ZooKeys 750: 1–40 (2018)
doi: 10.3897/zookeys.750.22764
http://zookeys.pensoft.net

RESEARCH ARTICLE

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

Isotomidae of Japan and the Asiatic part of Russia. I. *Folsomia 'inoculata'* group

Mikhail Potapov[1], Motohiro Hasegawa[2], Natalia Kuznetsova[1], Anatoly Babenko[3], Alexander Kuprin[4]

1 *Moscow State Pedagogical University, Kibalchich str., 6, korp. 3, Moscow 129278, Russia* **2** *Shikoku Research Center, Forestry and Forest Products Research Institute, Kochi 780-8077, Japan* **3** *The Severtsov Institute of Ecology & Evolution, Russian Academy of Sciences, Leninski pr. 33, Moscow 119071, Russia* **4** *Federal Scientific Center of the East Asia Terrestrial Biodiversity, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok-22, 690022, Russia*

Corresponding author: *Anatoly Babenko* (lsdc@mail.ru)

Academic editor: *L. Deharveng* | Received 4 December 2017 | Accepted 7 February 2018 | Published 16 April 2018

http://zoobank.org/B10B5506-EF9F-4774-80F4-BC5A776FA266

Citation: Potapov M, Hasegawa M, Kuznetsova N, Babenko A, Kuprin A (2018) Isotomidae of Japan and the Asiatic part of Russia. I. *Folsomia 'inoculata'* group. ZooKeys 750: 1–40. https://doi.org/10.3897/zookeys.750.22764

Abstract

The paper considers blind species of the genus *Folsomia* having two pairs of macrosetae on both meso- and metathorax and united in so-called '*inoculata*' group, which is given a new, more laconic definition. Morphological characters important in the group's taxonomy are discussed and a further division into four subgroups is proposed. Eight new species, i.e., *F. amurica* Potapov & Kuznetsova, **sp. n.**, *F. breviseta* Potapov & Kuznetsova, **sp. n.**, *F. calcarea* Potapov, **sp. n.**, *F. imparis* Potapov & Hasegawa, **sp. n.**, *F. laconica* Potapov & Kuznetsova, **sp. n.**, *F. tertia* Potapov, **sp. n.**, *F. trisensilla* Potapov, **sp. n.**, and *F. tubulata* Potapov & Babenko, **sp. n.**, are described. *F. hidakana* Uchida & Tamura and *F. inoculata* Stach are redescribed basing on new material, for the latter species the Stach's individuals were also examined. A key to species of the group is given.

Keywords

α-taxonomy, Collembola, Far East of Russia, Japan, key

Introduction

The present revision is based on a vast material recently collected by the authors in various parts of the Eastern Palaearctic and older collections kindly provided by our colleagues. All used materials are deposited in the Tottori Prefectural Museum (Japan) and Moscow State Pedagogical University (Russia).

Traditional methods of morphological taxonomy were mainly used. Multi-dimensional scaling was also applied for variability analysis of widespread *F. inoculata*. Nine metric characters (ratios) were defined for 84 individuals from five large regions of the Palearctic (see the legend to Fig. 89). Metric characters were inferred from body measurements as following ratios: PAO length : inner edge of unguis, PAO length : width of Ant.I, manubrium length: mucro length, dens length: mucro length, dens length: macrosetae length at the end of abdomen, head diagonal : PAO length, macrosetae length at the end of abdomen : mucro length, accp2-s length : accp3-s length (Abd.V), macrosetae length at the end of abdomen : accp3-s length (Abd.V). The correlation index was used to estimate the distance between individuals. Only adults and subadults of a similar size were studied for this analysis, as well as for the species descriptions.

Abbreviations used:

Abd.	abdominal segments;	***ms***	micro *s*-seta(e) or *ms*-setae;
alt.	altitude;	**MSPU**	Moscow State Pedagogical University;
Ant.	antennal segments;		
AO	antennal organ;	**PAO**	postantennal organ;
bms	basal *ms* on antennal segments;	***s***	in the text and figures – macro *s*-setae or *s*-setae;
Md, Mdl, Ml	macrosetae in dorsal, dorso-lateral and lateral position;	**Th**.	thoracic segments;
		TPM	Tottori Prefectural Museum

Taxonomy

Remarks on *Folsomia inoculata* group

The group was firstly characterized by three basic characters, i.e., the presence of dorsal macrosetae on Th.II-III, posterior position of medial s-setae on abdominal segments, and the presence of ventral setae on Th.III (Potapov 2001).

Now it became clear that there are some important exceptions, namely three species with mid-tergal position of s-setae (*breviseta* sp. n., *calcarea* sp. n., and *torpeda*) and two species without ventral setae on Th.III (*breviseta* sp. n. and *hidakana*). Otherwise, all these species are obvious members of the same very characteristic East Asiatic group. This fact forces us to propose a new definition of the group: *Folsomia* with eyes absent,

macrosetae on dorsum (= Md) of each Th. II and III present resulting in 22/333 formula, body shape tubular, head massive, PAO long and slender.

