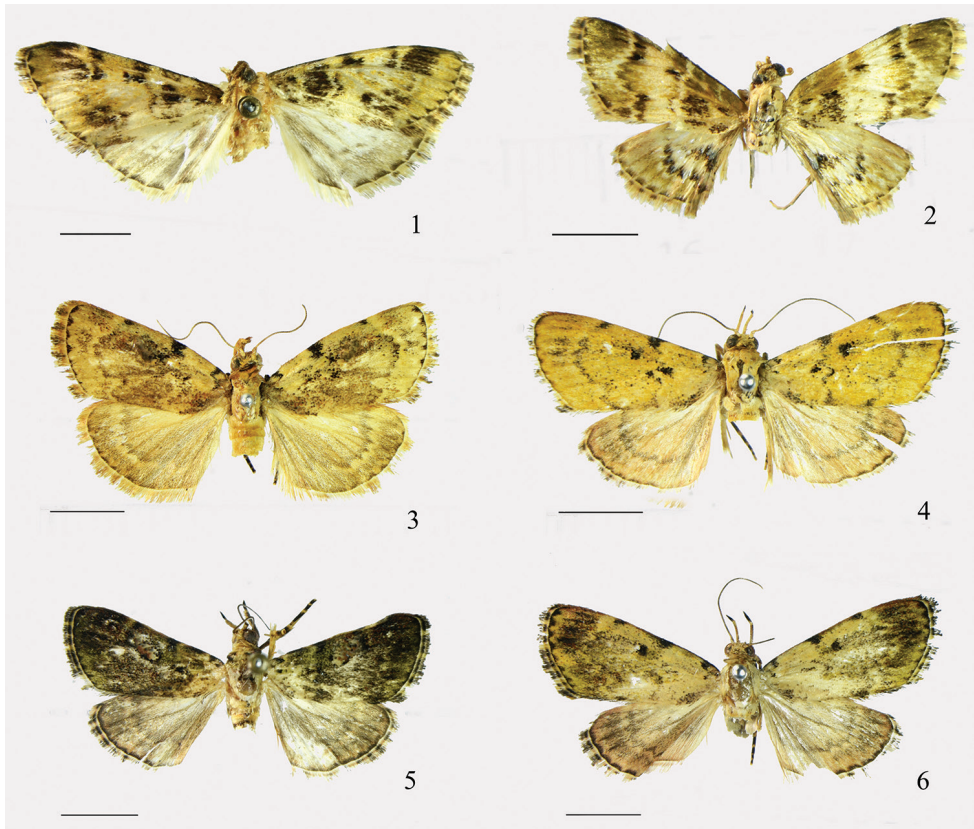
Arcanusa apexiarcanusa Wang, Chen & Wu, sp. n.

<http://zoobank.org/77E22945-54B3-4B8F-9E35-267B05BB2D86>

Figs 1, 7, 14

Differential diagnosis. The new species is very similar to *Ar. sinuosa* comb. n. in external characters, especially the forewing. However, the hindwing is obviously paler than the forewing in the new species, while lightly paler in *Ar. sinuosa*. In male genitalia, *Ar. apexiarcanusa* Wang, Chen & Wu, sp. n. has the gnathos beaked and the sacculus with a bifurcated stick-like process while *Ar. sinuosa* has the gnathos trifurcate with a spine-like apex and the sacculus has a spine-like process. In addition, there are more minute spines on the juxta of the new species than on that of *Ar. sinuosa*.

Description. Adult male. Forewing length 15.5 mm (n=1). Head yellow mixed with fuscous; first and second segments of labial palpus with fuscous scales on outer side and pale yellow scales on inner side; third segment with pale brown scales; antenna yellow, scape extension fuscous, mixed with black scales on outer side and pale yellow scales on inner side; apical 2/3 of scape extension with yellow hair-like scales. Thorax mixed with yellow and small number of brown scales. Forewing covered with pale yellow, yellow and black scales; base black mixed with yellow scales, antemedial



Figures 1–6. Adults. **1** *Arcanusa apexiarcanusa* Wang, Chen & Wu, sp. n., male, holotype **2** *Ar. sinuosa* (Moore, 1888), comb. n., male **3** *Androconia rallusa* Wang, Chen & Wu, sp. n., male, paratype **4** *An. rallusa* Wang, Chen & Wu, sp. n., female, paratype **5** *An. morulusa* Wang, Chen & Wu, sp. n., male, holotype **6** *An. morulusa* Wang, Chen & Wu, sp. n., female, paratype. Scale bars: 5.0 mm.

line black, waved, a black patch above discocellular; central area suffused with yellow scales; postmedial line black, waved, arched outward medially; outer area covered with yellow scales; cilia mixed with yellow and brown. Hindwing pale fuscous, with a blurry waved postmedial line.

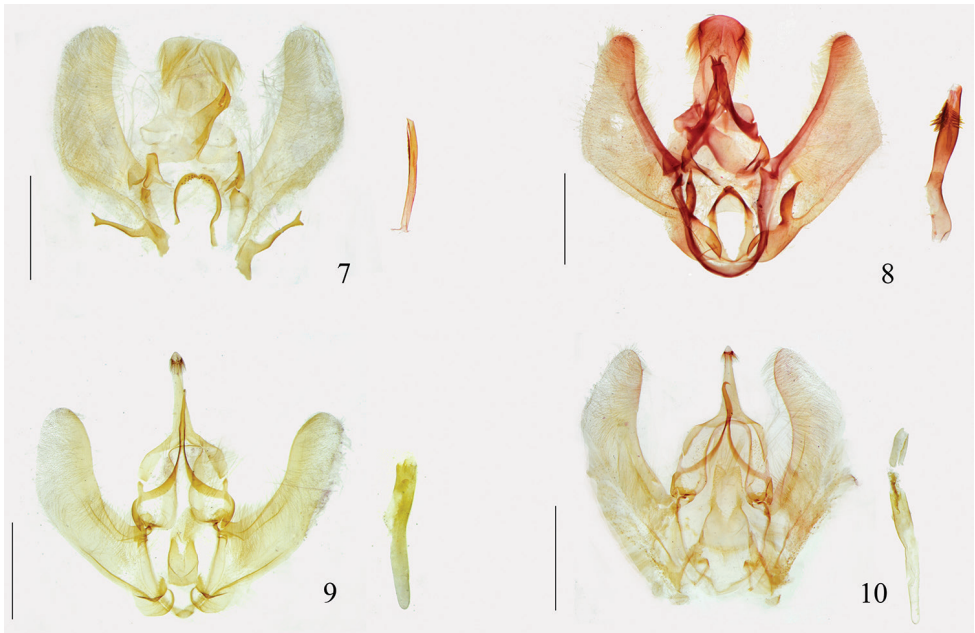
Male genitalia. Uncus broad, slightly expanded at apex, densely suffused with setae laterally, apex truncated. Gnathos strongly sclerotized, beaked. Valva widening from base to apex, apex expanded; sacculus with stick-like sclerotized process in middle, bifurcated at apex. Juxta with two strongly sclerotized lateral lobes joined in apex, apex with minute spines. Phallus cylindrical, curved slightly, with many spinules laterally.

Female genitalia. Unknown.

Holotype. ♂, **Yunnan:** Jinghong, 2700 m, 4.VII.1980, gen. slide. no. Ep537 (IZCAS).

Distribution. Yunnan.

Etymology. The specific name is derived from the Latin “*apex*” (= apex) and “*arcanus*” (= closed) in accordance with the lateral lobes of juxta joined distally in the male genitalia.



Figures 7–10. Male genitalia. **7** *Arcanusa apexiarcanusa* Wang, Chen & Wu, sp. n., holotype, gen. slide no. Ep537 **8** *Ar. sinuosa* (Moore, 1888), comb. n., gen. slide no. Ep112 **9** *Androconia rallusa* Wang, Chen & Wu, sp. n., holotype, gen. slide no. Ep680 **10** *An. morulusa* Wang, Chen & Wu, sp. n., holotype, gen. slide no. Ep691. Scale bars: 1.0 mm.

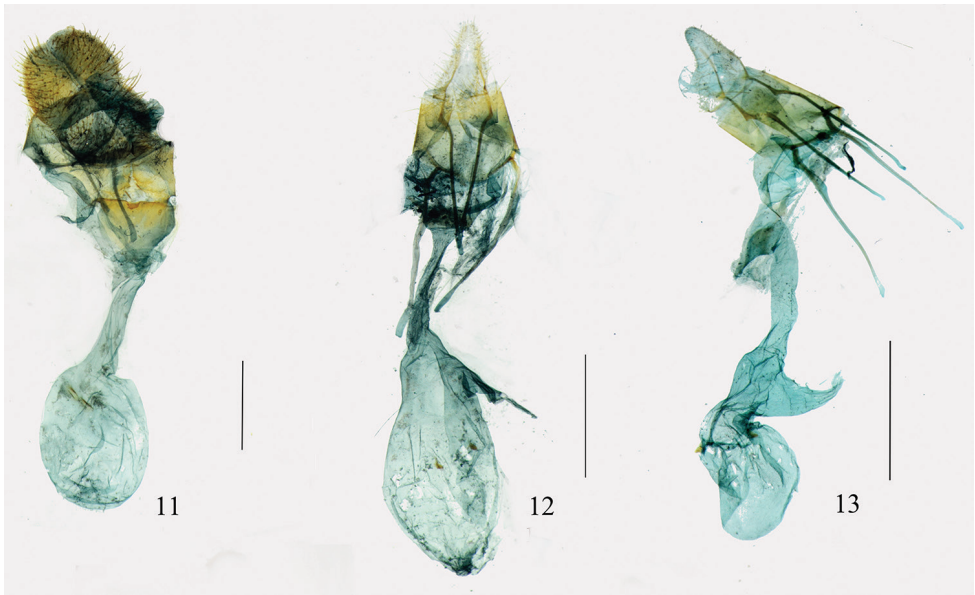
***Arcanusa sinuosa* (Moore, 1888), comb. n.**

Figs 2, 8, 11, 15

Scopocera sinuosa Moore, 1888: see Moore 1888: 203. Type Locality: India (Darjeeling).
Stericta sinuosa (Moore): see Hampson 1896: 122; Wang et al. 2003: 117; Rong and Li 2017: 470.

Differential diagnosis. The species is unique in both the external and genital characters than other species of *Stericta* by its distinct antemedial line and the different juxta. The species is similar to *Ar. apexiarcanusa* Wang, Chen & Wu, sp. n. Their differences are described above.

Redescription. Adult. Forewing length 11.0–15.0 mm (n=7). Head yellow mixed with fuscous; labial palpus first segment of labial palpus with pale brown scales, second segment with more fuscous scales than first; third segment with pale yellow scales, apically exceeding metathorax; antenna suffused with yellowish-brown scales. One-third length of scape extension at base with yellow and mixed with black scales; 2/3 length of scape extension closer apex with yellow and black hair-like scales. Thorax mixed with yellow and small number of blackish-brown scales. Forewing covered with yellow, yellowish-brown and black scales; base covered with black scales, antemedial line black, waved, a black patch located on discocellular; central



Figures 11–13. Female genitalia. **11** *Arcanusa sinuosa* (Moore, 1888), comb. n., gen. slide no. Ep538 **12** *Androconia rallusa* Wang, Chen & Wu, sp. n., paratype, gen. slide no. Ep702 **13** *An. morulosa* Wang, Chen & Wu, sp. n., paratype, gen. slide no. Ep692. Scale bars: 1.0 mm.

area suffused with pale yellow scales; postmedial line black, waved, arched outward medially; outer area covered with yellowish-brown scales; cilia mixed yellow and brown. Hindwing paler than forewing, with distinct waved postmedial line and more or less black basal area.

Male genitalia. Uncus broad, expanded at apex, densely suffused with setae laterally. Gnathos strongly sclerotized, apex with trifurcate spine-like process. Valva nearly the same width from base to apex, apex obliquely truncated; costa strongly sclerotized, apex swollen; sacculus expanded at base, with a spine-like process in middle. Juxta with two strongly sclerotized lobes joined at apex, apex with minute spines. Phallus cylindrical, with many slender spines distally, curved slightly.

Female genitalia. Ovipositor obviously expanded. Apophysis anterioris lightly longer than apophysis posterioris. Antrum lightly sclerotized. Ductus bursae short, membranous. Corpus bursae rounded, signa consisting of two sclerotized incurved plates.

Material examined. **Fujian:** Wuyishan, Sangang, 1♂, gen. slide. no. Ep704 (IZCAS); Chong'anxingcun, Sangang, 740 m, 1♀, 17.VI.1960, Zhang Yiran, gen. slide. no. Ep538 (IZCAS). **Hainan:** Jianfengling, 1♂, 23.X.1981, Gu Maobin (IZCAS). **Yunnan:** Jinping, Hetouzai, 1600 m, 1♂, 13.V.1956, Huang Keren, gen. slide. no. Ep112 (IZCAS); Pingbian, Daweishan, 1500 m, 1♂, 20.VI.1956, Huang Keren, gen. slide. no. Ep705 (IZCAS); Pingbian, 1200–1600 m, 1♀, 18.VII.1958, Huang Keren (IZCAS); Xishuangbanna, Menghai, 1500 m, 1♂, 20.VI.1956, Wang Shuyong (IZCAS).

Distribution. China (Fujian, Hainan, Yunnan), Bhutan, India.



Figures 14–15. Head of *Arcanusa* Wang, Chen & Wu, gen. n. species. **14** *Ar. apexiarcanusa* Wang, Chen & Wu, sp. n., male, holotype **15** *Ar. sinuosa* (Moore, 1888), comb. n., male.

Remarks. This species was firstly reported in China (Wuyishan Nature Reserve, Fujian) by Wang et al. (2003). We reexamined their voucher material from Fujian (Ep704), which are in accordance with the original description of *Stericta sinuosa* (Moore, 1888). The species was originally described in *Scopocera* (junior synonym of *Stericta*). However, the species is closer to *Lista* than *Stericta*, because it does not have hairs on the outer side of mid-leg tibiae and has quite different genitalia to those of *Lista*. Thus, a new genus is erected to place the species and a new species, *Ar. apexiarcanusa* Wang, Chen & Wu, sp. n. In addition, the female is reported for the first time here.

***Androconia* Wang, Chen & Wu, gen. n.**

<http://zoobank.org/5B123A0D-CDD7-4F54-BB5C-D65A41CB5A7A>

Type species. *Androconia rallusa* Wang, Chen & Wu, sp. n.

Diagnosis. The new genus is similar to *Stericta* Lederer, 1863 based on the wing pattern, especially the black discocellular spot on the forewing. However, it can be easily distinguished from *Stericta* by its males having an androconium at the discocellular cell of the forewing and the slender uncus which is obviously thinner than that of the other genera of Epipaschiinae.

Description. Medium sized to Pyralidae (9.0–12.0 mm in forewing length). Head covered with dense scales; labial palpus upturned, third segment slender and pointed obviously; antenna filiform. Forewing with an androconium at discocellular cell in male, two black spots located at basal and terminal cell, respectively; antemedial and postmedial lines wavy, distinct, hindwings suffused with pale red scales.

Venation (Fig. 23). In forewing, Sc reaching 2/3 of costa; R_1 arising from 2/3 of upper angle of cell; R_2 arising before upper angle of cell; R_{3+5} and M_1 from upper angle of cell and short stalked at base; R_{3+4} stalked with R_5 at mid-length; M_2 and M_3 from lower angle of cell in same point; CuA_1 and CuA_2 nearly parallel; $1A+2A$ anastomosed at base. In hindwing, $Sc+R_1$ and Rs connected at middle of $Sc+R_1$; Rs shortly stalked with M_1 ; M_2 and M_3 separated from lower angle of cell in same point; CuA_1 and CuA_2 nearly parallel; three A veins present.

Male genitalia. Uncus slender, densely setose. Gnathos with slender lateral arms, apex hooked. Valva slender, costa lightly sclerotized; sacculus swollen and warped in base. Juxta bifurcated. Phallus slender.

Female genitalia. Ovipositor covered with dense setae. Apophysis anterioris nearly as same length as apophysis posterioris. Antrum and ductus bursae membranous. Corpus bursae nearly elliptic, with two signa.

Distribution. China (Fig. 24).

Etymology. The generic name is in accordance with the androconium of the male forewing, derived from the Greek “*andro*” and “*konos*”.

Remarks. The species of the new genus is sexually dimorphic in color. Although both sexes have the same wing pattern on both wings, the female has the forewing with less black scales and androconium absent, and the hindwing looks redder than the forewing.

Key to species of *Androconia* Wang, Chen & Wu, gen. n.

- 1 Forewing suffused with yellow scales. Male with juxta nearly same width from base to apex and cornuti absent (Figs 3, 9); female genitalia with ductus bursae and ductus seminalis relatively narrow *Androconia rallusa* Wang, Chen & Wu, sp. n.
- Forewing suffused with fuscous scales. Male genitalia with juxta constricted from base to apex and an irregular cornutus (Figs 5, 10); female genitalia with ductus bursae and ductus seminalis relatively broad *Androconia morulusa* Wang, Chen & Wu, sp. n.

Androconia rallusa Wang, Chen & Wu, sp. n.

<http://zoobank.org/7BFC4AE6-CFC3-47BC-82D3-CBB97375A692>

Figs 3–4, 9, 12, 16–17, 20–21

Differential diagnosis. The species is similar to *An. morulusa* Wang, Chen & Wu, sp. n. in external characters. However, *An. morulusa* Wang, Chen & Wu, sp. n. has darker wings than *An. rallusa* Wang, Chen & Wu, sp. n. In the male genitalia, the juxta of *An. rallusa* Wang, Chen & Wu, sp. n. is thinner than *An. morulusa* Wang, Chen & Wu, sp. n.

Description. Adult. Forewing length 9.0–12.0 mm (n=7). Male. Head yellow mixed with fuscous scales; first and second segment of labial palpus with yellow scales; third segment of female slender, and with black scales, approximately 1/3 length of whole labial palpus; third segment of male short; antenna pale yellow scales. Thorax mixed with yellow and small number of fuscous scales. Forewing yellow mixed with fuscous scales; base covered with yellow scales, base 1/3 and 2/3 of costa with a black spot respectively; antemedial line black, indistinct; two black spots located at basal and terminal of cell, respectively. Central area suffused with pale yellow mixed brown; an androconium presents on the discocellular; postmedial line thin, waved, black with yellow edges, outer area covered with yellow scales; cilia mixed with yellow and fuscous. Hindwing paler than forewing and more or less reddish, postmedial line waved. Female. Similar with male, but forewing with less fuscous scales and androconium absent, hindwing redder.



Figures 16–19. Head of *Androconia* Wang, Chen & Wu, gen. n. species. **16** *An. rallusa* Wang, Chen & Wu, sp. n., male, paratype **17** *An. rallusa* Wang, Chen & Wu, sp. n., female, paratype **18** *An. morulusa* Wang, Chen & Wu, sp. n., male, holotype **19** *An. morulusa* Wang, Chen & Wu, sp. n., female, holotype.



Figures 20–21. *Androconia rallusa* Wang, Chen & Wu, sp. n., resting position and habitat. **20** Male, holotype **21** Habitat, China, Southeast of Tibet, Medog, 799 m (photo by Mingqiang Wang).

Male genitalia. Uncus slender, densely suffused with setae at lateral apex. Gnathos with slender lateral arms, apex hooked. Valva slender, costa lightly sclerotized; sacculus swollen and warped in base. Juxta nearly same width from base to apex, apex bifurcated. Phallus slender.

Female genitalia. Ovipositor narrow and pointed at apex, covered with dense setae. Apophysis anterior nearly as same length as apophysis posterior. Antrum membranous. Ductus bursae membranous, slightly shorter than corpus bursae. Ductus seminalis relatively narrow, arising from basal corpus bursae. Corpus bursae nearly elliptic, with two signa, tongue-shaped.

Holotype. ♂, **Xizang:** Medog, 1005 m, 15.VIII.2015, Wang Mingqiang, gen. slide. no. Ep537 (IZCAS).