All species of the group also share several ordinary characters: four sublobal hairs on maxillary outer lobe, bifurcate maxillary palp, labral formula 4/5,5,4, not reduced edge of labrum, unguis without lateral or inner teeth, the absence of foil setae at the tip of abdomen. Therefore, we exclude all these characters from the species diagnoses given below.

Classification of the group

The group is not homogenous and its members can be classified by appearance into three types: 'long-furcated' common for *Folsomia,* 'short-furcated' slender cylindrical ('*tatarica*' subgroup), and stout with massive head (*F. inoculata*). Moreover, the group can be divided into four subgroups basing on well visible although not necessary evolutionary significant characters:

– '*hidakana*' subgroup. It consists of the most primitive species having long furca, complete sets of s-setae and common (for the genus) number of ms-setae on body (43/22235, 10/100, as in Figs 21, 22) and without ventral setae on Th.III (Fig. 10). *F. breviseta* sp. n., *F. hidakana*.
– '*macrochaetosa*' subgroup. Unlike the previous group, its species have ventral setae on Th.III (Fig. 9). *F. amurica* sp. n., *F. brevisensilla*, *F. imparis* sp. n., *F. macrochaetosa*, *F. setifrontalis*. An odd species, *F. bashkira*, characterized by unusual reduction of s-setae at the middle part of the body (42/11235), in other features resembles these species and so is also placed into this subgroup.
– '*laconica*' subgroup. Species with incomplete set of s-setae (33/22224) and ms-setae (10/000) on body (as in Figs 55, 56). *F. laconica* sp. n., *F. tertia* sp. n., *F. trisensilla* sp. n. Other characters as in '*macrochaetosa*' subgroup.
– '*tatarica*' subgroup. The species are habitually specific due to slender body (Figs 69, 70), rather short macrosetae and short furca. They have complete set of s-setae (43/22235), ms of Abd.I present or absent. *F. baida*, *F. calcarea* sp. n., *F. tatarica*, *F. torpeda*, *F. tubulata* sp. n.

Folsomia inoculata holds a unique position in the group due to s-pattern on Abd.V, chaetotaxy of furca, and specific appearance (for details see Remarks for the species).

The state of knowledge of the group

We believe that representatives of the '*inoculata*' group were previously collected and recorded by other researchers in the eastern areas of Asia. In the associated regional papers (Yosii 1939, 1977; Tanaka 1970, Lee 1973; Kurcheva 1977; Solntseva and Molodova 1979; Suma 1997; Yamauchi and Suma 1999; Furuno et al. 2000; Niijima and

Hasegawa 2011; Hishi et al. 2012) they were possibly listed as either '*F. fimetaria*', '*F.* cf. *fimetaria*' or '*Folsomia* sp.' Indeed, species of the '*inoculata*' group share several superficial characters with '*fimetaria*' group members and so could be confused with them. If considering essential characters, PAO in the latter group is oval and short, thoracic Md macrosetae are absent, and abdominal tip often has foil setae.

Distribution and ecology

The known species of the group mostly inhabit the boreal zone of the Eastern Asia. If considering our unpublished materials from North America, one species (*F. inoculata*, together with its junior synonym *F. ezoensis*) has almost trans-Holarctic range. Subgroup of short-furcated species ('*tatarica*' sgr.) occupies areas close to the Ural Mts (excl. *F. tubulata* sp. n.) although does not penetrate to the main part of Europe. In North America (unpubl. material, coll. A. Fjellberg) the group is not so diverse and we have discovered only few, mostly new species. Representatives of the '*inoculata*' group often predominate in litter of native forests and such ecological niche may be used as an additional difference from the '*fimetaria*' group. The latter group prefers various disturbed habitats, organically enriched sites, etc. (*F. candida*, *F. fimetaria*, and *F. litsteri*, for example).

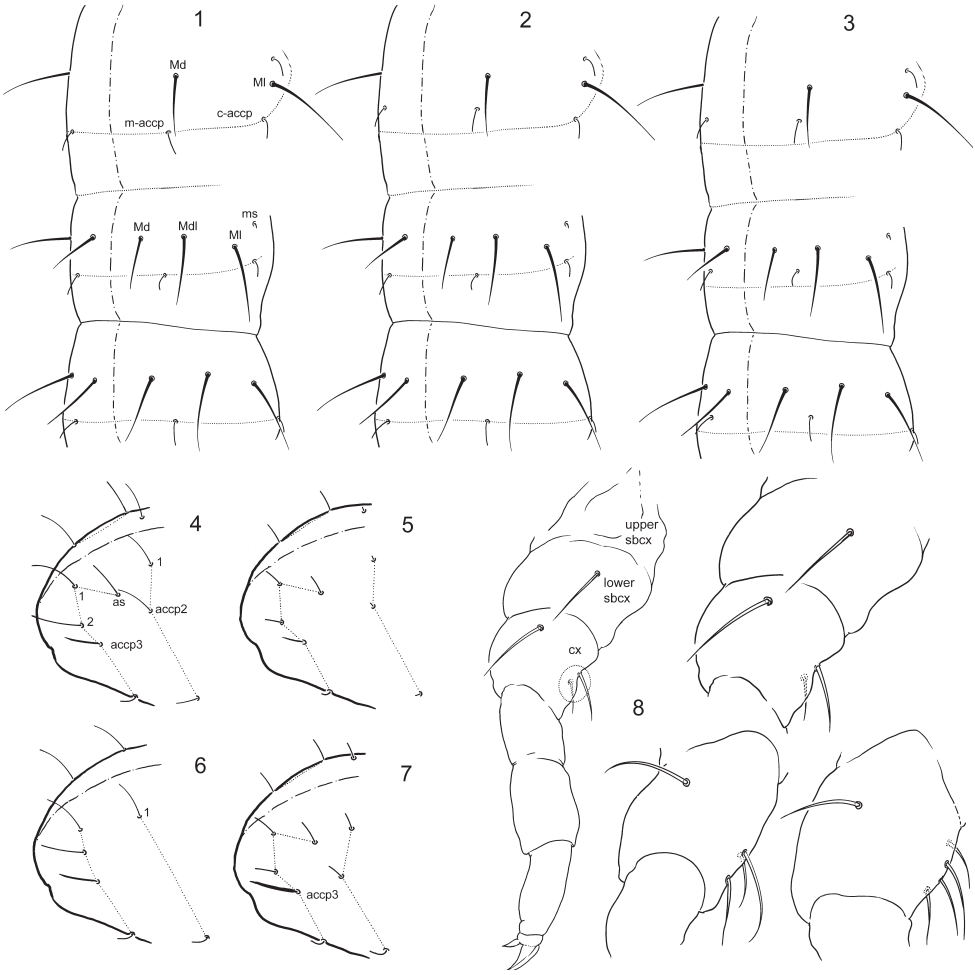
Key taxonomic characters of the group

Position of s-setae on tergites. The group show a high diversity of position of medial s-setae relatively to p-row – four patterns can be discriminated (Table 1). Three most frequent variants are shown in Figs 1–3.

S-pattern on Abd.IV and V. Position and differentiation of s-setae on Abd.V is one of the keys to understanding of evolution of the genus *Folsomia* (Potapov and Greenslade 2010). Most species of the '*inoculata*' group show '4+1' or weakly differentiated '3+1+1' s-pattern widely distributed in the genus (Fig. 4). Three new species (*F. laconica* sp. n., *F. tertia* sp. n., and *F. trisensilla* sp. n.) loose two s-setae: lateral accp-s in dorsal pair of s-setae on Abd.IV and anterior as-s on Abd.V resulting in a pattern showing in Fig. 6. These three species also loose corner accp-s on Th.II and ms on

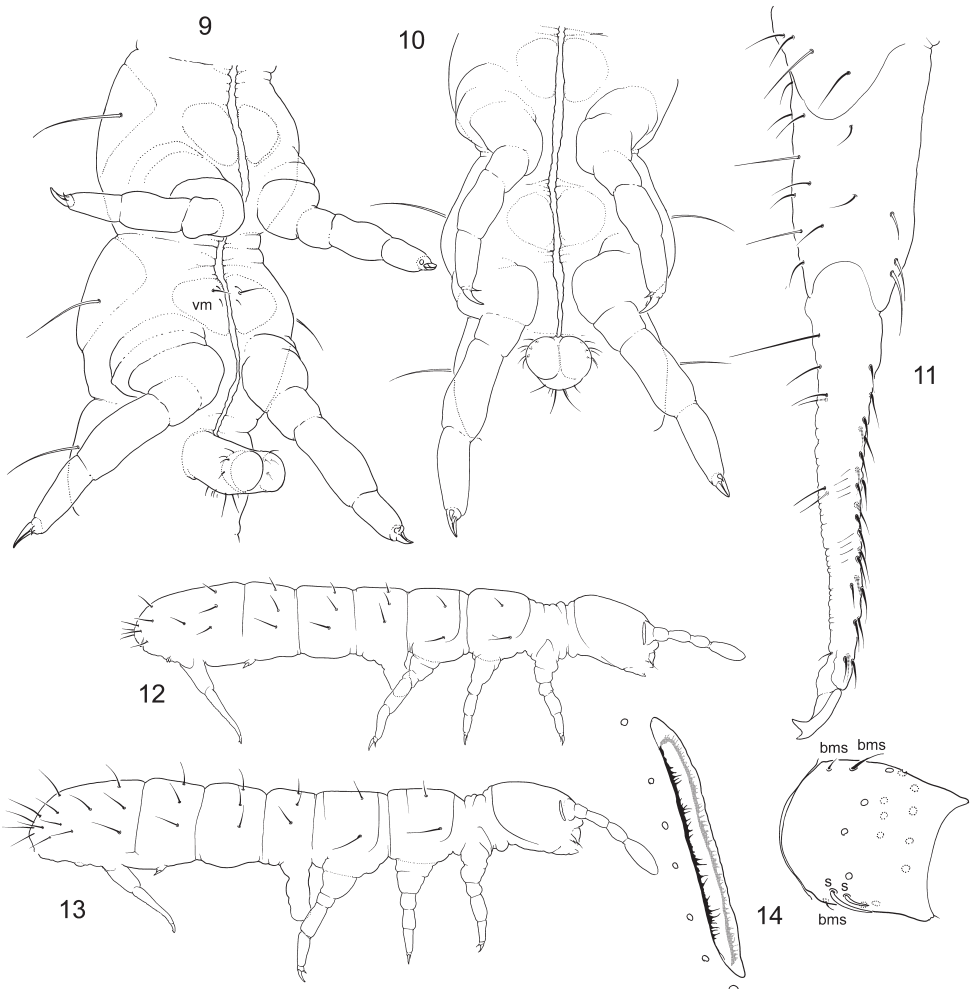
Table 1. Position of medial s-setae on tergites in the '*inoculata*' group.