Paratypes. **Fujian:** Wuyishan, Guadun, 1200 m, 1♂, 12.VIII.1979, Song Shimei, gen. slide. no. Ep701 (IZCAS). **Xizang:** Medog, Beibeng, 870 m, 1♀, 17.VIII.2006, Chen Fuqiang, gen. slide. no. Ep702 (IZCAS); Medog, Beibeng, 799 m, 3♀♀, 19.VIII.2015, Wang Mingqiang, gen. slide. no. Ep669, Ep684, Ep689 (IZCAS).

Distribution. China (Fujian, Xizang).

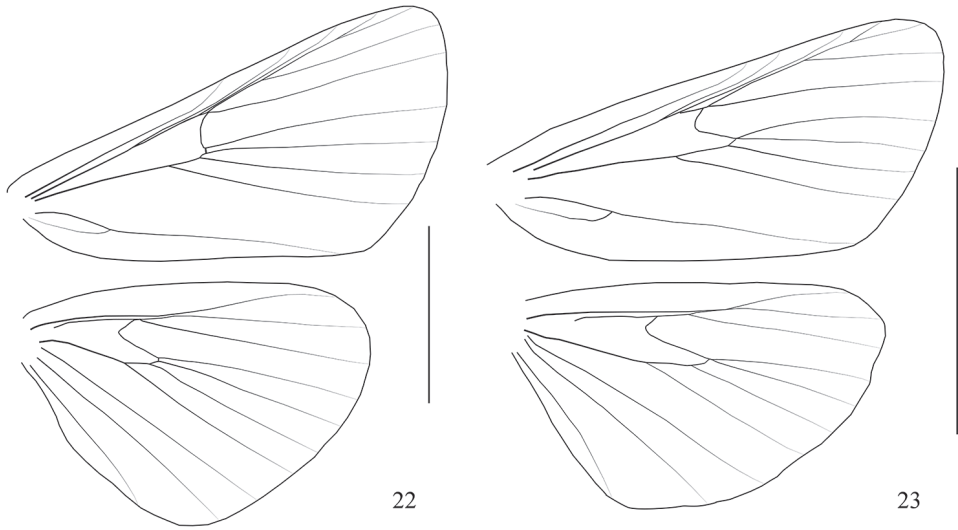
Etymology. The specific name is derived from the Latin “*rallus*” (= thin) in accordance with the thin antemedial line.

***Androconia morulosa* Wang, Chen & Wu, sp. n.**

<http://zoobank.org/4C53CB46-CF2C-4477-BD1E-72A7EEA9148D>

Figs 5–6, 10, 13, 18–19

Differential diagnosis. The species is similar to *An. rallusa* Wang, Chen & Wu, sp. n. in external characters. It can be distinguished from the latter by the darker wings. In male genitalia, the juxta of *An. morulosa* Wang, Chen & Wu, sp. n. is broader than *An. rallusa* Wang, Chen & Wu, sp. n.



Figures 22–23. Venation. **22** *Arcanusa sinuosa* (Moore, 1888), comb. n. **23** *Androconia rallusa* Wang, Chen & Wu, sp. n. Scale bars: 5.0 mm.

Description. Adult. Forewing length 10.0–11.5 mm ($n=3$). Male. Head mixed with black and fuscous scales; first and second of labial palpus segments mixed with yellow and fuscous scales; third segment slender, with black scales; antenna with brown scales. Thorax with fuscous or yellow scales. Forewing covered with blackish-green scales; base area yellow, antemedial line indistinct, central area with a rufous androconium present on the discocellular; postmedial line blurry, waved; outer area black; cilia mixed with yellow and black. Hindwing fuscous and more or less reddish. Female. Similar with male, but forewing with less black scales and androconium absent, hindwing redder.

Male genitalia. Uncus slender, densely suffused with setae at lateral apex. Gnathos with slender lateral arms, apex hooked. Valva slender, costa lightly sclerotized; sacculus swollen and warped. Juxta constricted from base to apex, apex bifurcated. Phallus slender, an irregular cornutus present.

Female genitalia. Ovipositor narrow, nearly triangle, covered with dense setae. Apophysis anterioris nearly as same length as apophysis posterioris. Antrum and ductus bursae membranous, slightly longer than corpus bursae. Ductus seminalis relatively broad, then extremely constricted, arising basally from corpus bursae. Corpus bursae nearly elliptic, with two signa, nearly triangle.

Holotype. ♂, **Guangxi:** Maoershan, Gaozhai, 448 m, 13.VIII.2012, Chen Fuqiang, gen. slide. no. Ep691 (IZCAS).

Paratypes. **Guangxi:** Maoershan, Jiuniutang, 1146 m, 1♀, 19.VIII.2012, Chen Fuqiang, gen. slide. no. Ep690 (IZCAS). **Yunnan.** Xiaomengyang, 810 m, 1♀, 31.III.1957, Pu Fuji, gen. slide. no. Ep692 (IZCAS).

Distribution. China (Guangxi, Yunnan).

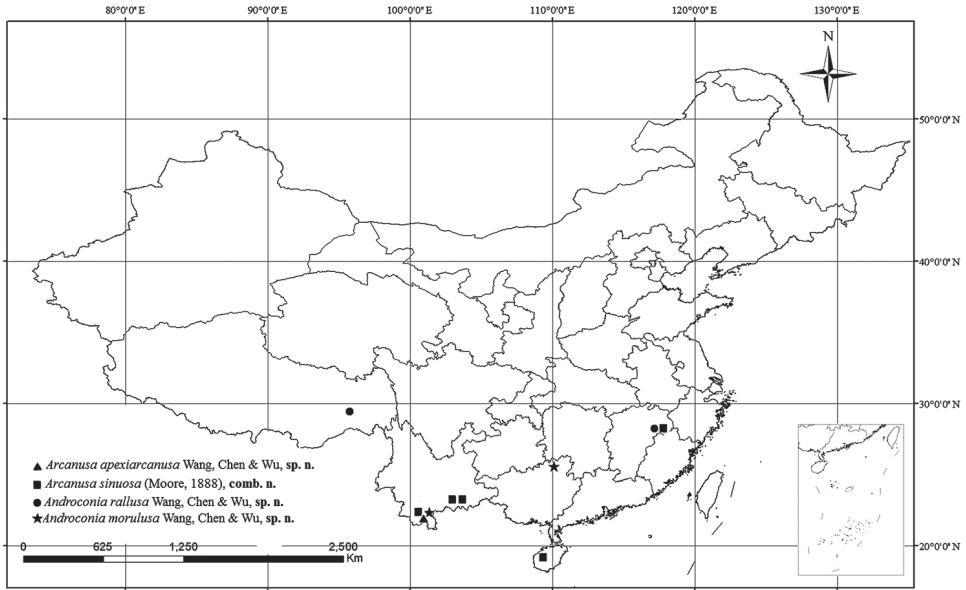


Figure 24. Distribution map of *Arcanusa* Wang, Chen & Wu, gen. n. and *Androconia* Wang, Chen & Wu, gen. n. in China.

Etymology. The specific name is derived from the Latin “*morulus*” (= dark-colored) in accordance with the black scales on forewing.

Remarks. The species is sexually dimorphic in color. The male holotype (gen. slide no. Ep691) and a female paratype (gen. slide. no. Ep690) were collected from Maershan, Guangxi. Although they have different elevations, their localities are adjacent (approximately 3.2 km in straight line). Both of these specimens have the same wing pattern and are thus treated as conspecific.

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The avian community of the Karen Mogensen Reserve, a wealth of biodiversity within the poorly investigated and threatened environments of northwestern Costa Rica

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Abstract

Despite being characterized by some of the most threatened forest ecosystems of Mesoamerica, the Nicoya Peninsula is among the least known regions of neotropical Costa Rica in terms of its birdlife. Within this region, in the framework of an ongoing international cooperation program between Italy and Costa Rica, we had the opportunity to investigate the Karen Mogensen Reserve, a protected area distinguished by the presence of a variety of habitats, including tropical dry forest and moist forest. Species richness in the Reserve was relatively high compared with similar areas in northwestern Costa Rica. A series of surveys carried out over a 20-year period documented an avian community consisting of 207 species, of which 115 were breeding in the zone and another 14 were potentially breeding. We recorded five IUCN globally Vulnerable or Near-Threatened species, along with six species reported for the first time from the Nicoya Peninsula, each representing range extension of more than 100 km. Twenty-six species, mostly breeding in the area, are at their southernmost range borders, and are likely susceptible to global environmental alterations, such as the effects of climate change. Furthermore, our study revealed the presence of two species endemic to a restricted area of Central America and four subspecies endemic to Costa Rica, along with breeding populations of two species that are geographically isolated from the main ones. The present analysis led to the ecological characterization of the resident avian community, showing that

65% of the species are strictly associated with forested environments, and especially with the understory or middle tree level, hence more vulnerable to environmental change (climatic, anthropogenic, etc.) and susceptible to local extinction. These results underscore the importance of the Karen Mogensen Reserve for bird conservation within a vulnerable environmental context, and warrant the continuation of periodic bird surveys, taxonomic study of isolated populations or endemic taxa, and improvement of local conservation measures. The data collected will be an important tool for future studies aimed at evaluating the consequences of habitat fragmentation and to monitor the effects of climate change on the resident avifauna. We exhort the creation of programs that integrate bird monitoring, ecological research, conservation initiatives, and the involvement of the local communities, by promoting environmental education, capacity-building, and income generation. To this purpose, the Karen Mogensen Reserve may represent a convincing model and valuable example to apply in similar neotropical contexts.

Keywords

Aves, biogeography, birds, conservation biology, Mesoamerica, tropical ecology, tropical forests

Introduction

Despite its relatively small size of approximately 51,000 km², Costa Rica exhibits an extremely rich biodiversity, with more than 500,000 known species, corresponding to nearly 5% of the species estimated worldwide (INBio 2017). The avian checklist of the country accounts for 927 species: almost one tenth of those known worldwide (Gill and Donsker 2017, Lepage 2017). Over 600 species are resident, and the remaining are migratory (mainly from North America) or accidental (Stiles et al. 2003, Garrigues et al. 2015, Lepage 2017). Ten species are endemic to Costa Rica, approximately 80 show a limited distribution in Central America, and 26 species are threatened on a global scale (Lepage 2017), of which four are endangered (Stattersfield et al. 1998). The key of this richness derives firstly from tropical latitudes and the geographic position of Costa Rica, which is a natural bridge between North and South America, but also topography and its influence on climate plays an important role (Wege and Long 1995).

Movements of the tectonic plates over approximately the past ten million years led to the formation of four volcanic mountain ranges, aligned in a northwest-southeast orientation, which in some cases exceed 3,500 m in altitude. These ridges act as barriers to the passage of moist air, creating marked differences in rainfall and temperatures between the Pacific and Caribbean slopes of the country, and also between lowlands and highlands. This climate and habitat complexity is the basis for the presence of at least six main life zones (excluding the Cocos Island), each characterized by unique avian communities, namely: Northern Pacific and Southern Pacific lowlands and foothills, Middle elevations, Highlands, Caribbean lowlands and Caribbean foothills (Slud 1964, Reid et al. 2010, Garrigues and Dean 2014).

The extreme biological richness of Costa Rica, together with its favorable socio-political context, a national forest conservation program, and its regeneration policy, have drawn the attention of many scientists, especially during the last 50 years. Numerous surveys have contributed to the knowledge of the Costa Rican avifauna since

the pioneering studies of Alexander von Frantzius and José Castulo Zeledón during the nineteenth century. At present, the bird life of the country is considered one of the best known in Central America (Garrigues and Dean 2014). Nevertheless, there are still various poorly explored locations, and detailed studies of birds and other metazoan groups are warranted in some parts of the country.

The Nicoya Peninsula, an important geological unit in the northwestern part of Costa Rica (Castillo-Muñoz 1977), is probably the least studied area of the country in terms of ornithological knowledge. Various authors have reported a lack of information for the greatest part of this region (Castro et al. 2001, Villareal Orias et al. 2003, Solano et al. 2004). The peninsula is situated in the northern Pacific lowlands and foothills life zone. Its main habitat is tropical dry forest, characterized by a rainy season followed by a strong desiccation of the vegetation from December to May, resulting from dry winds, constant sunshine, and lack of precipitation (Holdridge 1967, Gomez 1985, Herrera 1985, Mata and Echeverría 2004). Recently, it has been shown that local conditions affect the duration of the dry season at different sites of the region creating some local ecosystem variability (Sánchez-Murillo et al. 2013). Precipitation patterns influence the vegetation, which is dominated by deciduous taxa with evergreen species along rivers and streams (Hartshorn 1983). This seasonally dry climate and deriving habitats are typical of other Central American countries from Costa Rica up to Mexico. These environments are of high conservation interest because they are considered the most threatened forest ecosystems of Mesoamerica (Janzen 1988, Huettmann 2015). Birds living in such conditions normally show wide ranges, covering most of the Pacific slope of Central America. For this reason, many species inhabiting this life zone in Costa Rica tend to be at the southern limit of their range (Slud 1964). However, recent studies based on both morphological and molecular data have reported that at least some of these taxa, such as the Plain Wren (*Cantorchilus modestus*), are in fact species complexes (Saucier et al. 2015), thus warranting analyses of similar species complexes.

During the first half of the twentieth century, major parts of the Nicoya Peninsula were deforested and converted to cattle pasture. More generally, the northwestern Costa Rican dry forest was reduced to a series of small patches surrounded by large areas used for cattle pastures or crops (e.g., sugar cane) (Quesada and Stoner 2004). Although in its native state this land should be almost entirely forested, at present, the dry forest covers only 0.1% of its original extension (Janzen 1988). As a result, the terrestrial avifauna is confined to these isolated forest patches, with little prospect of reconnection (Barrantes et al. 2016). In fact, it has been shown that the populations of some species are restricted to the highest mountains or foothills of the Peninsula (Slud 1964).

One of these forest patches is the Karen Mogensen Reserve, an area located in the southeastern portion of the Peninsula. Since the foundation of the Karen Mogensen Reserve in 1996, some ornithological expeditions were conducted. The latest of these were in 2016 and 2017, after the opening of the research station “Italia-Costa Rica”. These expeditions were part of a project aimed at investigating the local avian community and the meteorological aspects of the area, in order to assess a possible correlation between biodiversity data and climate change. Here we provide the results of

these surveys, along with an annotated checklist of the birds of the Karen Mogensen Reserve and the ecological characterization of the avian community, focusing on the phenological, biogeographic, and conservational aspects of the encountered species.

Study area

The Karen Mogensen Reserve, placed in the SE Nicoya Peninsula, northwestern Costa Rica, is an inland foothill zone comprised between 9.85 and 9.88 degrees of latitude (N), and 85.04 and 85.08 degrees of longitude (W). It comprises approximately 1,000 hectares and shows an altitudinal range of almost 500 meters, from 130 to approximately 600 m a.s.l. (Figs 1, 2). Close to the Karen Mogensen Reserve is Cerro Pozo (maximum elevation 755 m a.s.l.), with its forested environments in direct continuity with those of the Reserve. The area is characterized mainly by a dry to moist transitional forest, and includes patches of pure dry and moist forest (Fig. 3; see the habitat classification by Holdridge 1967). Several rivers and streams created the growth conditions of a moist forest, contiguous with the widespread northwestern Costa Rican dry forest. In some parts of the area there are gallery forests. The interior part of the Karen Mogensen Reserve consists of primary forest, while the remaining is a second growth of different ages (20 to more than 50 years), partially resulting from conservation measures adopted from the 1990s which prompted the natural regeneration of the land previously used for cattle pastures and subsistence farming. Information on the age of the forest portions of the Karen Mogensen Reserve is shown in Fig. 2. The Karen Mogensen Reserve is currently a National Wildlife Refuge and part of the Biological Corridor of the Nicoya Peninsula. The lowest zones of the Karen Mogensen Reserve show a transition from forests to pastures and grassland. The protected area borders some cattle pastures and other diversely protected or unprotected second growth forested land, covering almost 12,000 hectares. The distances of the Karen Mogensen Reserve from the Gulf of Nicoya and from the open Pacific Ocean are approximately 10 km and approximately 15 km, respectively.

Materials and methods

Since the foundation of the Karen Mogensen Reserve in 1996, nearly twenty ornithological surveys have been carried out, the latest of which ended in March 2017. The surveyed periods normally corresponded to the dry season or to the months characterized by lower precipitations (late October-late December and mid-January-beginning of May). We underline that long-term data sets from tropical regions collected under more rigorous protocols are not available from the majority of Neotropical study sites, for a number of reasons, as reported by other recent studies (see Boyle and Sigel 2015). However, in the present study, a more standardized data collection procedure was at-

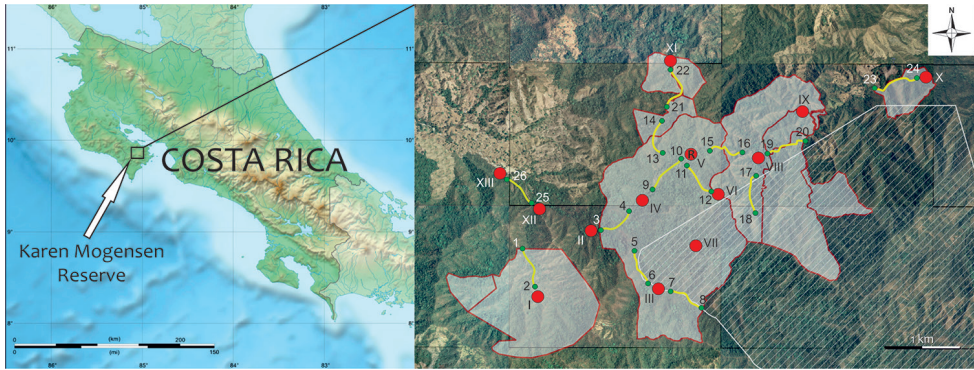


Figure 1. Map of Costa Rica and the Karen Mogensen Reserve. The areas in white, bordered by red lines, are parts of the Karen Mogensen Reserve added to the original nucleus over years. The area filled by a striped pattern represents the biological corridor of the Nicoya Peninsula and the additional protected forested land adjacent to the Karen Mogensen Reserve. “R” shows the position of the Research Station. Red dots are the fixed points, yellow lines are the transects used for the data collection during the surveys; green dots represent the transects endpoints. Numbers and Roman numerals refer to Table 1.

tempted in the last 12 surveys, carried out since 2005. The techniques adopted follow Bibby et al. (1998, 2000), Sutherland et al. (2004), and Woog et al. (2010). Bird registration was based on fixed points and transects, placed in order to sample different altitudes and all the main types of habitats. Environmental surveys to assess the altitudinal distribution and habitats of birds were based on Ferrer (2002) and Mendez and Mendez (2004), the latter relying on the classification by Holdridge (1967). A total of 13 fixed points were located at least 750 m from each other, and 13 transects established, each with an average length of 500 m, resulting in nearly 7 km of linear transects (Figure 1). Species diagnosis was based on direct observation or identification of vocalizations. Observations were made during ca. 10 minutes at each fixed point, often in alternating morning (6:00–09:00) and afternoon sampling periods (14:00–17:00). During the same hours, the transects were walked at an average speed of 1 km/h. The fixed points and transects were georeferenced with a GPS Garmin GPSMAP 64S (GPS accuracy: 3 m). The coordinates of fixed points, transects endpoints, altitudes, and habitats are reported in Table 1. The surveys normally lasted 5 to 15 days. This procedure resulted in mainly qualitative information. Several opportunistic observations or identification of vocalizations at night, the latest of which led until September 2017, were used to supplement the list of species. From November 2016 to March 2017, some individuals of mainly passerine birds were legally trapped using mist nets and then released, under a scientific investigation permit granted by the “Sistema Nacional de Areas de Conservación – Dirección Programa de Investigación, Area de Conservación Tempisque” (code: ACT-OR-DR-119-16). Species accumulation curves based on the last 12 surveys, led from 2005 to 2017, were created with the software PRIMER 6.0 (Clarke and Gorley 2006), under 1000 permutations and the Chao 1, Chao 2, first- and second-order Jackknife estimators.