Th.II–III	Abd.I–II	Abd.III	Species
in p-row	in p-row	in p-row	*F. amurica* sp. n., *F. imparis* sp. n., *F. laconica* sp. n., *F. macrochaetosa*, *F. setifrontalis*, *F. tertia* sp. n., *F. trisensilla* sp. n., *F. baida*, *F. tubulata* sp. n.
in front of p-row	in p-row	in p-row	*F. bashkira*, *F. brevisensilla*, *F. hidakana*, *F. inoculata*
in p-row	in p-row	in front of p-row	*F. tatarica*
in front of p-row	in front of p-row	in front of p-row	*F. breviseta* sp. n., *F. calcarea* sp. n., *F. torpeda*



Figures 1–8. *Folsomia* spp. **1–3** Variants of position of medial *s*-setae on Th.III, Abd.I, and Abd.II **4–7** Sensillar patterns at the end of abdomen in *F. amurica* sp. n. (**4**), *F. bashkira* (**5**), *F. laconica* sp. n. (**6**), and *F. inoculata* (**7**) **8** Position and different number (two, three, and four) of frontal setae on coxa of leg I (encircled). Abbreviations: Md, Mdl, Ml–dorsal, dorso-lateral and lateral macroseta, m-accp, c-accp–medial and corner accp-s-setae, ms–ms-seta, as–as-s-seta, accp2, accp2 –accp-s-seta, upper sbcx, lower sbcx–upper and lower subcoxae, cx–coxa.

Abd.I (Figs 55, 58, 65). These three s-setae loss (on Th.II, Abd.IV, and Abd.V) is a unique character for the genus: s-formula 33/22224 (instead of common for the genus 43/22235) was known neither in the '*inoculata*' group nor in the genus, although similar but not identical reduction is typical of several species of the '*sensibilis*' group (33/22225). In the latter case, as-s-setae of Abd.V remain in the set. Another trend is a differentiation of complete terminal set: s-setae of Abd.IV can undergo shortening (Fig. 5). Differentiation of Abd IV–V s-pattern is most marked in *F. inoculata* (Fig. 7).



Figures 9–14. *Folsomia* spp. **9–10** Ventrum of Th.II, Th.III, and Abd.I in *F. imparis* sp. n. (**9**), setae on Th.III present and *F. hidakana* (**10**), setae absent **11–12, 14** *F. breviseta* sp. n., furca, lateral view (**11**), appearance (**12**), PAO and Ant.I (**14**) **13** Appearance of *F. hidakana*. Abbreviation: vm–ventro-medial setae.

Front setae on coxa of leg I. Species of the '*tatarica*' subgroup, *F. inoculata*, *F. brevisensilla*, *F. breviseta* sp. n., and *F. tertia* sp. n. have two such setae, *F. laconica* sp. n., *F. trisensilla* sp. n., and species of the '*macrochaetosa*' subgroup – three, and *F. hidakana* – four (Fig. 8). This trait probably reflects general number of setae on legs and furca while shows some exceptions.

Setae on ventrum of metathorax. The species of the '*inoculata*' group normally have three ventral setae on each side of Th.III, one of which is long and two are short (Fig. 9). Several species have fewer or more variable number of ventral thoracic setae or all these setae are subequal in size (*F. inoculata*, *F. brevisensilla*, and all species of the '*tatarica*' subgroup). Two species sharply differ from other congeners of the group having no ventral setae on Th.III (*F. breviseta* sp. n., *F. hidakana*) (Fig. 10).

Characters of lower taxonomic value

– PAO in all '*inoculata*' species is slender, with parallel edges, and more than 1.3 times longer than width of Ant.I (Figs 14, 24, 62, 78) that is probably a sharp characteristic of the group discriminating it from adjoining '*fimetaria*' and '*sensibilis*' groups. The so-called "inner denticles" along its edges and middle constriction are usually seen in all species in different extend while both characters considerably vary within populations.
– All species have three basal ms-setae on Ant.I: one ventral and two dorsal. Two dorsal bms-setae are arranged in a longitudinal line, proximal bms is longer (Figs 14, 23, 24). The proximal bms usually hardly differs from common setae and herewith should be carefully excluded if calculating common setae on Ant.I. Species of the '*tatarica*' subgroup have proximal bms clearly shorter than common setae (Fig. 78) while its length also varies depending on specimens.
– The members of '*hidakana*', '*macrochaetosa*', and '*laconica*' subgroups have minute subapical setae on posterior side of dens. The size of the seta varies depending on specimens and often hardly detectable. Small wrinkle in which this seta set in is always visible.