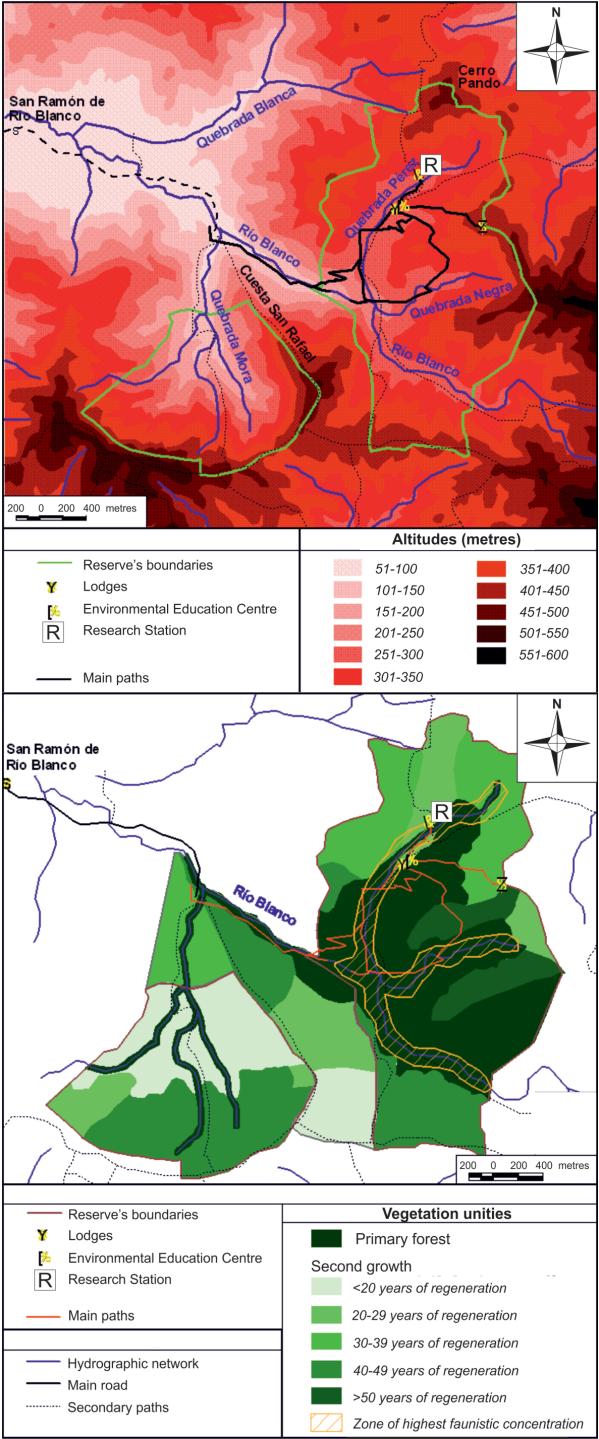


Figure 2. Innermost part of the Karen Mogensen Reserve, with altitudes (above), vegetation unities and their age (below), and hydrographic network shown.



Figure 3. Main habitats of the Karen Mogensen Reserve. **A**, Moist forest **B** Dry forest **C** Dry to moist transitional forest **D** Forest borders and grassland. Photographs by: M. Dal Zotto (**A**, **C**, **D**) and G. Romeo (**B**).

Information was collected on the horizontal and vertical distribution of the avian community. Species recorded in the same habitat were pooled to estimate habitat utilization. The habitat types were classified following Miller et al. (2015) in: (1) moist forest, (2) dry forest, (3) forest border, (4) grassland-pasture. The vertical distribution was based on grouping the species from the same forest height levels, in order to analyze community dynamics at different levels. The classification of forest height levels followed Levey and Stiles (1994) with some modifications: (1) understory (from ground level to 4 m), (2) middle level (main trees trunk), (3) canopy (uppermost level of the forest), (4) open air.

To characterize the resident avian community of the Karen Mogensen Reserve, waterbirds were excluded, i.e., members of the families Anatidae, Scolopacidae, Fregatidae, Ardeidae, Ciconiidae, and Threskiornithidae. Migratory and wintering birds were also excluded as well as a few occasional native species far from their normal geographic breeding distribution ranges. Thus, the typical resident bird community of the area was composed of breeding or potentially breeding species with mainly terrestrial habits. Bird breeding was ascertained by the direct observation of nests or through the collection of indirect evidence (e.g., presence of pulli, adults carrying material for nesting, adults in courtship, adults displaying territorial behavior during the breeding season). Each species was assigned to a forest dependency category, following Stiles

Table 1. Transects endpoints and fixed points used for data collection. Coordinates, altitudes, and main habitats covered are reported. The numbers (transects endpoints) and Roman numerals (fixed points) refer to Fig. 1.

Point	Latitude (N)	Longitude (W)	Altitude (m)	Habitat
<i>Transects endpoints</i>				
1	9°51'41.443"	85°4'22.616"	169	forest border
2	9°51'23.389"	85°4'17.476"	209	second growth moist forest
3	9°51'49.331"	85°3'51.354"	208	forest border
4	9°51'57.042"	85°3'37.429"	303	primary moist forest
5	9°51'39.708"	85°3'34.978"	281	primary moist forest
6	9°51'26.557"	85°3'30.434"	302	primary moist forest
7	9°51'23.868"	85°3'21.470"	304	primary moist forest
8	9°51'15.858"	85°3'7.722"	322	primary moist forest
9	9°52'6.845"	85°3'31.392"	314	primary moist forest
10	9°52'19.934"	85°3'19.199"	344	primary transitional forest
11	9°52'15.571"	85°3'15.552"	360	primary transitional forest
12	9°52'5.887"	85°3'2.880"	441	second growth transitional forest
13	9°52'17.663"	85°3'27.983"	333	second growth transitional forest
14	9°52'33.085"	85°3'25.711"	419	second growth dry forest
15	9°52'23.282"	85°3'6.106"	357	second growth transitional forest
16	9°52'22.922"	85°2'51.821"	351	second growth dry forest
17	9°52'14.794"	85°2'44.171"	338	second growth moist forest
18	9°51'57.402"	85°2'44.948"	399	second growth moist forest
19	9°52'21.130"	85°2'41.482"	323	second growth moist forest
20	9°52'26.152"	85°2'25.642"	297	second growth transitional forest
21	9°52'39.241"	85°3'22.784"	418	second growth dry forest
22	9°52'56.755"	85°3'20.632"	388	second growth dry forest
23	9°52'49.343"	85°1'54.440"	216	forest border
24	9°52'54.185"	85°1'35.731"	204	second growth dry forest
25	9°52'5.250"	85°4'20.438"	138	grassland
26	9°52'13.350"	85°4'37.826"	134	grassland
<i>Fixed points</i>				
I	9°51'22.010"	85°4'16.738"	191	second growth moist forest
II	9°51'49.097"	85°3'54.065"	168	forest border
III	9°51'24.757"	85°3'26.129"	302	primary moist forest
IV	9°52'2.154"	85°3'34.945"	307	primary moist forest
V	9°52'20.734"	85°3'17.316"	348	primary transitional forest
VI	9°52'4.746"	85°3'0.396"	411	second growth dry forest
VII	9°51'41.875"	85°3'10.228"	377	second growth transitional forest
VIII	9°52'20.734"	85°2'44.444"	329	second growth transitional forest
IX	9°52'39.076"	85°2'21.340"	270	second growth transitional forest
X	9°52'55.027"	85°1'33.020"	180	forest border
XI	9°53'1.122"	85°3'22.064"	369	second growth dry forest
XII	9°52'1.916"	85°4'19.247"	143	grassland
XIII	9°52'15.254"	85°4'41.401"	121	grassland

(1985) and Sandoval and Barrantes (2009), namely: (1) species that live and reproduce in extensive mature forests, (2) species that inhabit habitats with 40–50% of forest cover, (3) species that live in open areas.

The taxonomic sequence and the scientific and common names of the registered taxa follow the AOU Checklist (American Ornithologists' Union) through the 2016 supplement (Chesser et al. 2016) and the IOC World Bird List (v. 7.3) by Gill and Donsker (2017), with some modifications according to del Hoyo and Collar (2017) and del Hoyo et al. (2017c). The official checklists for Costa Rica considered for comparisons are those provided by Garrigues et al. (2015) and Lepage (2017). The information on the status of each species is derived from the IUCN database (last access: October 2017; IUCN 2017); other information on conservation aspects derives from Species+ database (UNEP 2017) accessed on 20 February 2017 and from the Red list provided by the Ornithological Association of Costa Rica (AOCR 2005). Additional features regarding the biology or the biogeography of some species were obtained from the Handbook of the birds of the world by del Hoyo et al. (1996, 1999, 2001, 2002, 2004), in some cases referring to the updated online version, and from the Global Biodiversity Information Facility (GBIF 2017).

Data resources

The data reported in this paper is deposited at GBIF, the Global Biodiversity Information Facility, http://ipt.pensoft.net/resource.do?r=cr_karen_aves.

Results

In total, 207 bird species in 153 genera, 47 families, and 23 orders were recorded (Table 2; Figs 4–7). The 22 orders of non-passerine birds account for 29 families, 75 genera, and 95 species, while the order Passeriformes includes 18 families, 78 genera, and 112 species. Tyrannidae was the most species rich family, with 29 species, followed by Parulidae (19 species), and Trochilidae (10 species; Fig. 4). These three families mainly included species that normally live in forested areas, being insect or nectar feeders, and that are chiefly resident (Trochilidae, Tyrannidae), or migrant or winter visitors from North America (Parulidae). Thirteen families included a single species each. It must be noted that five of these, namely Anatidae, Scolopacidae, Fregatidae, Ciconiidae, and Threskiornithidae, included water- or seabirds; these species were observed only occasionally in the mainly forested environment of the Karen Mogensen Reserve.

The species accumulation curve based on the surveys led from 2005 to 2017 tended to stabilize, providing an indication of the completeness of the investigations. Plotted values for Chao 1 and 2, Jackknife 1 and 2 estimators were higher than the species richness observed (Fig. 5). The mist-netting activity led from November 2016 to March

Table 2. Checklist of the birds (Aves) observed at the Karen Mogensen Reserve, Nicoya Peninsula, north-western Costa Rica. The systematization, the scientific and common names follow the AOU Checklist (Chesser et al. 2016) and the IOC World Bird List v. 7.3 (Gill and Donsker 2017). Phenological and ecological categorizations follow Garrigues and Dean (2014) and Garrigues et al. (2015). Habitat types are classified following Miller et al. (2015). Height level classification follows Levey and Stiles (1994) with some modifications. Forest dependency categories follow Stiles (1985) and Sandoval and Barrantes (2009) with some modifications. Abbreviations. *Phenology*: **A**: accidental, **M**: migratory, **R**: resident, **RB**: resident breeding, **W**: wintering, **?**: doubtful phenology. *Habitat type*: **1**: moist forest, **2**: dry forest, **3**: forest border, **4**: grassland-pasture, **n.e.**: not evaluated. *Height level*: **1**: understory (from ground level to 4 m); **2**: middle level (main trees trunk); **3**: canopy (uppermost level of the forest); **4**: open air; **n.m.**: not measurable. *Forest dependency category*: **1**: species that lives and reproduces in extensive mature forest; **2**: species that inhabits habitats with 40–50% of forest cover; **3**: species that lives in open areas; **n.e.**, not evaluated.

Taxon	English name	Phenology	Habitat type	Height level	Forest Dependence category
TINAMIFORMES					
Tinamidae					
<i>Crypturellus cinnamomeus</i>	Thicket Tinamou	RB	1,2	1	1
<i>Crypturellus soui</i>	Little Tinamou	RB	1,2	1	1
ANSERIFORMES					
Anatidae					
<i>Cairina moschata</i>	Muscovy Duck	A	3,4	n.m.	n.e.
GALLIFORMES					
Cracidae					
<i>Crax rubra</i>	Great Curassow	RB	1,2	1	1
<i>Ortalis vetula</i>	Plain Chachalaca	RB	2,3	1,2	1,2
<i>Penelope purpurascens</i>	Crested Guan	RB	1,2	2,3	1
Odontophoridae					
<i>Colinus cristatus</i>	Crested Bobwhite	RB	4	1	3
COLUMBIFORMES					
Columbidae					
<i>Claravis pretiosa</i>	Blue Ground-Dove	R	3	1,2	n.e.
<i>Columbina inca</i>	Inca Dove	RB	4	1	2,3
<i>Columbina passerina</i>	Common Ground-Dove	RB	4	1	3
<i>Columbina talpacoti</i>	Ruddy Ground-Dove	RB	4	1	3
<i>Geotrygon montana</i>	Ruddy Quail-Dove	RB	4	1	n.e.
<i>Leptotila plumbeiceps</i>	Gray-headed Dove	R	1	1	n.e.
<i>Leptotila verreauxi</i>	White-tipped Dove	RB	1,2,3,4	1	1,2,3
<i>Patagioenas flavirostris</i>	Red-billed Pigeon	RB	2,3,4	2,3	2,3
<i>Zenaida asiatica</i>	White-winged Dove	RB?	2,3,4	2,3	2,3
CUCULIFORMES					
Cuculidae					
<i>Crotophaga sulcirostris</i>	Groove-billed Ani	RB	3,4	1,2	3
<i>Morococcyx erythropygus</i>	Lesser Ground-Cuckoo	R	2,3,4	1,2	n.e.
<i>Piaya cayana</i>	Squirrel Cuckoo	RB	1,2,3	2,3	1,2
<i>Tapera naevia</i>	Striped Cuckoo	RB	1,3	1,2	2
CAPRIMULGIFORMES					
Caprimulgidae					
<i>Chordeiles acutipennis</i>	Lesser Nighthawk	M	3,4	1,4	n.e.
<i>Chordeiles minor</i>	Common Nighthawk	M	3,4	1,4	n.e.

Taxon	English name	Phenology	Habitat type	Height level	Forest Dependence category
<i>Nyctidromus albigollis</i>	Common Pauraque	RB	1,2,3,4	1	1,2
NYCTIBIFORMES					
Nyctibiidae					
<i>Nyctibius jamaicensis</i>	Northern Potoo	RB	2,3,4	2	2,3
APODIFORMES					
Apodidae					
<i>Chaetura vauxi</i>	Vaux's Swift	R	1,2,3,4	4	n.e.
<i>Panyptila cayennensis</i>	Lesser Swallow-tailed Swift	RB	1	4	1,2,3
<i>Streptoprocne zonaris</i>	White-collared Swift	R	1,2,3,4	4	n.e.
Trochilidae					
<i>Amazilia rutila</i>	Cinnamon Hummingbird	RB	2,3	1	2
<i>Amazilia saucerottii</i>	Steely-vented Hummingbird	RB	1,2,3	1,2	1,2
<i>Amazilia tzacatl</i>	Rufous-tailed Hummingbird	RB	1,2,3	1,2	1,2
<i>Anthracothorax prevostii</i>	Green-breasted Mango	RB	1,2,3	1,2	1,2
<i>Archilochus colubris</i>	Ruby-throated Hummingbird	M, W	1,2,3	1,2	n.e.
<i>Chlorostilbon canivetii</i>	Caniver's Emerald	RB	1,3	1,2	2
<i>Helimaster constantii</i>	Plain-capped Starthroat	RB	2,3,4	2,3	2,3
<i>Hylocharis eliciae</i>	Blue-throated Goldentail	RB	1,2,3	1,2	1,2
<i>Phaeochroa cuvierii</i>	Scaly-breasted Hummingbird	RB?	1,2,3	1,2	1,2
<i>Phaethornis striigularis</i>	Stripe-throated Hermit	RB	1,3	1	1,2
GRUIFORMES					
Rallidae					
<i>Aramides cajaneus</i>	Gray-cowled Wood-Rail	RB	1,2,3	1	1,2
CHARADRIIFORMES					
Scolopacidae					
<i>Actitis macularius</i>	Spotted Sandpiper	A	n.e.	n.m.	n.e.
CICONIIFORMES					
Ciconiidae					
<i>Mycteria americana</i>	Wood Stork	A	4	1,2	n.e.
SULIFORMES					
Fregatidae					
<i>Fregata magnificens</i>	Magnificent Frigatebird	A	n.e.	n.m.	n.e.
PELECANIFORMES					
Ardeidae					
<i>Ardea alba</i>	Great Egret	M	3	1	n.e.
<i>Bubulcus ibis</i>	Cattle Egret	M	4	1	n.e.
<i>Butorides virescens</i>	Green Heron	M	1,2,3,4	1	n.e.
<i>Cochlearius cochlearius</i>	Boat-billed Heron	M	3,4	1,2	n.e.
<i>Egretta caerulea</i>	Little Blue Heron	M	3,4	1	n.e.
<i>Tigrisoma mexicanum</i>	Bare-throated Tiger-Heron	RB	1,3,4	1	1,2,3
Threskiornithidae					
<i>Eudocimus albus</i>	White Ibis	A	n.e.	n.m.	n.e.
CATHARTIFORMES					
Cathartidae					
<i>Cathartes aura</i>	Turkey Vulture	RB	1,2,3,4	3,4	2,3
<i>Coragyps atratus</i>	Black Vulture	RB	1,2,3,4	3,4	2,3
<i>Sarcoramphus papa</i>	King Vulture	R	1,2	3,4	n.e.

Taxon	English name	Phenology	Habitat type	Height level	Forest Dependence category
ACCIPITRIFORMES					
Pandionidae					
<i>Pandion haliaetus</i>	Osprey	A	n.e.	4	n.e.
Accipitridae					
<i>Buteo albonotatus</i>	Zone-tailed Hawk	M	4	4	n.e.
<i>Buteo brachyurus</i>	Short-tailed Hawk	M	1,2,3	4	n.e.
<i>Buteo plagiatus</i>	Gray Hawk	RB?	3,4	2,3	2,3
<i>Buteo platypterus</i>	Broad-winged Hawk	M, W	1,2,3	2,4	n.e.
<i>Buteo swainsonii</i>	Swainson's Hawk	A	4	4	n.e.
<i>Buteogallus anthracinus</i>	Common Black Hawk	A	1,2,3	2,4	n.e.
<i>Ictinia plumbea</i>	Plumbeous Kite	M	1	3,4	n.e.
<i>Leptodon cayanensis</i>	Gray-headed Kite	RB?	1,2,3	3	1,2
<i>Morphnarchus princeps</i>	Barred Hawk	A	1,3	2,4	n.e.
<i>Pseudastur albicollis</i>	White Hawk	RB	1,3	2,4	1,2
<i>Rupornis magnirostris</i>	Roadside Hawk	RB	1,2,3	1,4	2,3
STRIGIFORMES					
Tytonidae					
<i>Tyto alba</i>	Barn Owl	A	3,4	1,2	n.e.
Strigidae					
<i>Ciccaba nigrolineata</i>	Black-and-white Owl	A	1,3	2,3	n.e.
<i>Ciccaba virgata</i>	Mottled Owl	RB	1,2,3	2	1,2
<i>Glaucidium brasilianum</i>	Ferruginous Pygmy-Owl	RB	1,2,3	2,3	1,2
<i>Lophotrix cristata</i>	Crested Owl	RB	1,2,3	1,2	1,2
<i>Megascops choliba</i>	Tropical Screech-Owl	RB?	3	1,2	2
<i>Megascops cooperi</i>	Pacific Screech-Owl	RB	2,3,4	1,2	1,2,3
<i>Megascops guatemalae</i>	Vermiculated Screech-Owl	RB	1	1,2	1
<i>Pulsatrix perspicillata</i>	Spectacled Owl	RB	1,2	2,3	1
TROGONIFORMES					
Trogonidae					
<i>Trogon caligatus</i>	Gartered Trogon	RB	1,3	2,3	1,2
<i>Trogon elegans</i>	Elegant Trogon	RB	1,2,3	2,3	1,2
<i>Trogon melanocephalus</i>	Black-headed Trogon	RB	1,2,3	1,2	1,2
CORACIIFORMES					
Momotidae					
<i>Eumomota superciliosa</i>	Turquoise-browed Motmot	RB	1,2,3	1,2	1,2
<i>Momotus coeruliceps</i>	Blue-capped Motmot	RB	2,3,4	1,2	1,2,3
Alcedinidae					
<i>Megaceryle torquata</i>	Ringed Kingfisher	R	1,3	2	n.e.
<i>Chloroceryle amazona</i>	Amazon Kingfisher	R	1,3	2	n.e.
<i>Chloroceryle americana</i>	Green Kingfisher	RB	1,3	1	2
PICIFORMES					
Bucconidae					
<i>Notharchus hyperrhynchus</i>	White-necked Puffbird	RB	1,2,3	3	1,2
Ramphastidae					
<i>Pteroglossus torquatus</i>	Collared Aracari	RB	1,3	2,3	1,2
Picidae					
<i>Campephilus guatemalensis</i>	Pale-billed Woodpecker	RB	1,2,3	1,2,3	1,2
<i>Dryocopus lineatus</i>	Lineated Woodpecker	RB	1,2,3,4	1,2,3	2

Taxon	English name	Phenology	Habitat type	Height level	Forest Dependence category
<i>Melanerpes hoffmannii</i>	Hoffmann's Woodpecker	RB	2,3,4	2,3	1,2,3
FALCONIFORMES					
Falconidae					
<i>Caracara cheriway</i>	Crested Caracara	RB?	2,3,4	1,3	2,3
<i>Falco rufigularis</i>	Bat Falcon	RB	1,3	3,4	1,2
<i>Herpetotheres cachinnans</i>	Laughing Falcon	RB	1,2,3	2,3	1,2,3
<i>Micrastur semitorquatus</i>	Collared Forest-Falcon	RB	1,2,3	2	1
PSITTACIFORMES					
Psittacidae					
<i>Amazona albifrons</i>	White-fronted Amazon	RB	2,3	2,3	1,2
<i>Amazona auropalliata</i>	Yellow-naped Amazon	R	2,3,4	2,3	2,3
<i>Amazona autumnalis</i>	Red-lored Amazon	RB	1,3	3	1,2
<i>Brotogetis jugularis</i>	Orange-chinned Parakeet	RB	1,2,3	3	2
<i>Eupsittula canicularis</i>	Orange-fronted Parakeet	RB	2,3	3	2
PASSERIFORMES					
Thamnophilidae					
<i>Thamnophilus doliatus</i>	Barred Antshrike	RB	1,2,3	1	1,2
Furnariidae					
<i>Dendrocincla fuliginosa</i>	Plain-brown Woodcreeper	RB?	1	1,2	1
<i>Dendrocincla homochroa</i>	Ruddy Woodcreeper	RB	1,2	1,2	1
<i>Dendrocolaptes sanctithomae</i>	Northern Barred-Woodcreeper	RB	1,2,3	1,2	1,2
<i>Glyphorhynchus spirurus</i>	Wedge-billed Woodcreeper	RB?	1	1,2	1
<i>Lepidocolaptes souleyetii</i>	Streak-headed Woodcreeper	RB	1,2,3	2	1,2
<i>Sittasomus griseicapillus</i>	Olivaceous Woodcreeper	RB	1,2,3	2	1,2
<i>Xenops minutus</i>	Plain Xenops	RB	1,2,3	1,2	1,2
<i>Xiphorhynchus flavigaster</i>	Ivory-billed Woodcreeper	RB	2,3	1,2	1,2
<i>Xiphorhynchus susurrans</i>	Cocoa Woodcreeper	A	1,2,3	1,2,3	1,2
Tyrannidae					
<i>Attila spadiceus</i>	Bright-rumped Attila	RB	1,2,3	1,2	1,2
<i>Camptostoma imberbe</i>	Northern Beardless-Tyrannulet	A	2,3	2,3	n.e.
<i>Contopus sordidulus</i>	Western Wood-Pewee	A	1,2,3	1,2	n.e.
<i>Contopus virens</i>	Eastern Wood-Pewee	M	1,2,3	1,2	n.e.
<i>Elaenia flavogaster</i>	Yellow-bellied Elaenia	RB	3	1,2	2
<i>Empidonax flaviventris</i>	Yellow-bellied Flycatcher	M	1,2,3	1,2	n.e.
<i>Empidonax traillii</i>	Willow Flycatcher	M, W	3	1	n.e.
<i>Legatus leucophaeus</i>	Piratic Flycatcher	A	3	3	n.e.
<i>Megarhynchus pitangua</i>	Boat-billed Flycatcher	RB	1,2,3	2,3	1,2
<i>Mionectes oleagineus</i>	Ochre-bellied Flycatcher	RB	1,3	1,2	1,2
<i>Myiarchus crinitus</i>	Great Crested Flycatcher	M, W	1,2,3	2,3	n.e.
<i>Myiarchus nuttingi</i>	Nutting's Flycatcher	RB	2,3	1,2	1,2
<i>Myiarchus tuberculifer</i>	Dusky-capped Flycatcher	RB	3	1,2	2
<i>Myiarchus tyrannulus</i>	Brown-crested Flycatcher	RB	2,3,4	1,2	2,3
<i>Myiodynastes luteiventris</i>	Sulphur-bellied Flycatcher	A	1,2,3	2,3	n.e.
<i>Myiodynastes maculatus</i>	Streaked Flycatcher	RB	1,2,3	2,3	1,2,3
<i>Myiopagis viridicata</i>	Greenish Elaenia	RB	1,2,3	1,2	1,2
<i>Myiozetetes similis</i>	Social Flycatcher	RB	1,2,3	2,3	2

Taxon	English name	Phenology	Habitat type	Height level	Forest Dependence category
<i>Oncostoma cinereigulare</i>	Northern Bentbill	RB	1,2	1,2	1,2
<i>Onychorhynchus coronatus</i>	Royal Flycatcher	RB	1,2,3	1,2	1,2
<i>Pitangus sulphuratus</i>	Great Kiskadee	RB	1,2,3,4	2	2,3
<i>Platyrinchus cancrominus</i>	Stub-tailed Spadebill	RB	1,2	1	1,2
<i>Poecilotriccus sylvia</i>	Slate-headed Tody-Flycatcher	RB	1,2	1	1,2
<i>Todirostrum cinereum</i>	Common Tody-Flycatcher	RB	1,2,3	1,2	1,2
<i>Tolmomyias sulphurescens</i>	Yellow-olive Flycatcher	RB	1,2,3	1,2	1,2
<i>Tyrannus forficatus</i>	Scissor-tailed Flycatcher	M, W	3,4	2	n.e.
<i>Tyrannus melancholicus</i>	Tropical Kingbird	RB	3,4	2	3
<i>Tyrannus verticalis</i>	Western Kingbird	M, W	2,3,4	2	n.e.
<i>Zimmerius vilissimus</i>	Paltry Tyrannulet	RB	1,2,3	2,3	2
Tityridae					
<i>Pachyramphus aglaiae</i>	Rose-throated Becard	RB	1,2,3	2,3	1,2
<i>Pachyramphus cinnamomeus</i>	Cinnamon Becard	RB?	3	1,2	2
<i>Pachyramphus polychopterus</i>	White-winged Becard	RB	1,3	2,3	1,2
<i>Tityra inquisitor</i>	Black-crowned Tityra	RB?	1,2,3	3	1,2
<i>Tityra semifasciata</i>	Masked Tityra	RB	1,2,3	3	1,2
Cotingidae					
<i>Procnias tricarunculatus</i>	Three-wattled Bellbird	M	1	2,3	n.e.
Pipridae					
<i>Chiroxiphia linearis</i>	Long-tailed Manakin	RB	1,2,3	1,2	1,2
Vireonidae					
<i>Cycalrhis gujanensis</i>	Rufous-browed Peppershrike	RB	1,2,3	2,3	1,2
<i>Pachysylvia decurtata</i>	Lesser Greenlet	RB	1,2,3	2,3	1,2
<i>Vireo flavifrons</i>	Yellow-throated Vireo	M, W	1,2,3	2	n.e.
<i>Vireo flavoviridis</i>	Yellow-green Vireo	A	1,2,3	2	n.e.
<i>Vireo olivaceus</i>	Red-eyed Vireo	M	1,2,3	2,3	n.e.
<i>Vireo philadelphicus</i>	Philadelphia Vireo	M, W	1,2,3	2,3	n.e.
<i>Vireo solitarius</i>	Blue-headed Vireo	M, W	1,2,3	2,3	n.e.
Corvidae					
<i>Cyanocorax formosus</i>	White-throated Magpie-Jay	RB	2,3,4	2	2
Hirundinidae					
<i>Hirundo rustica</i>	Barn Swallow	M	4	4	n.e.
<i>Petrochelidon pyrrhonota</i>	Cliff Swallow	M, W?	4	4	n.e.
<i>Progne chalybea</i>	Gray-breasted Martin	RB	4	4	3
Troglodytidae					
<i>Campylorhynchus capistratus</i>	Rufous-naped Wren	RB	2,3	2,3	1,2
<i>Cantorchilus modestus</i>	Cabanis's Wren	RB	3	1	2
<i>Thryophilus pleurostictus</i>	Banded Wren	RB	1,2,3	1	1,2
<i>Thryophilus rufalbus</i>	Rufous-and-white Wren	RB	1,2,3	1,2	1,2
<i>Troglodytes aedon</i>	House Wren	RB?	3,4	1	2
Poliopitilidae					
<i>Polioptila albiloris</i>	White-lored Gnatcatcher	RB	1,2,3,4	1	2
<i>Polioptila plumbea</i>	Tropical Gnatcatcher	RB	1,2,3	2,3	1,2
<i>Ramphocaenus melanurus</i>	Long-billed Gnatwren	RB	1,2,3	1,2	1,2

Taxon	English name	Phenology	Habitat type	Height level	Forest Dependence category
Turdidae					
<i>Catharus aurantirostris</i>	Orange-billed Nightingale-Thrush	RB	1,3	1	1,2
<i>Catharus ustulatus</i>	Swainson's Thrush	M	1,2,3	1,2	n.e.
<i>Hylocichla mustelina</i>	Wood Thrush	M, W?	1,2,3	1	n.e.
<i>Turdus grayi</i>	Clay-colored Thrush	RB	1,2,3	1,2	2
Fringillidae					
<i>Euphonia affinis</i>	Scrub Euphonia	RB	2,3	2,3	1,2
<i>Euphonia hirundinacea</i>	Yellow-throated Euphonia	RB	1,2,3	2,3	1,2
Parulidae					
<i>Basileuterus rufifrons</i>	Rufous-capped Warbler	RB	1,2,3	1,2	1,2
<i>Cardellina pusilla</i>	Wilson's Warbler	M, W	1,2,3	1,2,3	n.e.
<i>Geothlypis formosa</i>	Kentucky Warbler	M, W	1,2,3	1	n.e.
<i>Geothlypis poliocephala</i>	Gray-crowned Yellowthroat	RB?	4	1	3
<i>Geothlypis trichas</i>	Common Yellowthroat	M	4	1	n.e.
<i>Helmitheros vermivorum</i>	Worm-eating Warbler	M	1,2	1,2	n.e.
<i>Mniotilta varia</i>	Black-and-white Warbler	M, W	1,2,3	2,3	n.e.
<i>Myiothlypis fulvicauda</i>	Buff-rumped Warbler	RB?	2,3	1	1,2
<i>Oreothlypis peregrina</i>	Tennessee Warbler	M, W	3	1,2,3	n.e.
<i>Parlesia motacilla</i>	Louisiana Waterthrush	M	1	1	n.e.
<i>Parlesia noveboracensis</i>	Northern Waterthrush	M, W	1,3	1	n.e.
<i>Protonotaria citrea</i>	Prothonotary Warbler	M, W?	1,3	1	n.e.
<i>Seiurus aurocapilla</i>	Ovenbird	M, W	1,2,3	1	n.e.
<i>Setophaga fusca</i>	Blackburnian Warbler	M	1,3	2,3	n.e.
<i>Setophaga magnolia</i>	Magnolia Warbler	M, W	1,3	2	n.e.
<i>Setophaga pensylvanica</i>	Chestnut-sided Warbler	M, W	1,3	1,2	n.e.
<i>Setophaga petechia</i>	Yellow Warbler	A	3	1	n.e.
<i>Setophaga ruticilla</i>	American Redstart	M	1,2,3	1,2,3	n.e.
<i>Setophaga virens</i>	Black-throated Green Warbler	M, W	1,3	2,3	n.e.
Thraupidae					
<i>Cyanerpes cyaneus</i>	Red-legged Honeycreeper	RB	1,2,3	2,3	1,2
<i>Eucometis penicillata</i>	Gray-headed Tanager	RB	1,2,3	1	1,2
<i>Saltator coerulescens</i>	Grayish Saltator	RB	3	1	2
<i>Saltator maximus</i>	Buff-throated Saltator	RB	3	2	2
<i>Sporophila torqueola</i>	White-collared Seedeater	RB	4	1	3
<i>Thraupis episcopus</i>	Blue-gray Tanager	RB	1,2,3,4	2	1,2,3
<i>Tiaris olivaceus</i>	Yellow-faced Grassquit	RB?	4	1	3
<i>Volatinia jacarina</i>	Blue-black Grassquit	RB	4	1	3
Passerellidae					
<i>Arremonops rufivirgatus</i>	Olive Sparrow	RB	2,3	1	1,2
<i>Peucaea ruficauda</i>	Stripe-headed Sparrow	RB	3,4	1	2,3
Cardinalidae					
<i>Cyanocopsa cyanoidea</i>	Blue-black Grosbeak	RB	1,3	1	1,2
<i>Habia rubica</i>	Red-crowned Ant-Tanager	RB	1,2	1	1
<i>Passerina caerulea</i>	Blue Grosbeak	RB?	2,3,4	1	2,3
<i>Passerina ciris</i>	Painted Bunting	M	1,2,3,4	1	n.e.
<i>Passerina cyanea</i>	Indigo Bunting	M, W	4	1	n.e.

Taxon	English name	Phenology	Habitat type	Height level	Forest Dependence category
<i>Pheucticus ludovicianus</i>	Rose-breasted Grosbeak	M, W	3	1,2	n.e.
<i>Piranga ludoviciana</i>	Western Tanager	M, W	1,2,3	2,3	n.e.
<i>Piranga olivacea</i>	Scarlet Tanager	M	1,2,3	2,3	n.e.
<i>Piranga rubra</i>	Summer Tanager	M, W	1,2,3	2,3	n.e.
Icteridae					
<i>Amblycercus holosericeus</i>	Yellow-billed Cacique	RB	1,2,3	1	1,2
<i>Icterus galbula</i>	Baltimore Oriole	M, W	3	2,3	n.e.
<i>Icterus pustulatus</i>	Streak-backed Oriole	RB	2,3	2,3	1,2
<i>Molothrus bonariensis</i>	Shiny Cowbird	A	3,4	1,2	n.e.

2017 allowed to capture over 60 species of mainly passerine birds, one of which, *Vireo flavoviridis* (Vireonidae), was not previously recorded in the Karen Mogensen Reserve. In addition, individuals of species observed only occasionally were captured (e.g., the tyrant flycatcher *Myiodynastes luteiventris*). The capture of *Dendrocincla fuliginosa* (Furnariidae) was interesting as well, because it provided information on a species considered only potentially breeding in the Karen Mogensen Reserve. The capture of the following species was relevant nonetheless for different reasons: *Hylocichla mustelina* (Turdidae) and *Passerina ciris* (Cardinalidae), threatened at a global scale, *Campylorhynchus capistratus*, present with a subspecies limited to the Nicoya Peninsula (*C. capistratus nicoyae*; see below), and *Catharus aurantiirostris*, characterized by a local breeding population (see below for details). Eventually, the use of mist-nets allowed to collect data on species rarely observed, namely: *Xenops minutus* and *Dendrocincla homochroa* (Furnariidae), *Tolmomyias sulphureus*, *Mionectes oleagineus* and *Platyrinchus cancrominus* (Tyrannidae), *Ramphocaenus melanurus* (Poliopitidae), *Protonotaria citrea* (Parulidae).

Overall, 138 species were documented (70 non-passerines and 68 Passeriformes) that were resident in the Karen Mogensen Reserve and/or in the surrounding areas. Of these, 115 species (56 non-passerines and 59 Passeriformes) were breeding in the surveyed area (not always regularly), while another 14 species (six non-passerines and eight Passeriformes) were potentially breeding in the protected zone or, likely, in the adjacent forested land, as they were observed during their breeding season and showed territorial behavior. Eight species were resident but not breeding in the area. Forty-nine species were migratory; 23 of these also spent the winter in the Karen Mogensen Reserve, and another three were potentially wintering species. The remaining 20 species have been recorded one to ten times in the study period, thus were considered accidental in the Karen Mogensen Reserve (Fig. 8A).

Two species, i.e., *Melanerpes hoffmannii* (Picidae) and *Procnias tricarunculatus* (Cotingidae), are endemic to an area ranging from southern Honduras to Panama. *M. hoffmannii* was found breeding in the area, whereas *P. tricarunculatus* was observed only irregularly. In addition, we report the presence and breeding of four subspecies endemic to northwestern Costa Rica, namely: *Crypturellus cinnamomeus praepes* (Tinamidae), *Chlorostilbon canivetii salvini* (Trochilidae), *Xiphorhynchus flavigaster ultimus* (Furnariidae) and *Campylorhynchus capistratus nicoyae* (Troglodytidae; Fig. 7B). Furthermore,

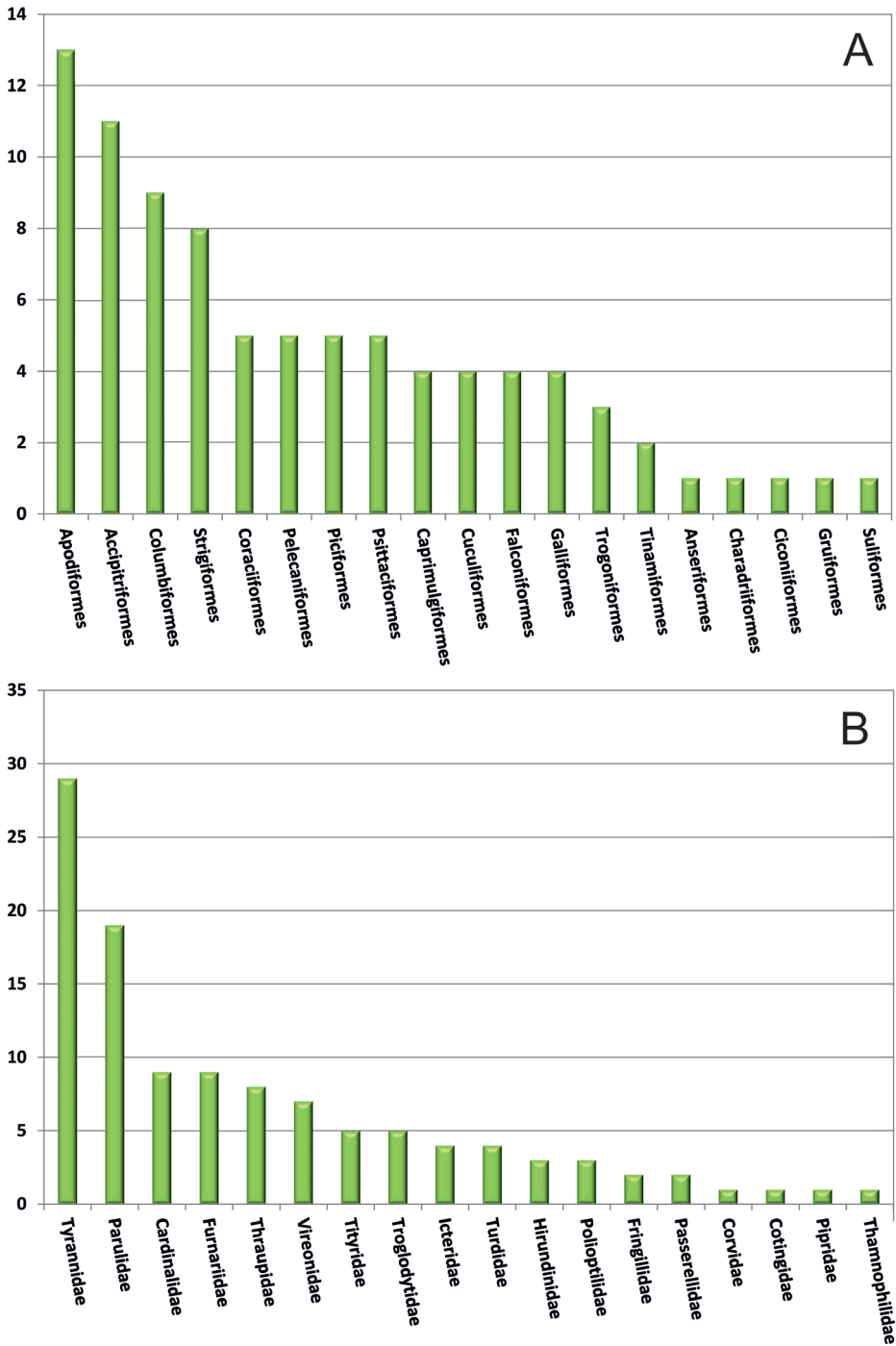


Figure 4. Avian richness of the Karen Mogensen Reserve. Histograms reporting the number of recorded species for each of the non-passerine orders (**A**) and of the passerine families (**B**).