Descriptions of species

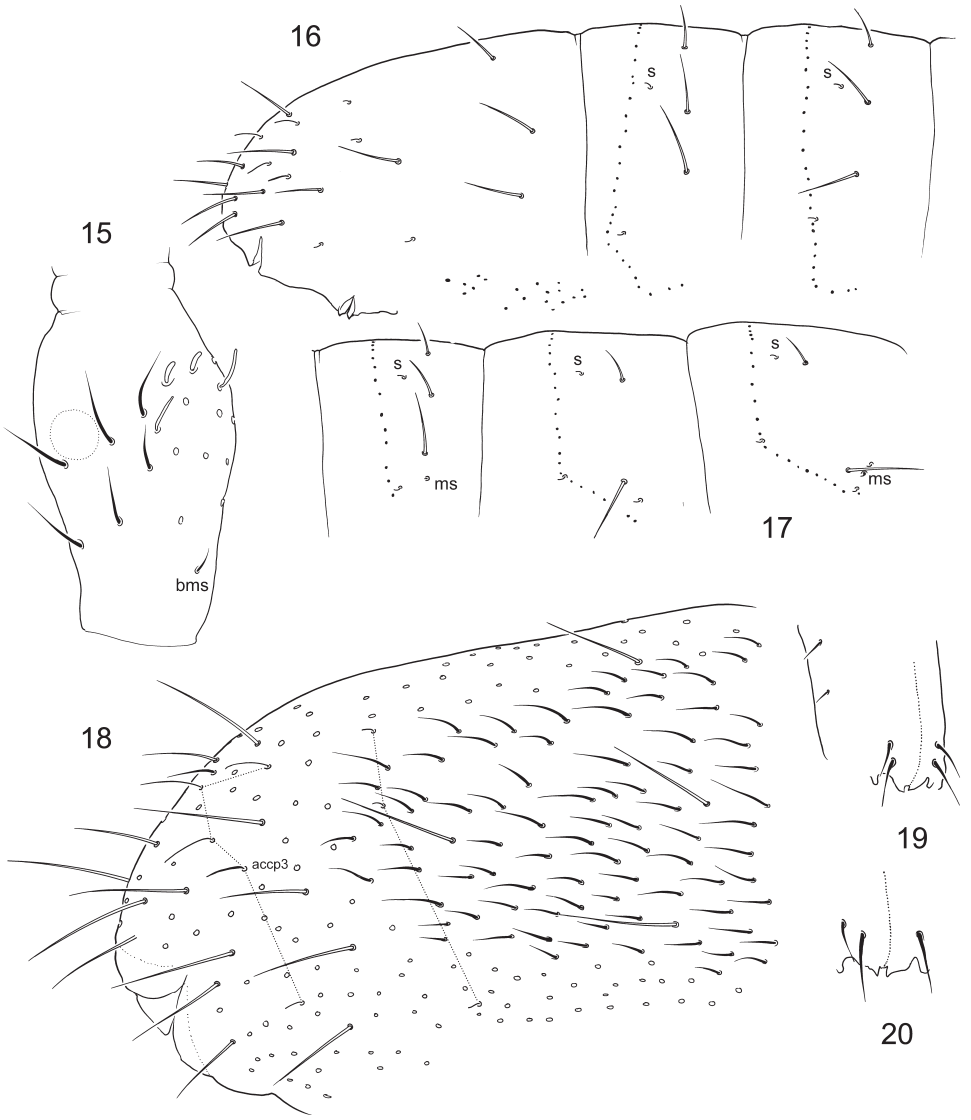
Subgroup '*hidakana*'

***Folsomia breviseta* Potapov & Kuznetsova, sp. n.**
http://zoobank.org/62BCDE0A-6F11-4162-B7EA-58A0B2061542
Figs 11, 12, 14–20

Type material. Holotype, female, Russia, NE Yakutia, Middle Indigirka, near Ust-Nera, 700 m alt., larch forest with thick lichen cover, litter, 22.vii.1992. Ten paratypes from the same biotope, five paratypes from mountain tundra (1500 m alt.) with bushes of *Betula nana* and one paratype from mosses in stony niche on northern slope (1600 m alt.) in the same location. All collected by N. Kuznetsova and M. Potapov. Deposited in MSPU.

Diagnosis. Blind. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula complete (43/22235; 10/100). Medial s-setae on body tergites short, set in anterior position. Macrosetae short. Ventral setae on Th.III absent. Anterior side of manubrium normally with 2+2 setae, dens with 18–22 anterior setae. Mucro bidentate.