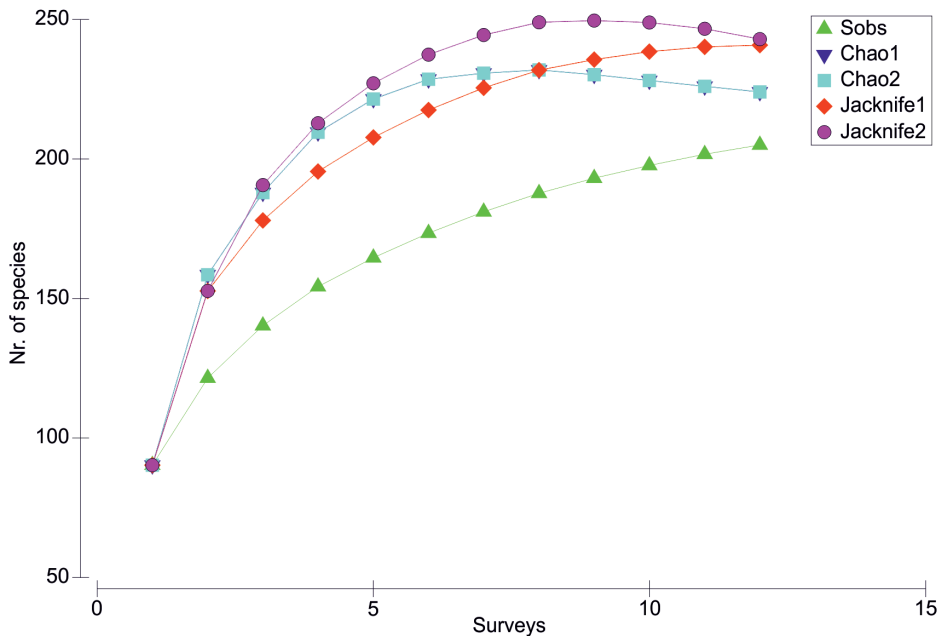


Figure 5. Species accumulation curves based on the surveys from 2005 to 2017. “Sobs” is the permuted observed species accumulation (1000 permutations).

the presence of isolated breeding populations of *Ortalis vetula* (Cracidae) and *Catharus aurantiirostris* were detected (Turdidae; Fig. 7D; see below for further information).

Interestingly, 26 mainly resident breeding or potentially breeding species reach their global southernmost range border within the Nicoya Peninsula or the adjacent areas, i.e., *Crypturellus cinnamomeus* (Tinamidae), *Ortalis vetula* (Cracidae), *Columbina inca* (Columbidae), *Morococcyx erythropygus* (Cuculidae), *Nyctibius jamaicensis* (Nyctibiidae), *Amazilia rutila* and *Chlorostilbon canivetii* (Trochilidae), *Buteo plagiatus* (Accipitridae), *Megascops cooperi* (Strigidae), *Trogon elegans* and *T. melanocephalus* (Trogonidae; Fig. 6E), *Eumomota superciliosa* (Momotidae; Fig. 6F), *Melanerpes hoffmannii* (Picidae), *Eupsittula canicularis* and *Amazona albifrons* (Psittacidae), *Xiphorhynchus flavigaster* (Furnariidae), *Chiroxiphia linearis* (Pipridae; Fig. 7A), *Cyanocorax formosus* (Corvidae), *Polioptila albiloris* (Poliptilidae), *Campylorhynchus capistratus* (Fig. 7B) and *Thryophilus pleurostictus* (Troglodytidae), *Euphonia affinis* (Fringillidae), *Arremonops rufivirgatus* and *Peucaea ruficauda* (Passerellidae), *Passerina caerulea* (Cardinalidae), and *Icterus pustulatus* (Icteridae). In addition, a migratory species, *Piranga ludoviciana* (Thraupidae), reaches its southernmost wintering area within the Peninsula, and a second species, *Amazona auropalliata* (Psittacidae), resulted resident in the past but has been reported only occasionally in recent years.

Focusing on the habitat type, eight species were strictly connected to moist forest environments, and six of them potentially reproduced in the area. Another 24 species were associated to moist forests and forest borders. Eighty-seven species were related

to either moist or dry forests, and, in some cases, also forest borders. None of the registered species was strictly associated to dry forests, but 12 taxa were associated to dry forests and their borders, and 13 species were associated to dry forests, forest borders, and grassland. Fifteen species were associated to forest borders, and 18 to grassland only (Fig. 8B). Thirteen species were typically associated to both forest edges and grassland. Eventually, eleven species did not show any preference for specific habitats, and can be found from moist forests to grasslands. To sum up this information, as expected a priori, the majority (65%) of the registered species is strictly connected to a forested environment: 32 to moist forests and their borders, 12 to dry forest environments and their edges, and 86 to either moist or dry forests (Fig. 8B).

Regarding vertical distribution (tree height level), 54 species were associated to the understory, 53 to either the understory and middle tree level, 15 to middle level only, 42 to both middle level and canopy, nine to canopy, four to middle level and open air, five to canopy and open air, eleven to open air, and only six species show no preference, being found from understory to canopy (Fig. 8C).

Of 129 resident breeding or potentially breeding species, eleven species were found and reproduced only in extensive mature forests, 20 in habitats with 40–50% of forest cover, 65 in both extensive mature forests and in habitats with 40–50% of forest cover, ten in open areas, 14 in both open areas and habitats with 40–50% of forest cover, and nine appeared to be not specifically associated to any of the three categories (Fig. 8D).

Five species that are on the Red List of globally threatened bird species (IUCN 2017) were detected, comprising three species classified as Vulnerable (*Crax rubra*, *Amazona auropalliata* and *Procnias tricarunculatus*), and two species classified as Near Threatened (*Hylocichla mustelina* and *Passerina ciris*). *C. rubra* was a resident breeder in the Karen Mogensen Reserve (Fig. 6A), whereas *H. mustelina* (Fig. 7C), and *P. ciris* were regular winter visitors, and *P. tricarunculatus* was observed only occasionally in the area during the winter season. *A. auropalliata* was resident in the first years after the establishment of the Karen Mogensen Reserve but has been observed only occasionally during the last surveys (see below). Another eight species are considered threatened at the national level and are included in the Costa Rican red list (AOCR 2005). These species are characterized by declining populations, namely: *Cairina moschata*, *Penelope purpurascens*, *Sarcoramphus papa* (Fig. 6C), *Lophotrix cristata*, *Falco rufigularis*, *Amazona autumnalis* (Fig. 6B), *Brotogeris jugularis*, and *Eupsittula canicularis*. More generally, this red list reports all the species included in Appendix II of CITES (UNEP 2017), thus all the 36 (overall) members of the families: Trochilidae (ten spp.), Pandionidae (one sp.), Accipitridae (eleven spp.), Falconidae (four spp.), Tytonidae (one sp.), and Strigidae (eight spp.). Summarizing, approximately one fourth (49 species altogether) of the total number of species recorded in the Karen Mogensen Reserve is considered significant in terms of bird conservation at a global or national level.

Based on the range maps by Garrigues and Dean (2014) and del Hoyo et al. (1996, 1999, 2001, 2002, 2004, plus online update), six species previously unknown from the Nicoya Peninsula were actually present within the Karen Mogensen Reserve, and represent range extensions of at least 100 km. These are: *Geotrygon montana* (Colum-

idae), *Panyptila cayennensis* (Apodidae), *Ciccaba nigrolineata* (Strigidae), *Xiphorhynchus susurrans* (Furnariidae), *Hylocichla mustelina* (Turdidae), and *Molothrus bonariensis* (Icteridae). Two of these, viz. *G. montana* and *P. cayennensis*, were found breeding in the area, and another one, *H. mustelina*, was a regular winter visitor. The presence of *C. nigrolineata* and *Xiphorhynchus susurrans* was detected in some occasions only during the last ornithological surveys (November 2016–March 2017), hence these species were considered accidental in the protected zone. We highlight that the icterid *M. bonariensis* is reported for the first time from the northwestern Pacific slope of Costa Rica (see below for additional details). Eventually, another species present in the area, *Tiaris olivaceus* (Thraupidae), was not reported in range maps prior to this study (e.g., Garrigues and Dean 2014), although previous records by MacArthur (1972), Villareal Orias et al. (2003), and Rising (2017) were known.

In the following accounts details on eight species of particular taxonomic, biogeographic, and/or conservational interest are provided.

Accounts on species of interest

Great Curassow (*Crax rubra* Linnaeus, 1758; Fig. 6A)

Great Curassow is considered globally Vulnerable (IUCN 2017) and listed in the Appendix III of CITES (UNEP 2017). The species has undergone a rapid decline due to a high hunting pressure and habitat loss and fragmentation (BirdLife International 2016a). Although widespread in Costa Rica, it is observed mainly in protected areas and results uncommon to rare in the northwestern part of the country, where a reintroduction project has taken place recently (Zepeda 2006). Until the 1990s the distribution of this species in the Nicoya Peninsula was limited to the Cabo Blanco Absolute Natural Reserve, at the southernmost point of the peninsula. In the last decade, due to the natural forest regeneration, *C. rubra* has reached the Karen Mogensen Reserve, where it was historically known to occur. Several direct observations of isolated adult individuals were made, frequently during feeding activity on *Manilkara chicle* fruits. The species reproduced in the surveyed zone with an estimated three to four pairs. Further investigations are needed to verify the size of the local population in suitable habitats of the Karen Mogensen Reserve. This knowledge is the basis for the development of local conservation actions aimed at widening land protection and reducing hunting as suggested by BirdLife International (2016a).

Plain Chachalaca (*Ortalis vetula* [Wagler, 1830])

This species was often associated to dry forests or shrub covering the foothills. The Plain Chachalaca is sedentary breeding in the Karen Mogensen Reserve, where it is commonly observed or detected due to its typical loud call. It represents one of the most intriguing



Figure 6. Non-passerine birds observed within the Karen Mogensen Reserve. **A** *Crax rubra* (Cracidae), a globally vulnerable species that reproduces in the area **B** *Amazona autumnalis* (Psittacidae), species resident and potentially breeding in the area, characterized by declining populations and considered threatened on a national scale **C** *Sarcoramphus papa* (Cathartidae), species resident in the area, with declining populations and considered locally threatened **D** *Chlorostilbon canivetii* (Trochilidae), female at nest, characterized by traits (e.g., the colour of the lower mandible) which resemble the congeneric *C. assimilis* **E** *Trogon melanocephalus* (Trogonidae) and **F** *Eumomota superciliosa* (Momotidae), two species that reach their southernmost range border approximately in the surveyed zone. Photographs by: M. Dal Zotto (**F**) and G. Romeo (**A, B, C, D, E**).

taxa of the site, since the individuals from the Karen Mogensen Reserve are part of the southernmost isolated population occurring in NW Costa Rica, and isolated from the main range of the species, which covers an area from N Nicaragua to S Texas. This population was formerly considered as White-bellied Chachalaca (*O. leucogastra*), a species living in NW Nicaragua, and more recently assigned to the present species, distinguished from the congeneric Gray-headed Chachalaca (*O. cinereiceps*) which is found elsewhere in Costa Rica. Recent studies hypothesize that this isolated population may represent an undescribed subspecies of the present species or even a distinct species, as the plumage coloration and voice differ from northern populations (del Hoyo and Kirwan 2017).

Canivet's Emerald (*Chlorostilbon canivetii* [Lesson, 1832])

The presence of Canivet's Emerald in the Karen Mogensen Reserve falls within the range documented for this species, which inhabits only the northwestern highlands of the country. Three subspecies of *C. canivetii* are known, one of which, *C. c. salvini* (Cabanis & Heine, 1860), is endemic to Costa Rica (see del Hoyo et al. 2017). Beyond the observation of this subspecies, an interesting record concerns a breeding pair (Fig. 6D) which showed traits that resembled *C. assimilis*, endemic to central and southern Costa Rica and Panama. The most relevant features, which differed from typical *C. canivetii*, were the shallower tail fork and the mostly black bill with red coloration restricted to the basis of the lower mandible. According to the information of the National Biodiversity Institute (INBio, see Calderón 2017), the populations of *C. assimilis* living in the area of the Carara National Park (some 50 km to the east of the Karen Mogensen Reserve) and southwards show similar traits to those observed by us. It is likely that the range of this peculiar population reaches also the Nicoya Peninsula. Further studies are warranted to verify the possible presence of *C. assimilis* in the Karen Mogensen Reserve.

Yellow-naped Amazon (*Amazona auropalliata* [Lesson, 1842])

The distribution of this Psittacid is limited to the northwestern part of the country, where it reaches the southernmost portion of its global range (del Hoyo et al. 2017b). *A. auropalliata* was resident and relatively common in the Karen Mogensen Reserve during the 1990s, but its range has contracted over years. At present it is mainly found a few kilometers away from the protected area in other localities of the Nicoya Peninsula and on the Nicoya Gulf Islands. Paradoxically, the main cause of this trend is the reforestation of the area, which had a negative impact on this species, which prefers semi-arid woodlands, savannas, and similar environments. A second, more general, cause of the progressive local decline is capture for the cage bird trade. The global population is estimated at less than 50,000 and possibly fewer than 10,000 individuals (del Hoyo et al. 2017b). For these reasons, the Yellow-naped Amazon is considered Vulnerable on a global scale (IUCN 2017).

Three-wattled Bellbird (*Procnias tricarunculatus* [Verreaux & Verreaux, 1853])

The Three-wattled Bellbird was encountered on different occasions from 1998 to 2016, from December to May. This species is known to be a winter visitor in the inner and eastern portion of the Nicoya Peninsula and migrates to the highlands of Central Costa Rica or to other countries for breeding (Stiles and Skutch 1989; Powell and Bjork 2004). A major threat of this species is habitat loss, especially in its wintering areas, which are poorly represented in the protected area system (Powell and Bjork 2004). Since this species is considered globally Vulnerable (IUCN 2017), mainly because of rapid population declines deriving from deforestation in its non-breeding areas (Bird-Life International 2016b), our observations hopefully will stimulate further efforts to assess its presence in the Karen Mogensen Reserve, and improve conservation action within its wintering range.

Orange-billed Nightingale-Thrush (*Catharus aurantiirostris* Salvin, 1866; Fig. 7D)

This species is relatively easy to observe in the Karen Mogensen Reserve during the breeding season (March-August), but is more difficult to find during the rest of the year. The Costa Rican populations of Orange-billed Nightingale-Thrush are considered to belong to the subspecies *C. a. costaricensis* Hellmayr, 1902, except for those in southwestern Costa Rica, which are treated as a different subspecies *C. a. griseiceps* Salvin, 1866 (see Collar 2017). Within the Nicoya Peninsula this species is typically observed above 600 m a.s.l. (Villareal Orias et al. 2003). In the Karen Mogensen Reserve it was normally seen at around 300 m a.s.l. Apparently, the external morphology of the individuals from the surveyed area resembles that of the populations from the Central Cordilleras of Costa Rica, but the vocalizations are different. It must be noted that since the 1930s, a population was known from the highest hills of the Peninsula, isolated from those of the Central Cordilleras. This population was initially named as a distinct subspecies, *C. a. bathoica* (Bangs and Griscom 1932), but is currently merged with *C. a. costaricensis* (Collar 2017). This fact, together with the aforementioned reasons, warrant further study of morphological and molecular characters to ascertain the taxonomic status of the population inhabiting the Karen Mogensen Reserve.

Wood Thrush (*Hylocichla mustelina* Gmelin, 1789; Fig. 7C)

This thrush is a regular winter visitor and migrant in Costa Rica (October to April), reaching its southernmost range in Panama and NW Colombia. Thanks to the present study *H. mustelina* is reported for the first time from the Nicoya Peninsula and NW Costa Rica. The species is currently considered Near Threatened. The main threat to this species is believed to be loss and fragmentation of forests in both the breeding and wintering ranges (Collar and Sharpe 2017), along with brood-parasitism by the



Figure 7. Passeriformes observed within the Karen Mogensen Reserve. **A** *Chiroxiphia linearis* (Pipridae), a species typical of Central American tropical dry forests reaching its southernmost range border in the area **B** *Campylorhynchus capistratus nicoyae* (Troglodytidae), a subspecies endemic to NW Costa Rica, which reaches its southernmost breeding areas in the surveyed zone **C** *Catharus aurantirostris* (Turdidae), species characterized by a local isolated breeding population **D** *Hylocichla mustelina* (Turdidae), regular winter visitor in the Karen Mogensen Reserve, but never recorded before from the Nicoya Peninsula. Photographs by: M. Dal Zotto (**A, B, D**) and G. Romeo (**C**).

Brown-headed Cowbird (*Molothrus ater*; Etterson et al. 2014). Various studies have recommended that population trends be monitored to investigate the direct causes of the decline, and to increase the protection of suitable habitats in both breeding and non-breeding ranges (see BirdLife International 2017).

Shiny Cowbird (*Molothrus bonariensis* Gmelin, 1789)

The main range of this species is located in South America and is expanding northwards. It has recently reached Panama and, in 2004, the eastern slope of Costa Rica (Sandoval et al. 2010, Garrigues and Dean 2014). There have been one record from Cocos Island (550 km from the Pacific shore of Costa Rica; Garrigues et al. 2015)

and a few records from the Southern Pacific slope of the country are known (GBIF 2017). The observation of two flocks in the Karen Mogensen Reserve in March 2016 is the first report for the Nicoya Peninsula and northwestern Costa Rica. Since Shiny Cowbird is a generalist brood parasite of many other passerine birds (approximately 30 species breeding in the Karen Mogensen Reserve are potential hosts), and has strongly negative effects on the hosts' reproduction rates (Massoni and Reboreda 1999), further monitoring is recommended to assess whether this species has permanently colonized the area and whether conservation actions are warranted within the protected zone.

Discussion

The species list resulting from our study is one of the most comprehensive for any site in the Nicoya Peninsula. Compared to other areas, the Karen Mogensen Reserve shows one of the highest species richness of the inland Peninsula. For instance, Villareal Orias et al. (2003) recorded 46 to 130 species from nine different zones in the Peninsula, and Solano et al. (2004) registered 158 species from three sites altogether. The relative richness of the Karen Mogensen Reserve (207 species altogether) may be attributed to its habitat heterogeneity, the presence of moist forest patches (which are otherwise rare in the region), and from its moderately complex topography, a factor known to increase bird diversity (see e.g., Mayr and Diamond 2001). Nonetheless, some National Parks of Costa Rica or the adjacent Panama show a higher overall avian species richness, typically reaching 300 to over 400 species (e.g., Slud 1980, Angehr et al. 2006). This is likely due to these areas being larger in size, but also to the general trend of lower species richness in more seasonal, drier habitats of the northern Pacific slope relative to the wetter, less seasonal southern Pacific or Caribbean forests, as pointed out by similar investigations led in Panama (Karr 1976; Ridgely and Gwynne 1989).