Description. Body size from 1.0 (one adult male) to 1.7 mm. Body shape relatively tubular, general appearance not typical of '*inoculata*' group due to short macrosetae (Fig. 12). Without ocelli and pigmentation. Cuticle with fine, hexagonal primary granulation ("smooth"). PAO slender and long, middle constriction varies, 'inner denticles' usually well developed, PAO length 1.8–1.9 as long as width of Ant.I and 2.3–2.5 as long as inner unguis length (Fig. 14). Labium complete, guard setae e7 present, three proximal and four basomedian setae. Ventral side of head with 4+4 postlabial setae.



Figures 15–20. *F. breviseta* sp. n. **15** Ant.III (area of common position of lateral s-setae marked) **16–17** Position of macrosetae, setae of p-row, and s-setae on posterior (**16**) and anterior (**17**) half of corpus **18** Chaetotaxy of Abd. IV–VI **19–20** Chaetotaxy of anterior side of manubrium, variations. bms–basal ms.

Ant.I with 13–15 common setae, two ventral s-setae (s) and three basal micro s-setae (bms): two dorsal bms (short and long) and one ventral bms. Ant.II with three bms and one latero-distal s, Ant.III with one bms and four distal s (lateral s absent, Fig. 15). Several tubular s-setae on Ant.IV. Organite small.

Common setae short. Sensillary formula as 43/22235 (s) and 10/100 (ms). S-setae short, four s-setae on dorsal side of Abd.V longer. Medial s-setae on Th.II–Abd.III

situated in front position, on Abd.I–III between Md and Mdl (Figs 16, 17). Abd.V with five s-setae arranged as three in dorsal position, thin, as long as common setae (as, accp1, accp2), one lateral, thicker than dorsal, and one latero-ventral, short ('3+1+1' pattern) (Fig. 18), accp3 s-setae subequal to accp2. Macrosetae smooth and short, 2,2/3,3,3 in number, medial ones on Abd.V much shorter than dens (2.3–3.1) and 1.8–2.3 times longer than mucro (Fig. 18). Axial chaetotaxy as 10–12,7–8,/5–6,5,5. Thorax without ventral setae.

Empodial appendage as long as 0.5–0.6 unguis. Tibiotarsi with 24–27 setae on legs I–II, and 28–32 on leg III. Upper and lower subcoxae of legs I–III with 0,1/3,6–8/5–7,7–9 setae, respectively. Coxae of leg I with two front setae. Ventral tube with 4+4 latero-distal and 5–7 posterior setae (two in distal transversal row and 3–5 in more proximal position), anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 12–15, posterior one with six setae. Anterior side of manubrium normally with 2+2 setae at distal edge, arranged in two longitudinal lines (Fig. 19). One additional seta often present on one side in a distance from main group resulting in 2+3 set (Fig. 11). One of the paratypes shows 2+1 anterior setae on manubrium (Fig. 20). Posterior side of manubrium with 4+4 latero-basal, two apical setae (ap), 2+2 setae in distal transversal row (M1, L1), two pairs of lateral setae, and 5–6+5–6 in central part (Fig. 11). Dens with 18–22 anterior setae. Posterior side of dens crenulated and with seven setae: four basal, two at the middle, and one (not especially small) at base of mucro (Fig. 11). Mucro bidentate. Ratio of manubrium : dens : mucro = 4.1–4.5 : 5.1–5.8 : 1. Males present.

Remarks. *Folsomia breviseta* sp. n. combines several characters rare for the group: short macrosetae and s-setae, anterior position of medial s-setae on body tergites, the absence of ventral setae on Th.III. A loss of lateral s-setae on Ant.III is a very peculiar character while the nature of this character is not easy to interpret since all species of the family Isotomidae, if not all Collembola, have these s-setae. The absence of s-setae was confirmed in all available specimens. Beyond '*inoculata*' group several blind species with two pairs of setae on manubrium can be confused with *F. breviseta* sp. n., for example, *F. bisetosa* Gisin, *F. cephalota* Bu et al., and *F. sensibilis* Kseneman. All these species belong to other groups and therefore differ essentially by characters of high rank.