The present study shows that the avian community of the Karen Mogensen Reserve represents an assemblage of species typical of both the Central American dry forest environments and the moist forest of southern Pacific Costa Rica (see Stotz et al. 1996). Examples of the former group are *Morococcyx erythropygus* (Cuculidae), *Megascops cooperi* (Strigidae), *Xiphorhynchus flavigaster* (Furnariidae), *Platyrhynchus cancrinus* (Tyrannidae), *Chiroxiphia linearis* (Pipridae; Fig. 7A), and *Cyanocorax formosus* (Corvidae), while of the latter *Cyanocompsa cyanoides* (Cardinalidae) and *Euphonia hirundinacea* (Thraupidae). Similar results were reported by Solano et al. (2004) from other foothill areas of the Nicoya Peninsula. As written above, the presence of patches of moist forest and a widespread dry to moist transitional forest, together with the local occurrence of a relatively short dry season (see Sánchez-Murillo et al. 2013), distinguish this area from the greatest part of the Nicoya Peninsula, making it rather similar to the southern Pacific lowlands, which are among the richest of Costa Rica in terms of bird diversity and presence of endemic taxa.

Most (138 of 207) species were resident in the Karen Mogensen Reserve, and most of these were also breeding in the area or in the adjacent forested land (115 species plus

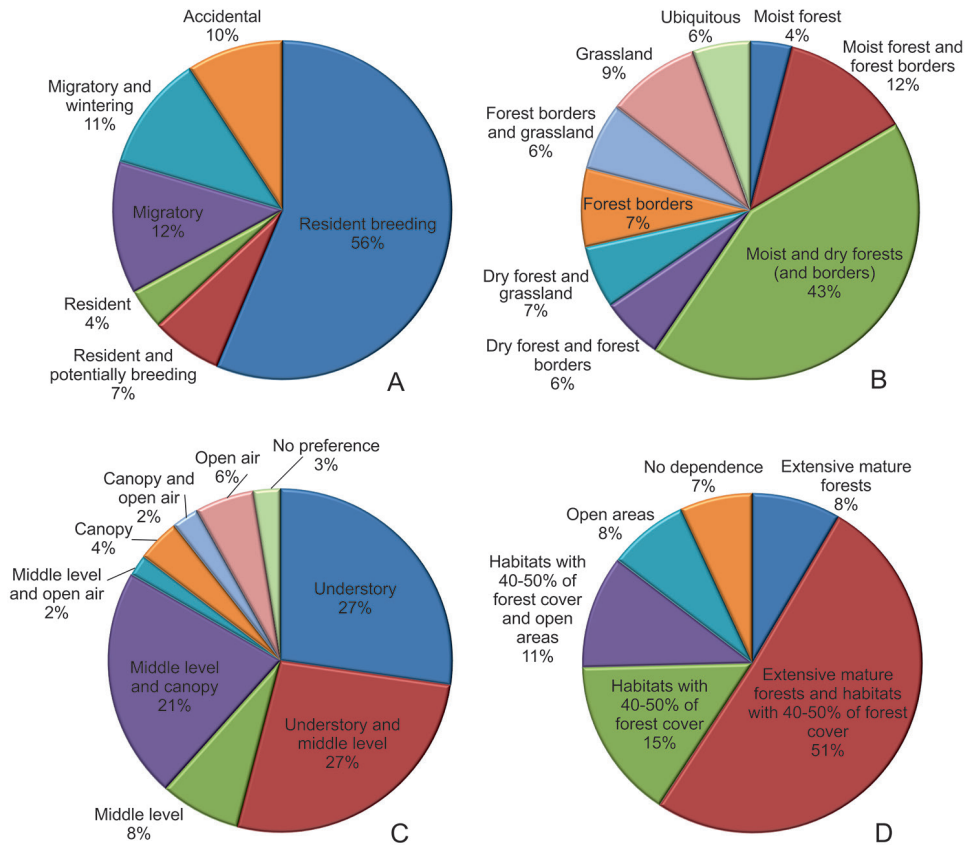


Figure 8. Ecological characterization of the avian community of the Karen Mogensen Reserve. Percentage of the recorded species based on: **A** Phenology **B** Habitat type **C** Height level **D** Forest dependency category.

other 14 species potentially breeding; Fig. 8A). These numbers are similar to the findings of Barrantes et al. (2016), who reported 109–135 breeding species from the dry forests of four National Parks of NW Costa Rica (Diriá, Palo Verde, Rincón de la Vieja, Santa Rosa), the smallest of which covering more than 5,000 hectares, and 104 species from the Cabo Blanco Absolute Natural Reserve (ca. 1000 hectares): the first protected area of the country. This comparison underscores the species richness of the Karen Mogensen Reserve despite its relatively small dimensions, even if it must be noted for the purpose that the surrounding and partially protected forests constitute a natural extension of the Wildlife Refuge, where some of the above mentioned species spend part of their life and may reproduce as well. The number of bird species in the Karen Mogensen Reserve increases during migration and late winter, often exceeding 160 species. From a biogeographic perspective, our study has expanded the known breeding range of two species (*G. montana* and *P. cayennensis*) formerly unknown for NW Costa Rica, and the wintering range of another, *H. mustelina*, which was never observed before within this region.

As reported above, 28 species are at the southernmost borders of their range. These populations are likely vulnerable to the future effects of climate change, and may eventually decline or even disappear, moving to more suitable areas, (see, e.g., La Sorte and Jetz 2010). An additional concern derives from several authoritative studies (see, e.g., Thomas et al. 2004, Mora et al. 2013 and related literature) reporting that exceptional climate change will occur earliest in the tropics. Since these areas have less variability in their weather than moderate-climate countries, the organisms that constitute their ecosystems are unlikely to tolerate temperatures outside their narrow range, which has existed for thousands of years, and, consequently, these taxa will reach extinction faster and earlier than those living at intermediate latitudes. As a consequence of this, most of the species recorded, starting with those that are primarily connected to tropical forests as resident breeding, should be considered at risk.

To address future conservation problems properly, it is necessary to focus on the specific ecological traits of these species. The majority of the species recorded during our study were restricted to forested environments, and this aspect underscores the importance of the Karen Mogensen Reserve as a wildlife refuge for such specialized taxa. Our analysis pointed out that 59% of the total number of species (122/207) was connected to either the understory or the middle tree level, and another 20% (42 species) is associated to middle level and canopy or open air (Fig. 8C). These proportions are similar to those in other protected areas from NW Costa Rica, as, e.g., the Bosque Nacional Diríá (Villareal Orias et al. 2003). The vertical distribution of the species is a very important factor to understand the structure of the habitat (Braker and Greene 1994), since it suggests the behaviour of the animals and their susceptibility to the modifications of vegetation. As reported by Levey and Stiles (1994), the aforementioned taxa are normally sedentary or have limited ranges, and for these reasons they are much more vulnerable to the alterations to the structure of the vegetation, which can fragment isolated populations and promote the local extinction of some species. For instance, the opening of paths, the building of infrastructures or cutting off vegetation, affect the taxa associated to these forest levels in different ways.

More generally, the species connected to the upper middle level exhibit major local horizontal or altitudinal shifting (Levey and Stiles 1994), while the birds of the understory or the understory and middle level are more vulnerable to human alterations. Since these latest taxa normally occupy restricted areas and tend to be sedentary, their local populations are more vulnerable to fragmentation, which is among the first steps toward extinction, at least on a local scale (Levey and Stiles 1994). Nonetheless, the majority of the species associated to the middle level are both ecologically and geographically restricted. For all the above mentioned reasons, most of the recorded taxa were restricted to a few protected areas, in contrast to the species typical of forest borders or not strictly related to forested environments, which tend to occupy a variety of habitats in different geographic areas (Stiles 1985). The ongoing natural forest regeneration that has characterized the surveyed area from the mid 1990s, allowed several species to colonize (e.g., *G. montana* or, likely, *C. nigrolineata*) or, mainly, recolonize the zone after many years of absence due to land use as cattle pasture. This process is

likely to generate a progressive disappearance of species typical of open land, such as some Thraupidae, and also a globally threatened species (*A. auropalliata*, see above). By reducing habitat diversity, spontaneous ecological succession is likely to reduce the overall species richness of the Karen Mogensen Reserve, even if the ecological value of the whole community gradually increases.

The occurrence of three globally Vulnerable species, plus other two Near Threatened, out of the 23 listed from the all of Costa Rica, and the finding of other 44 species – mainly resident and breeding or potentially breeding in the Karen Mogensen Reserve – considered threatened on a national scale (AOCR 2005), provide a strong argument for increased conservation efforts in the area. Moreover, the occurrence and breeding of three endemic species and four endemic subspecies (see above) together with isolated populations of *Ortalis vetula* and *Catharus aurantiirostris* (Fig. 7D), disjunct from the species' main ranges, are additional arguments for supporting the development of conservation actions in the area. The presence and breeding of large species, including *Crax rubra* (Fig. 6A) and *Penelope purpurascens* (Cracidae), provide additional evidence that the avian community of the Karen Mogensen Reserve is relatively intact, and therefore has considerable conservation value.

Furthermore, based on the forest dependence categorization, the proportion of species included in the three categories of forest dependency was roughly similar to the one detected by Barrantes and colleagues (2016) in other much broader protected areas of the Nicoya Peninsula (see above), underlining the importance of the Karen Mogensen Reserve for the local avian conservation. Most of the resident breeding species, i.e., 97 out of 129 (Fig. 8D), corresponding to almost half of the total number of recorded species (207), are restricted to forested environments. From a conservation perspective, these taxa are most affected by habitat fragmentation and more susceptible to global climatic change, since they require large mature forests to maintain stable populations (Stiles 1985). The expected increase of droughts in the region (Sheffield and Wood 2008), and the changes that could follow the increasing frequency of El-Niño Southern Oscillation (ENSO) events (Cai et al. 2014), are likely to cause longer and more intense dry seasons. The consequent intensification of the frequency of wild fires is progressively changing the structure of the northwestern Costa Rican forests (Barlow and Peres 2004) which are considered the most threatened forest ecosystem in Mesoamerica (see Janzen 1988, Huettmann 2015). These processes are altering the avian communities associated to the typical habitats of the Nicoya Peninsula (Barrantes et al. 2016).

Human induced habitat destruction and the reduction of connectivity due to the removal of isolated forest patches are likely to be additional causes of the progressive disappearance of bird populations. The genetic variability of populations limited to isolated forest patches and affected by global and local environmental alterations, may decrease in a short-term, greatly reducing their viability (see e.g. Evans and Sheldon 2008). As pointed out by Barrantes et al. (2016), the fragmentation of the originally widespread dry forest in NW Costa Rica into small isolated patches, has originated a nested pattern of bird assemblages and species, for which long-term maintenance is threatened by lack of connectivity, habitat destruction, recurrent fires, and global climatic changes. Within

this problematic context, the Karen Mogensen Reserve has proven to be a reservoir of several species, many of which associated to the threatened Central American dry forests, thus playing a crucial role in the conservation of the local avifauna. The data collected during this study stimulates the development of concrete conservation actions as the creation of connections with other protected areas, the widening of the boundaries of Karen Mogensen Reserve, and the improvement of habitat restoration.

The present results underscore that further analyses are desirable, including studies aimed at clarification of (i) the taxonomic status of some local populations, (ii) the phenology of some species, (iii) the population-viability of the most vulnerable taxa, and (iv) the vulnerability of species to climate change. More generally, locally-based bird monitoring programs are essential for understanding and mitigating the effects of global change on tropical biodiversity. To measure population change and other demographic parameters – essential actions during the ongoing natural restoration of the forested environment – a long-term bird banding station should be established and supported, also considering that it would provide tools and staff for monitoring and conservation programs focused on other organisms. The presence of the recently inaugurated research station, “Italia-Costa Rica” within the Karen Mogensen Reserve represents an excellent basis for the development of this initiative.

Since birds are good environmental indicators, are relatively easy to monitor, and have a universal appeal as charismatic flagship taxa, they raise the interest of people worldwide. Therefore, short- and long-term bird monitoring and conservation initiatives need to be included in programs that involve the local communities, by promoting environmental education, capacity-building, and income generation or job creation. The educational activities should address students, villagers, conservationists, decision-makers, journalists, and other local people and should better comprise the participation of local universities, museums, and research institutions. Such integrated processes are known as some of the best examples of holistic biodiversity-monitoring programs (Latta and Faaborg 2009, Şekercioğlu 2012). The first steps in this direction have been carried out and we hope that many other will follow, in the consciousness that the spreading of scientific knowledge and the involvement of local stakeholders in the research are the main driving forces for the conservation of biodiversity.

Conclusions

Our results show that the Karen Mogensen Reserve hosts a rich and diversified avian community, and, acting as an island in the surrounding context of NW Costa Rica, is a potential refuge for several birds, as reported in the present analysis, and for other metazoans, such as amphibians and reptiles (which will be reported in further dedicated papers), characterized by a variety of taxonomic, ecological, biogeographic, and/or conservation peculiarities. The isolation of some organisms, the existence of endemic species, the presence of taxa typical of the threatened Central American dry forest environments, and the occurrence of populations at the extreme borders of their

species range, certainly encourage the development of new conservation measures together with further dedicated analyses, hopefully including a molecular investigation approach. The data collected during this study, and the characterization of the avian community of the Karen Mogensen Reserve, will be important tools for future analyses, useful to evaluate the consequences of habitat fragmentation and to monitor the effects of climate change and land use modifications on the local avifauna. We foster the creation of programs that integrate bird monitoring, ecological research, conservation initiatives, and the involvement of the local communities, by promoting environmental education, capacity-building, and income generation or job creation.

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Intra-specific structural variation among Hawaiian *Hoplothrips* (Thysanoptera, Phlaeothripidae), with ten new synonymies and one new species

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Abstract

Most of the 16 fungus-feeding species described from the Hawaiian Islands and now placed in the genus *Hoplothrips* were based on very few and incomplete specimens. The descriptions were published long before any studies on the biology and structural variation of fungus-feeding Phlaeothripinae. Ten of these species are here placed into synonymy, and doubts are expressed concerning the identity of some others. One new polymorphic species is described and compared to a species known only from Florida. In the absence of comprehensive studies on the *Hoplothrips* fauna of North America, there is little evidence of endemism or radiation on Hawaii within this genus.

Keywords

Synonyms, fungus-feeding, sexual dimorphism, polyphenism

Introduction

The genus *Hoplothrips* in the insect Order Thysanoptera comprises 130 described species (ThripsWiki 2017), almost all of which live on dead branches of woody angiosperm trees. The larvae and adults of these thrips feed either on fungal hyphae, or possibly the breakdown products of fungal decay (Kobro and Rafoss 2006). They often form considerable colonies, involving all life stages. Presumably in response to the transience of this fungal habitat, many species produce winged, dispersive, adults as well as wingless (or wing-reduced) adults. This wing dimorphism involves, in both sexes, considerable differences in body form and chaetotaxy. Moreover, there is great variation in adult body size, both within and between colonies, and presumably this too is related in some way to variation in the quality and quantity of fungal growth. Many *Hoplothrips* species also exhibit considerable sexual dimorphism, with size-associated allometry resulting in large males having enlarged fore femora and fore tarsi bearing an enlarged tooth. As a result, large males look very different from small males, and small males resemble females in body form. Crespi (1986, 1988) has demonstrated that this sex-related structural variation is associated with behaviour, including male/male competition. These patterns of structural variation within individual species, involving wing and sexual dimorphism, together with body size polyphenism, often cause problems for species recognition and generic diagnoses (Mound 2005).

In Hawaii, most descriptive work on *Hoplothrips* dates from 1910, with a few more species added in 1928 and 1936; these descriptions thus predate any serious appreciation of the intraspecific structural variation that is now known to be common in members of this genus. Moreover, that early work predated any appreciation of the extent to which the Hawaiian insect fauna includes adventive species (Beardsley 1962). The objective of the present study has been to reassess the taxonomic significance of the 16 species of *Hoplothrips* described from the Hawaiian Islands, based on a re-examination of the original specimens, together with more recently collected material acquired particularly during June 2016 (Mound et al. 2017).

Bagnall thrips collection

Of the 16 species of *Hoplothrips* listed from the Hawaiian Islands, 11 were described by Bagnall (1910) based on specimens collected by RCL Perkins between 1890 and 1900. Bagnall stated that this material “consists chiefly of about seven dozen dried and mounted specimens, though later a small collection in alcohol was submitted.” For subsequent workers, it is essential to remember that most of the descriptions by Bagnall were based on these dry and shrivelled, card mounted, specimens, and such descriptions must thus be interpreted with caution. Moreover, as Bagnall himself pointed out, six of his 11 species were based on single individuals, four of which had no antennae (the antennae of a fifth holotype also no longer exist). In 1967, the few remaining carded specimens from the original series were examined at the Natural History

Museum, London, and many were found to be covered in a long-established layer of white fungus. These specimens were all cleaned of fungus and then slide-mounted into Canada balsam (Mound 1968). From this historical background, it can be understood why useful information concerning these 11 species is at best meagre, whether from the original publication or from the few remaining specimens. Certainty about species identity cannot be secure when based on such specimens that lack legs, antennae and most setae. Moulton (1928, 1936) had available to him from Hawaii more extensive series of specimens, but in comparing his new species he sometimes gave little consideration to morph differences, and his comparisons to the Bagnall species were based on the words and drawings in the 1910 publication, not on personal observation of any Bagnall specimens.

Hawaiian *Hoplothrips* radiation

The studies presented here have led to some major conclusions. Of the 16 described species, 10 are here newly synonymised. As a result, it is concluded that there is little evidence of any major radiation within the genus *Hoplothrips* on the Hawaiian Islands. Moreover, the suggestion by Bagnall that different islands support different *Hoplothrips* species is not supported by the available evidence. Earlier studies were based on the *assumption* of endemism amongst the Hawaiian thrips fauna. However, the species discussed below under the name *dubius* cannot be distinguished satisfactorily from a species recorded commonly in North America; some of the other species also seem likely to represent recent introductions. In this genus, species taxonomy worldwide is difficult and confused. Despite 130 species being listed in the genus (ThripsWiki 2017), identification keys are available only to 11 species from Illinois (Stannard 1968), 8 species from Britain (Mound et al. 1976), 12 species from Germany (Schliephake and Klimt 1979), and 17 species from Japan (Okajima 2006). In contrast, Mound and Marullo (1996) listed 34 *Hoplothrips* species from the Neotropics, and Stannard (1957) listed 32 species that are now placed in this genus from North America, although the *Hoplothrips* fauna of western USA is clearly poorly known (Hoddle et al. 2012). Without comparative studies on the species from the American mainland there is no possibility of evaluating the status of the species recorded from Hawaii. One remarkably polymorphic new species of this genus is described below, and this shares particular character states with species from the Americas. The Hawaiian fauna of fungus-feeding Phlaeothripinae is possibly diverse, but future studies need to be based on good population samples, rather than on a few isolated individuals.

One species is here excluded from the Hawaiian list. Hood (1939) placed *japonicus* Karny as a synonym of *flavipes* Bagnall, as is discussed below under the latter name. When this synonymy was subsequently rejected, the name *japonicus* seems to have been retained on the Hawaiian checklist, but without any recorded specimens. It is a member of the *fungi* species-complex as discussed below under *dubius*.