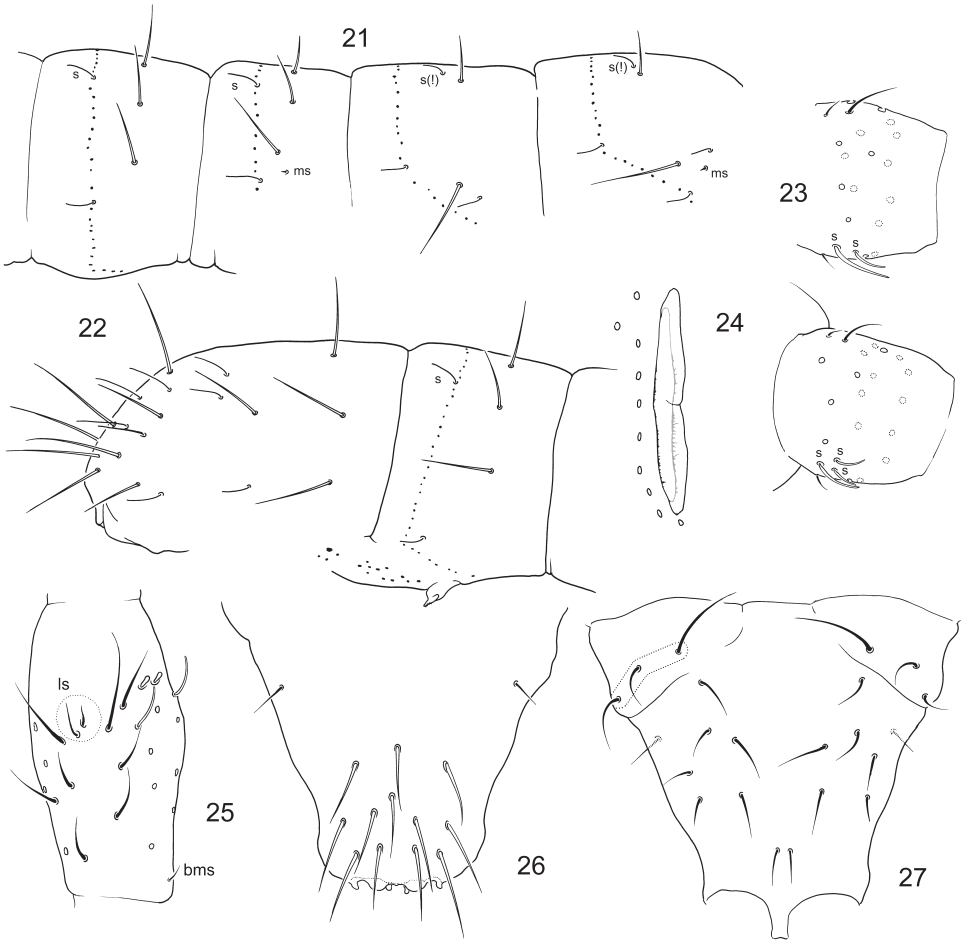
Distribution and ecology. The species is known only from the type locality where it inhabits mountain forests and tundra.

Derivatio nominis. The new species name reflects short setae on body.

Folsomia hidakana Uchida & Tamura, 1968

Figs 10, 13, 21–28, 90

Material. Japan, Honshu Island, Nobeyama, Nagano, 10.x.2012, coll. M. Hasegawa; Kitaibaraki, 2.xi.2011, coll. M. Hasegawa; Hokkaido Island. Shore of Harutori Lake, Kushiro city, 14.v.2014 and 19.viii.2014, coll. Y. Suma; Shiretoko Peninsula, surroundings of Utoro, litter of mixed forest, 90 m alt., 20.viii.2016, 44.1006°N,



Figures 21–27. *F. hidakana* **21–22** Position of macrosetae, setae of p-row, and s-setae on anterior (**21**) and posterior (**22**) half of corpus **23** Ant.I (S Primorye: Far East of Russia) **24** PAO and Ant.I (Honshu: Japan) **25** Ant.III **26–27** Manubrium, anterior (26) and posterior (27) views. Abbreviations: bms–basal ms, ls–lateral s.

145.0584°E, coll. M. Potapov and N. Kuznetsova; Shiretoko Peninsula, trail to Rausu Mount, ~200 m alt., 29.ix.2013, coll. R. Kitagawa and S. Fujii; ibidem, trail to Rausu Mount, ~1000 m alt, oak litter, coll. M. Potapov and N. Kuznetsova.

North Korea. Hamgyong-namdo Province (= South Hamgyong), valley N from Song-riong, 03.vi.1987, and SW from Tanchon, 30.v.1987, coll. A. Szeptycki.

Far East of Russia, Primorsky Krai, Lazovsky District, nearby Preobrazheniye, litter and rotten wood in deciduous and coniferous forests, 400–700 m alt., 21.ix.2011, coll. M. Potapov, Y. Bu, H. Chen-Wang; Khasansky District, Peschany Peninsula, near Beregovoye, litter under dogrose, 09.ix.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos, Khasansky District, ~15 km S Kraskino, Mramorny Cape, oak wood litter and soil under coastal reed, 28.ix.2004, coll. M. Potapov, L. Deharveng,