Key to *Hoplothrips* of Hawaii

- 1 All legs including coxae yellow *H. flavipes*
- Coxae and femora light brown to brown **2**
- 2 Head with one or more stout cheek setae (Fig. 13); antennal segment VIII only weakly narrowed to base; pelta with posterolateral corners clearly curving away from anterior margin of tergite II (Fig. 16); antennal segment IV usually sharply bicoloured with basal third yellow and slender, at least 1.8 times as long as wide (Fig. 14) **3**
- Head with cheek setae weak and not prominent (Fig. 7); antennal segment VIII strongly narrowed to base, sometimes with distinct pedicel; pelta with posterolateral corners either confluent with anterior margin of tergite II (Figs 9, 10), or only very weakly curving away (Figs 18, 21); antennal segment IV either uniformly brown (Figs 12, 20), or if weakly bicoloured and increasingly pale toward almost yellow pedicel then scarcely 1.6 times as long as wide (Fig. 19) **5**
- 3 Tergites III–IV with posteroangular setae at least 0.6 as long as median length of tergite; female with tergite IX setal pair S3 as long and slender as S1 *H. dubius*
- Tergites III–IV with posteroangular setae less than 0.3 as long as median length of tergite (Fig. 23); female with tergite IX setal pair S3 no more than 0.6 as long as S1 **4**
- 4 Female with tergites VI–VIII lateral setae no more 0.3 as long as median length of these tergites (Fig. 24) *H. lanaiensis*
- Female with tergites VI–VIII lateral setae more than 0.6 as long as median length of these tergites *H. perkinsi*
- 5 Female with pronotal anteroangular setae scarcely 0.5 as long as width of fore tibia; male sternite VIII apparently with no pore plate *H. laticornis*
- Female with pronotal anteroangular setae at least 1.5 times as long as width of fore tibia; male sternite VIII with transverse pore plate **6**
- 6 Posterolateral corners of pelta rounded but close to anterior margin of tergite II (Fig. 18); pore plate on sternite VIII of male large, occupying about half of sternite area; female with antennal segment IV paler on basal third (Fig. 19); tergites II–VII of macropterae each with two pairs of curved or sigmoid wing-retaining setae *H. flavitibia*
- Posterolateral corners of pelta drawn out along anterior margin of tergite II (Figs 3, 9, 10); pore plate on sternite VIII of male slender and transverse; female with antennal segment IV brown (Fig. 12); tergites III–VII of macropterae each with only posterior pair of wing-retaining setae curved or sigmoid [large male with tubercles behind eyes (Fig. 1), and fore tibia with tubercle at inner apex] *H. magnaccai* sp. n.

***Hoplothrips dubius* (Bagnall)**

Dolerothrips dubius Bagnall, 1910: 691

Dolerothrips barbatus Bagnall, 1910: 683. **Syn. n.**

Dolerothrips ovatus Bagnall, 1910: 686. **Syn. n.**

Dolerothrips angusticeps Bagnall, 1910: 688. **Syn. n.**

Dolerothrips bicolor Bagnall, 1910: 688. **Syn. n.**

Hoplothrips coprosmae Moulton, 1936: 186. **Syn. n.**

Remarks. This species is a member of the *Hoplothrips fungi* complex. This comprises *corticis*, *fungi*, *japonicus*, *karnyi*, *orientalis* and *ulmi*, and Stannard (1968: 459) suggested that these various names may refer to a single species that is widespread across the Holarctic; Schliephake and Klimt (1979) even placed *fungi* as a synonym of *ulmi*. However, as indicated below, each of these six species can, at present, be distinguished from the others. In contrast, *dubius* from the Hawaiian Islands cannot be distinguished satisfactorily from some individuals identified as *karnyi* from North America, including from Vancouver, Canada. In the absence of more extensive studies on the *Hoplothrips* fauna of Western North America, the name *dubius* seems appropriate to use for the form on Hawaii. Currently, the six species in the *fungi* complex are distinguished from each other as follows. Specimens with antennal segment IV brown are placed in *orientalis*, the other five all having antennal segments IV–V yellow at the base. The males of *fungi* share with those of *japonicus* and *orientalis* a particularly large pore plate on sternite VIII, but *fungi* is distinguished by having long slender sense cones on antennal segment III, particularly the one on the inner apical margin. According to Okajima (2006), *japonicus* has antennal segment III particularly elongate, more than 2.6 times as long as wide, although the sense cones on that segment are as short as in *ulmi*; in *orientalis*, these sense cones are intermediate in length between *fungi* and *ulmi*. Finally, *ulmi* has short sense cones on antennal segment III, and the median length of the pore plate on sternite VIII of males is much shorter than in *fungi* (Mound et al. 1976; Okajima 2006). Specimens identified as the North American species, *karnyi*, have the short antennal sense cones of *ulmi*, but the pore plate on sternite VIII of males is variable and intermediate between the condition found in *fungi* and *ulmi* from Europe. The species here identified as *dubius* was found quite commonly on Hawaii, in Volcano National Park, in June 2016, and also at two sites on Oahu – Makuleia trail and Manoa Cliffs trail.

Bagnall described *dubius* from five winged females and one “aptera”, taken variably on the three islands – Hawaii, Molokai and Lanai. However, only the macropterous female from “Molokai Mts” remains, and this has only one antenna (Fig. 14) and is slide mounted and designated lectotype (Mound 1968). The unique holotype of *barbatus*, a large micropterous male from Kona, Hawaii, was described as lacking the distal antennal segments, although segments III and IV are available and are brown

with the basal third yellow. Sternites III–VII have paired reticulate areas similar to those illustrated on the male syntype of *flavipes* (Fig. 22), and the median length of the pore plate on sternite VIII is about 30 microns. The lectotype of *ovatus* is the single large male that was taken on Haleakala, Maui, but of the original six females mentioned by Bagnall only two remain. The three specimens were slide mounted in 1967, and they retain antennae and most setae, but there is no reason to consider this as a different species from *dubius*. Antennae were not available on either of the two original specimens of *angusticeps*, and the lectotype is the male from Kalae, Molokai. Although much smaller than the *barbatus* holotype, it falls within the size range expected in species of *Hoplothrips* and has reticulate areas laterally on the sternites, and the pore plate on sternite VIII is about 40 microns long medially. Bagnall described *bicolor* from a single female taken on Kaala, Oahu. This lacked antennae, and the specimen is now slide mounted and lacks all major setae except for a single lateral seta on the third tergite; contrary to the original description, the tube is no paler than in other specimens here identified as *dubius*. Moulton based *coprosmae* on four females and six males from Nauhi, Hawaii. These specimens are in good condition, and they have been compared with macropterous and micropterous specimens of both sexes collected on Hawaii and Oahu in June 2016, all of which have variably prominent cheek setae on the head. The antennal sense cones are not as elongate as in *fungi* from Europe, and in males the sternites have reticulate areas laterally and the pore plate on sternite VIII is about 35 microns long medially. If these recent specimens, also the *coprosmae* types, had been collected in North America they would have been identified as *karnyi*. However, as indicated above, it is not possible at present to establish further synonymies between the fauna of Hawaii and that of the mainland until suitable studies are carried out on the North American *Hoplothrips* fauna.

Hoplothrips flavipes (Bagnall)

Dolerothrips flavipes Bagnall, 1910: 685.

Remarks. This species was based on “several specimens... in alcohol” from Maui but with no date of collection; also “numerous specimens” (presumably dry and carded) from Maui on Mt. Haleakala in 1896. In the BMNH, only 1 male and 2 female micropterae remain of this species; these were slide mounted by Bagnall presumably from the series in alcohol, but without data apart from Maui. Similar specimens were sent to Hood (1939: 587) who claimed that the yellow legs were the result of storage in alcohol, and placed *japonicus* and *major* as synonyms of *flavipes*. Certainly *flavipes* is a member of the northern hemisphere *fungi* species-complex to which *japonicus* and *major* (a synonym of *karnyi*) belong. These species share the character states of a rather slender antennal segment VIII, an extra pair of discal setae on the metanotum, and the head with prominent cheek setae. However, because the coxae of the available *flavipes* specimens are also clear yellow, it is possible that the leg colour may be natural

and not due to storage in ethanol. The identity and relationships of these specimens thus remain equivocal. They share many character states with *H. flavafemora* Okajima from southern Japan, but the available specimens are too poorly preserved to be sure that these two represent a single species. Moreover, if it were true that the pale legs of the *flavipes* specimens is due to storage in alcohol, then these specimens could not be distinguished from *dubius*. The male paralectotype is large, and laterally on sternites III–VII are extensive paired areas of iridescent reticulation (Fig. 22), and sternite VIII has a broad pore plate with a median length of about 35 microns. The female paralectotype is in particularly poor condition, but the lectotype female mounted onto a slide with the male has the lateral setae on tergites III–IV short, scarcely half as long as the tergite median length.

Hoplothrips flavitibia Moulton

Hoplothrips flavitibia Moulton, 1928: 117.

Remarks. Moulton described this species from 45 specimens taken in 1927 on Waipio Ridge, Oahu. He compared this briefly to *japonicus* as well as *lanaiensis*, *laticornis* and *ovatus*. However, *flavitibia* shares with *corticis* from the northern hemisphere the following character states: rather short antennal segment III but slender VIII; metanotum without sculpture medially but with an additional pair of discal setae (Fig. 17); pelta posterolateral angles almost confluent with tergite II anterior margin (Fig. 18). At present there is insufficient material to establish a formal synonymy, but no obvious character states have been observed to distinguish *flavitibia* from *corticis*, a species that is widespread in Europe, North America and Japan, and also known from New Zealand. Zimmerman (1948) indicated that *flavitibia* had been found on Kauai, Maui, and Hawaii in addition to Oahu, and nine females with four males (in BMNH) have been studied that were collected and identified by Sakimura as *flavitibia* from Olinda, Maui. During July 2016, several specimens were taken near Volcano, Hawaii, and also on the Makuleia Trail, Oahu.

Hoplothrips lanaiensis (Bagnall)

Dolerothrips lanaiensis Bagnall, 1910: 690.

Hoplothrips hawaiiensis Moulton, 1936: 185. **Syn. n.**

Remarks. In describing *hawaiiensis* from eight females and two males (presumably all micropterae) taken on Oahu and Maui, Moulton compared it to *perkinsi*, claiming that this was the only species from Hawaii with “spines so reduced at the posterior angles of abdominal segments”. However, Bagnall clearly stated of *lanaiensis* “abdominal bristles obsolete” when he described this species from 10 female and 8 male micropterae

taken on Lanai, Molokai and Hawaii. The tergal lateral setae on the only remaining specimens of this species (two females and the lectotype male from Lanai) are similar to those on *hawaiiensis* (Figs 23, 24). As in *perkinsi*, the metanotum is reticulate medially. However, in *perkinsi* the lateral setal pair on tergites VI–VIII are longer (on VII 180 microns) than on the type specimens of *lanaiensis* and *hawaiiensis* (on VII no more than 30 microns). The published year of collection differs for the type specimens of *perkinsi* and *lanaiensis*, but their collection numbers (Perkins 91 and 92) suggest that they were actually collected together at the same locality on Lanai. If more specimens become available, the differences in tergal setal lengths may be found to fall within the range of a single species, and *lanaiensis* would thus be a synonym of *perkinsi*. However, a single macropterous female was collected on Oahu, Mokuleia Trail, in July 2016 that is here identified as *lanaiensis*. The pronotal epimeral setae, and also setae S1 and S2 on tergite VIII, are short with curiously blunt apices.

***Hoplothrips laticornis* (Bagnall)**

Trichothrips laticornis Bagnall, 1910: 692.

Hoplothrips mauiensis Moulton, 1928: 119. **Syn. n.**

Remarks. Bagnall described this species from a single, slide-mounted, macropterous female collected at Kona, Hawaii, in 1892. This specimen is mounted ventral side uppermost, with the wings folded on the body. Moulton described *mauiensis* from 21 specimens taken at Olinda, Maui in 1926 and 1927. This species appears to be diagnosed by the following character states: antennal segment VIII slender and narrowed to base, segment III no more than 1.6 times as long as wide, segment IV not sharply paler in basal third and no more than 1.5 times as long as wide; pronotal anteroangular setae no more than 30 microns long; metanotal median area without sculpture, one pair of rather short median setae; pelta lateral lobes weakly curving away from anterior margin of tergite II; tergite IX with three pairs of setae about 0.8 as long as tube. The only available male of *mauiensis* appears to lack a pore plate on sternite VIII, but this is possibly an artefact due to poor slide preparation. The relatively short and broad, almost uniformly coloured, fourth antennal segment (Fig. 20) does not seem to have been reported in any other member of this genus from any part of the world, although an almost similar condition exists in a few specimens identified as *flavitibia*.

***Hoplothrips magnaccai* sp. n.**

<http://zoobank.org/C4F3EDFE-638E-4DEC-9048-0839D3DCF4EC>

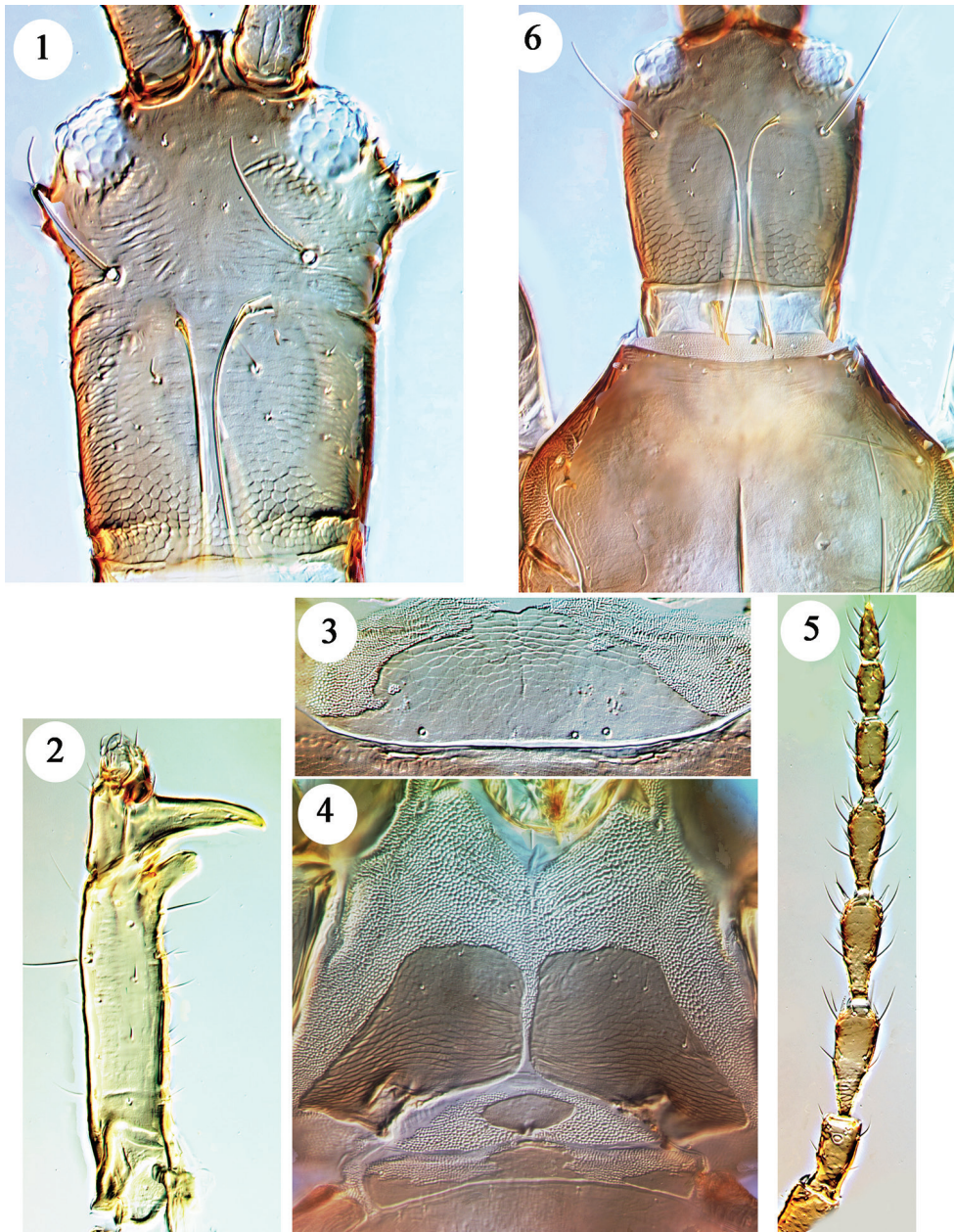
Description. Male microptera. Head yellowish-brown and darkest around antennal bases; fore legs yellowish-brown, prothorax and pterothorax brown, abdomen paler, tube with yellow sub-apical area; mid and hind femora brown, tibiae and tarsi yellow-

ish; antennal segment I brown, apex of II and basal half of III yellow, rest of antenna brown; major setae pale. Head slender, twice as long as width at base, with prominent lateral tubercles behind small eyes (Fig. 1); ocelli absent; postocular setae long and acute, longer than half of head width; maxillary stylets retracted to postocular setae, close together medially; ventrally all setae small, frons of largest male with pair of large irregular tubercles, absent in small male; mouth cone short and rounded. Antennae 8-segmented (Fig. 5); major male with segment I exceptionally long; VIII narrowed to small pedicel; 3 sense cones on III, 4 on IV, sense cone length little more than half of segment width. Pronotum massive, median longitudinal apodeme weak; anteromarginal setal pair very small, posteroangular pair unusually long in smaller male; prosternal basantra absent (Fig. 4), ferna large with median margins parallel in largest male but rounded in smaller males; mesopresternum of three weakly joined small sclerites; metathoracic sternopleural sutures present but short. Fore femora elongate, extending to apical margin of head in largest male, but not beyond mid-point of head in smaller males; fore tibia with large, broadly rounded tubercle at inner apex dorsal to the normal apical seta (Fig. 2); fore tarsal tooth as long as tarsal width. Meso and metanota transverse, metanotum without sculpture medially; fore wing lobe 50 microns long, bearing one seta. Pelta broadly D-shaped (Fig. 3), posterior margin confluent with anterior margin of tergite II; tergites II–VII each with 2 pairs of short, straight wing-retaining setae; tergite IX setae shorter than tube, tube much shorter than head. Sternite VIII with slender pore plate, median length about 15 microns, extending fully across sternite; median sternites without any lateral reticulate areas.

Measurements (holotype male and smallest paratype male in microns). Body length 3500 (2900). Head, length 380 (250); width posterior to tubercles 230 (215); po setae 125 (135). Pronotum, length 500 (280); width 500 (350); major setae: aa 20 (30), ml 100 (100), epim 120 (130), pa 180 (185). Tergite IX setae, S1 180 (185), S2 75 (70), S3 180 (160). Tube length 240 (215). Antennal segments I–VIII length 100 (65), 75 (60), 115 (85), 105 (85), 90 (70), 80 (?), 60 (?), 60 (?).

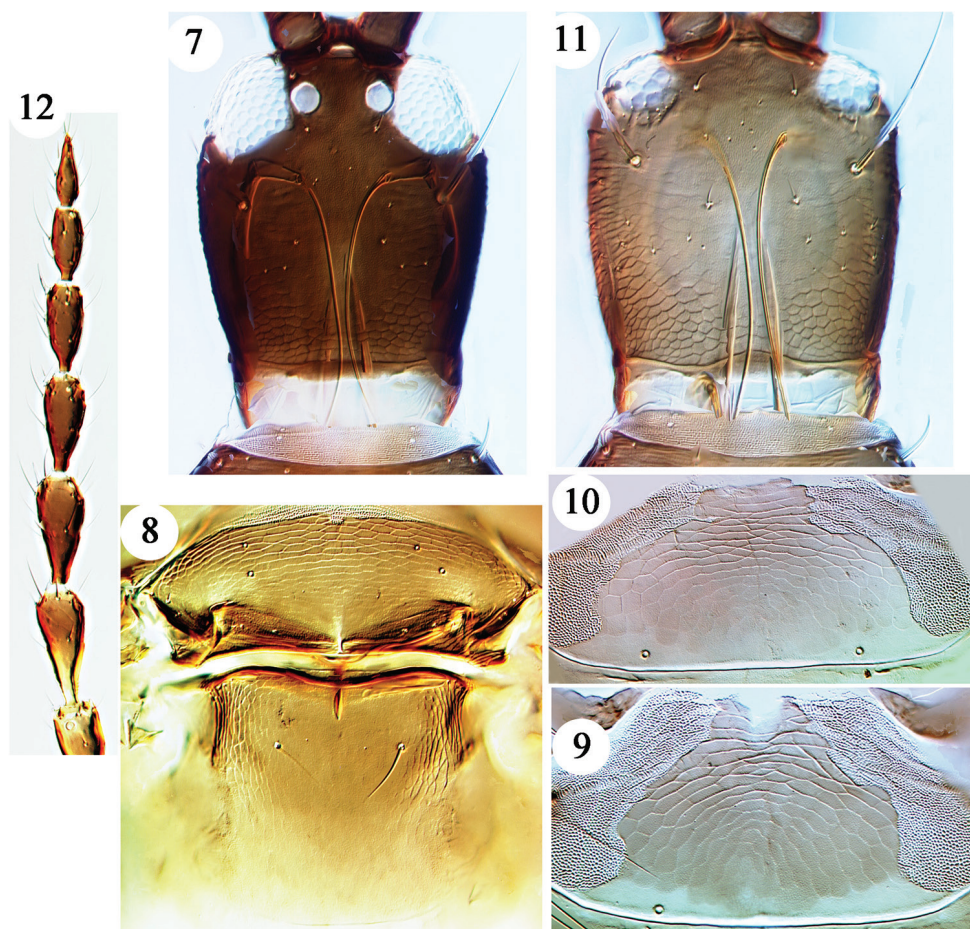
Female microptera. Body and femora brown, basal half of head paler than pronotum, antennae brown except for base of segment III (Fig. 12), tibiae and tarsi shading yellowish-brown to yellow. Head with convex cheeks (Fig. 11), constricted behind small eyes with small tubercle ventro-laterally just behind eyes; ocelli absent; po setae long and acute; maxillary stylets close together medially and retracted to eyes. Pronotum transverse, ml, epim and pa setae long. Prosternal ferna large, narrowing medially; mesopresternum of three small sclerites. Tergites similar to those of male microptera.

Female macroptera. Darker than microptera, head dark brown (Fig. 7) and darker than pronotum, mid and hind tibiae mainly brown; fore wings pale. Head with cheeks convex, slightly constricted behind large eyes, without any tubercles; ocelli large, stylets retracted to eyes. Body similar to microptera; metanotum with no sculpture medially (Fig. 8); mesopresternum almost entire with three sclerites joined; fore wing with only two pairs of long sub-basal setae; tergites III–VII each with only one pair of sigmoid wing-retaining setae, anterior pair short and straight on these tergites, and both pairs short and straight on tergite II.



Figures 1–6. *Hoplothrips magnaccai*, males. Holotype **1–5**: **1** head **2** fore tibia and tarsus **3** pelta **4** prosternites **5** antenna **6** Small male head and pronotum.

Measurements (macropterous female paratype in microns). Body length 3200. Head, length 300; width 250; po setae 140. Pronotum, length 230; median width 350; major setae: aa 15, am 75, ml 140, epim 130, pa 190. Fore wing length 1250;



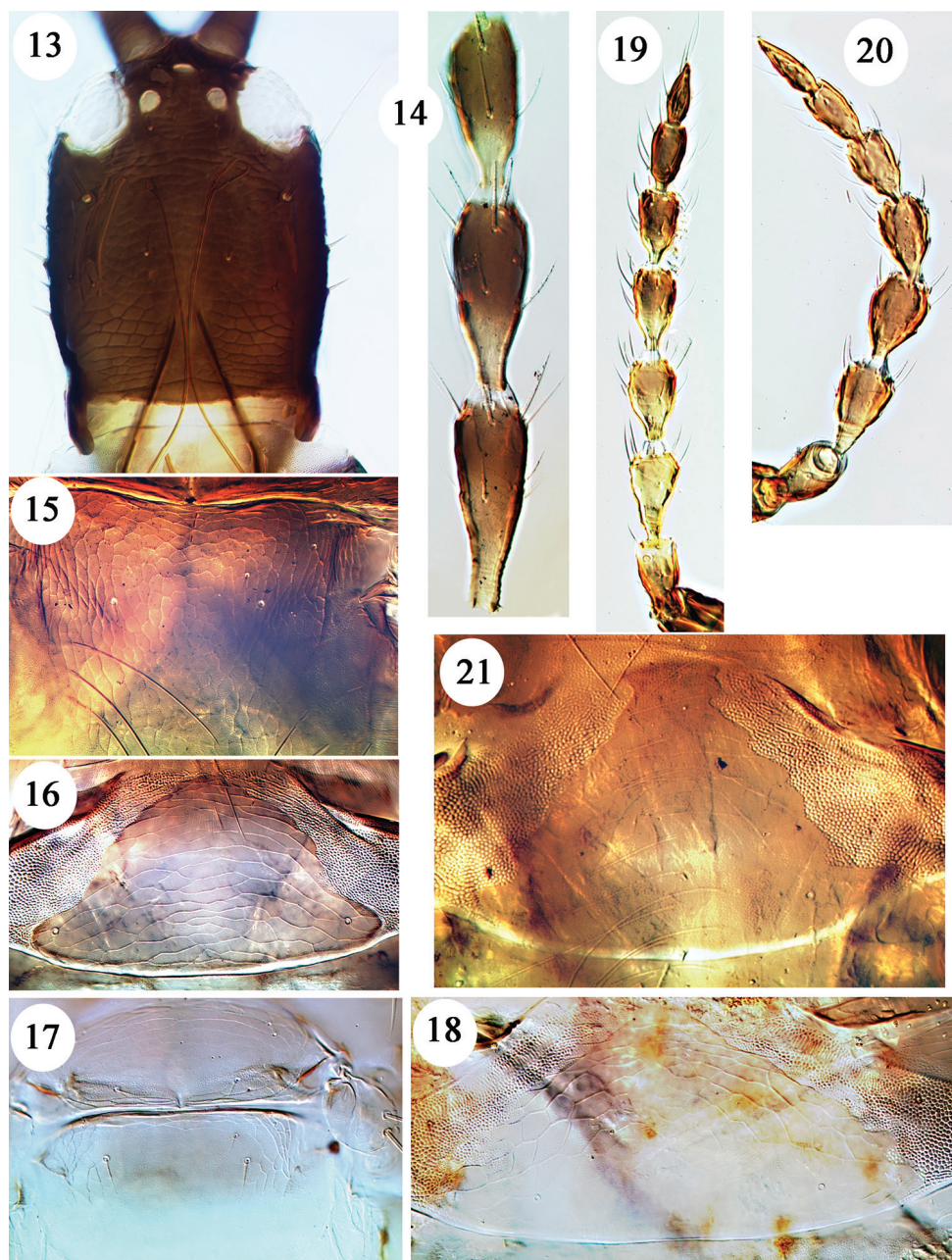
Figures 7–12. *Hoplothrips magnaccai*, females. Macroptera **7–9**: **7** head **8** meso and metanota **9** pelta. Microptera **10–12**: **10** pelta **11** head **12** antenna.

sub-basal setae 80. Posteroangular tergal setae: tergite II 30, tergite VI 180. Tergite VIII setae S1 180, S2 210, S3 240. Tube length 250. Antennal segments I–VIII length 60, 68, 100, 95, 90, 85, 60, 60.

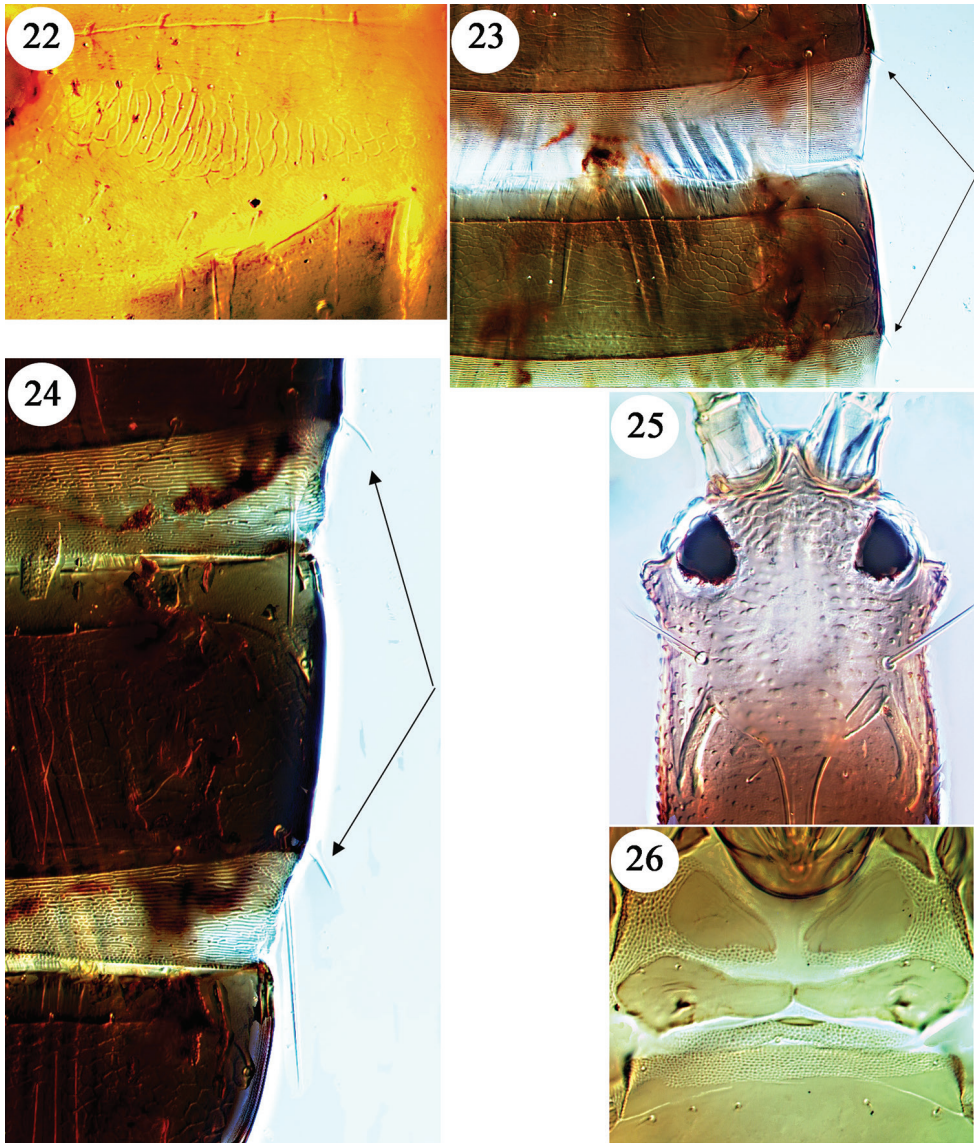
Material studied. Holotype male microptera, **OAHU**, Mokuleia Trail, from dead branches, 29.vii.2016 (LAM 6310), in BPBM, Hawaii.

Paratypes: 2 female macropterae, 6 female micropterae taken with holotype; at same site and date, 25 female macropterae (many de-alate), 3 female micropterae, 2 male micropterae (A. Wells 83, 84, 86, 87). **MAUI**, Io'a Needle, 2 female micropterae from dead branches, 26.vii.2016 (A. Wells 77).

Comments. The macropterae of *magnaccai* are particularly unusual among *Hoplothrips* species, in that on tergite II both pairs of wing-retaining setae are small and straight and on each of tergites III–VII only the posterior pair is sigmoid with each anterior pair short and straight. Moreover, there are only two long sub-basal setae on



Figures 13–21. *Hoplothrips* species. *H. dubius* **13–16**: **13** female head **14** lectotype antennal segments III–V **15** lectotype metanotum **16** lectotype pelta. *H. flavitibia* paratype female **17–19**: **17** meso and metanota **18** pelta **19** antenna. *H. laticornis* holotype **20–21**: **20** antenna **21** pelta.



Figures 22–26. *Hoplothrips* species. **22** *H. flavipes* paralectotype male, sternite V. *H. hawaiiensis* paratype female **23–24**: **23** tergites II–III **24** tergites VI–VII. *H. flavicauda* **25–26**: **25** large male microptera, head **26** female macroptera prosternites.

each fore wing. In large males, the head of *magnaccai* is similar in appearance to that of two species known only from eastern USA: *Hoplothrips flavicauda* (Fig. 25) from several northeastern states (Stannard 1968), and *Hoplothrips mutabilis* from Florida (Hood 1955). In each of these three species, the largest short-winged males have a prominent tubercle behind the eyes, although such tubercles are not present in winged males (where known) nor in smaller short-winged males. The species most closely similar to *magnac-*

cai seems to be *mutabilis*, because these two share with typical *Hoplothrips* species both the absence of prosternal basantra (= praepectus of Stannard, 1968) and the presence in males of a transverse pore plate on sternite VIII. In contrast, both *flavicauda* and also *Hoplothrips fungosus* Moulton from eastern Asia (Okajima 2006) are distinctive within the genus *Hoplothrips* for the presence of prosternal basantra (Fig. 26), and the absence in males of a pore plate on sternite VIII. This new species differs from *mutabilis* as follows: body and first two antennal segments brown to dark brown rather than mainly yellow, postocular setae longer in all morphs, fore wing with about 15 duplicated cilia rather than eight, and sense cones of macropterae not long and slender.

Hoplothrips perkinsi (Bagnall)

Dolerothrips perkinsi Bagnall, 1910: 687.

Dolerothrips intermedius Bagnall, 1910: 689. **Syn. n.**

Trichothrips nigricans Bagnall, 1910: 693. **Syn. n.**

Hoplothrips swezeyi Moulton, 1928: 120. **Syn. n.**

Remarks. Described from a single female taken on Lanai, this specimen was described as having the antennae dark brown with only segment III yellow at base, but no antennae were found when the holotype was slide mounted in 1967. Another species described by Bagnall from Hawaii that has antennal segment IV almost brown is *laticornis*, but that has the metanotal median area without sculpture, whereas in *perkinsi* this area is distinctly reticulate. However, *intermedius* was described from a single major male taken on Haleakala, Maui, and although the slide mounted holotype lacks the tube, the single remaining antenna has segment IV brownish-yellow on the basal third. Unfortunately, *nigricans* was described from a single winged female that lacked antennae, and the slide mounted holotype now lacks most major setae apart from one long lateral seta on tergite VIII. In contrast, Moulton described *swezeyi* from 12 females and four males taken at Olinda, Maui, and distinguished this from *intermedius* by “its differently colored antennae”. Micropterous females of *swezeyi* share with *perkinsi* a distinctly reticulate metanotum, also long lateral setae on tergites VI–VIII but with short lateral setae on tergites III and IV, and the largely brown antennal segment IV with the basal third brownish-yellow. The statement by Bagnall that *perkinsi* has “obsolete” lateral setae on tergite VIII is not correct, and was presumably based on examining the holotype dry on a card. In females, tergite IX setae S3 are unusually short, less than 0.6 as long as setae S1, the dorsal pair. The holotype of *intermedius*, also males of *swezeyi*, have reticulate areas laterally on sternites III–VII, and the median length of the pore plate on sternite VIII is about 35 microns. Apart from the differences in setal lengths, *perkinsi* and *dubius* are similar in many details, and unlike the other species considered here, the heads of both sexes and both morphs of these species have quite prominent cheek setae.

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I am particularly grateful to Paul Brown at the Natural History Museum, London, for negotiating the loan to Canberra of Bagnall specimens, also to Cheryle O'Donnell, USDA-ARS, Beltsville, for the loan of specimens of *H. flavicauda* from the Hood collection, and to Robert Zuparko of California Academy of Sciences for the loan of Moulton type specimens. Field work in Hawaii during 2016 was supported by Alice Wells and Mark Hoddle, and in particular by Karl Magnacca whose ecological expertise provided access to interesting areas of natural vegetation.

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Several errors related to the numbering in the dichotomous key appearing in the above paper came to our attention after our manuscript was published. The correct numbering to enable accurate identification of the world *Pseudobranchiomma* species is provided here.

Key to species of *Pseudobranchiomma*

The number of *Pseudobranchiomma* species considered as currently valid (17) follows Knight-Jones and Giangrande (2003) but includes subsequently described species. This key is based largely on descriptions in the literature, and most of them do not include

intraspecific variation, so caution should be taken if specimens diverge from statements in the key. Old descriptions also lack enough relevant information to clearly separate species. Therefore, such points of weakness in the key are marked with an asterisk (*).

- 1 Radioles with distinct, paired, serrated flanges **2**
- Radioles with flanges reduced to low ridges (lacking distinct serrations).... **10**
- 2 Serrations distinct along most (or all) length of radioles **3**
- Serrations only distinct on distal parts of radioles..... **8**
- 3 Radioles with paired compound eyes present
 ***P. grandis* (Baird, 1865)** (New Zealand) (Fig. 11) or *reportedly
 present..... ***P. serratibranchis* (Grube, 1878)** (Philippines)
- Radioles without distinct radiolar eyes **4**
- 4 Radioles with over 10 pairs of serrations on lateral flanges **5**
- Radioles with maximum of 10 pairs of serration on lateral flanges **6**
- 5 Radioles with up to 25 serrations and coloured transverse bands; thorax generally with eight thoracic chaetigers; thoracic uncini with 6–7 rows of teeth
 ***P. orientalis* (McIntosh, 1885)** (Hong Kong)
- Radioles with 13–19 serrations and 10–19 transverse pigmented bands; thorax with 6–10 thoracic chaetigers; 4–5 rows of teeth in thoracic uncini
 ***P. paulista* Nogueira et al., 2006** (Brazil)
- 6 Radiolar crown without pigmented transverse dark bands; radiolar lobes pigmented with purple and radioles white with yellow tips. Radioles with six serrations along their length; three rows of teeth above main fang of thoracic uncini ***P. pallida* sp. n.** (Australia)
- Radiolar crown with several pigmented transverse bands (regular or irregular) **7**
- 7 Radioles with up to 10 serrations and 10 narrow irregular purple bands; thorax with 4–8 chaetigers; 5–6 rows of teeth above main fang of thoracic uncini ***P. emersoni* Jones, 1962** (Caribbean)
- Radioles with 3–4 serrations and transverse bands (purple and yellow; a few white); thorax with 4–5 thoracic chaetigers; 4–5 rows of teeth above main fang of thoracic uncini..... ***P. paraemersoni* Nogueira et al., 2006** (Brazil)
- Radioles with 6–11 serrations and 4–6 transverse bands (of purple-orange-white); four rows of teeth above main fang of thoracic uncini; lateral margins of collar oblique and covering anterior peristomial ring
 ***P. schizogenica* Tovar-Hernández & Dean, 2014** (Gulf of California)
- 8 Radiolar eyes reportedly* present ***P. odbneri***
 (**Fauvel, 1921**) (Madagascar) or* ***P. bocki* (Johansson, 1922)** (Japan)
- Radiolar eyes absent..... **9**

- 9 Radiolar crown with 12 dark pigment bands (and 7 wide yellow bands between)..... ***P. tricolor* (Grube, 1881)** (Japan)
- Radiolar crown whitish, darker at base, lacking transverse pigmented bands; thorax with eight thoracic chaetigers; thoracic uncini with over five rows of teeth ***P. zebuensis* (McIntosh, 1885)** (Philippines)
- 10 Peristomial collar fused dorsally to sides of faecal groove.....
..... ***P. punctata* (Treadwell, 1905)** (Hawaii)
- Collar with free dorsal margins, widely separated from faecal groove..... **11**
- 11 Radioles with paired compound eyes **12**
- Radioles without distinct compound eyes (may have granular pigment patches)..... **13**
- 12 Thorax broader than long (with up to eight thoracic chaetigers); each side of crown in spiral of up to five whorls (mature specimens)
..... ***P. longa* (Kinberg, 1867)** (South Africa)
- Thorax longer than broad (with up to 13 thoracic chaetigers); radiolar lobes never spiralled..... ***P. perkinsi* Knight-Jones & Giangrande, 2003** (Florida)
- 13 Thorax with 4–6 segments; first thoracic chaetiger less than 1.5 times length of the following ones..... ***P. minima* Nogueira & Knight-Jones, 2002** (Brazil)
- Thorax with eight segments; first thoracic chaetiger 2–3 times length of the following ones..... ***P. tarantoensis* Knight-Jones & Giangrande, 2003** (Italy)

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