R. Pomorski, and A. Bedos; Khasansky District, ~15 km W Kraskino, Mayachnoye (Chertova Gorka), forest litter, 28.ix.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; Khasansky District, Krabbe Peninsula, Astafyeva Cape, deciduous litter, v.2007, coll. E. Sokolova; Khasansky District, "Kedrovaya Pad", mixed forest, litter, 29.vii.2016, coll. M. Potapov and N. Kuznetsova; ibidem, coniferous and deciduos litter, 29.ix.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; ibidem, 03.x.2009, coll. O. Smirnova, ibidem, v.2015, coll. A. Matalin; Khasansky District, near Barabash, oak wood on slope, litter, 27.ix.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; Partizansky District, vicinities of Ekaterinovka, Chondalaz (= Lazovy) Range, oak litter, 26.ix.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; Ussuriyski District, Ussuriyski Reserve, decaying wood, 5.x.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; Shkotovsky District, Khualaza Mount, 2.x.2004, coll. R. Pomorski; between Vladivostok and Artem, botanical garden, litter of mixed forest, ix.2012 and 04.x.2009, coll. O. Smirnova; Terneysky District, Sikhote-Alimski Reserve, Kabany station, forest litter, 08.viii.2017, coll. N. Kuznetsova, A. Geras'kina, A. Kuprin; Kavalerovski District, road Kavalerovo-Dal'negorsk, 44.3844°N, 135.3639°E, mossy larch forest with *Rhododendron*, 09.viii.2017, coll. N. Kuznetsova, A. Geras'kina, A. Kuprin; Khabarovsky Krai, Vaninsky District, nearby Datta, coastal larch-wood, 28.ix.2011, coll. M. Potapov; Vaninsky District, five km N Vysokogorny, valley of Mulinka River, larch-forest litter, ~ 600 m alt., 29.ix.2011, coll. M. Potapov.

Description. Body size from 1.2 to 1.7 mm. Body shape as common for the group, not slender (Fig. 13). Usually with large pigment grains rarely scattered on body, more on fused Abd.IV–VI. Cuticle with fine hexagonal primary granulation ("smooth"). Ocelli absent. PAO slender, with clear middle constriction, 'inner denticles' hardly developed, its length 1.2–1.7 as long as width of Ant.I and 1.6–2.0 as long as inner unguis length (Fig. 24). Labium complete, guard setae e7 present, three proximal and four basomedian setae. Ventral side of head with 4+4 postlabial setae. Ant.I with 15–17 common setae, 2–3 (see the discussion below, Figs 23, 24) ventral s-setae (s) and three basal micro s-setae (bms): two dorsal bms (short and long) and one ventral bms. Ant.II with three bms and one latero-distal s, Ant.III with one bms and with 5–6 distal s (one or two lateral s, Fig. 25). Organite varies in shape, often large.

Common setae middle-sized. Setae covering polychaetotic: Abd.IV with 7–9 p-setae between medial accp-s, Abd.V with m1-setae (marked on Fig. 28). Sensillary formula as 43/22235 (s) and 10/100 (ms). S-setae long and thin, as long as common setae. Medial s-setae on Th.II–III situated in front position, nearby Md macrosetae, on Abd.I–III in p-row, between Md and Mdl (Figs 21, 22). Abd.V with five s-setae arranged as four in dorsal position, rather long (as, accp1, accp2, accp3), and one latero-ventral, middle-sized (weakly differentiated '4+1' pattern), accp3 s-setae insignificantly shorter and thicker than accp2 (Fig. 28). Macrosetae smooth, their length vary from long to moderately long, 2,2/3,3,3 in number, medial ones on Abd.V a little shorter than dens (1.0–1.3) and 3.7–6.0 times longer than mucro. Axial chaetotaxy as 9–12,7–9,/4–5,4–5,4. Thorax without ventral setae (Fig. 10).

Empodial appendage approximately half as long as unguis. All tibiotarsi with many additional setae: 29–33 on legs I–II, ~38–42 on leg III. Upper and lower subcoxae of legs I–III with 0,1/4–6,8–11/8–12,8–11 setae, respectively. Coxae of leg I with four (rarely five) front setae. Ventral tube with 5–6+5–6 latero-distal and 6–8 posterior setae, anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 11–14, posterior one with four setae. Anterior side of manubrium with 4–6+4–6 pair setae and usually with two unpaired axial setae (Fig. 26). Posterior side of manubrium with 3+3 latero-basal, two apical setae (ap), 2+2 setae in distal transversal row (M1, L1), one pair of lateral setae, and 4(3)+4(3) in central part (Fig. 27). Dens with 19–23 anterior setae. Posterior side of dens crenulated and with six setae: three basal, two at the middle, and one rudimentary at base of mucro (often hardly visible). Mucro bidentate. Ratio of manubrium : dens : mucro = 3.7–6.2 : 4.5–7.0 : 1. Males present.

Remarks. Our specimens fit to the original description of *F. hidakana* in all significant features. Uchida and Tamura (1968) did not show in figures a subapical rudimentary seta on posterior side of dens and short latero-central setae (l2) on manubrium (probably overlooked). We also found wider variability in most characters that is certainly explained by larger material we have studied. Macrosetae on figures in first description (Figs 28, 35 in Uchida and Tamura 1968) seem to be shorter than in our material. *Folsomia hidakana* is a peculiar species due to anterior position of medial s-setae on thoracic segments, 5+5 or more latero-distal setae on ventral tube (vs 4+4 that is more common for the group), four setae on posterior furcal subcoxa (fewer than common for the group), 3+3 latero-basal and 1+1 latero-central setae on posterior side of manubrium (fewer than common for the group). The absence of ventral setae on Th.III is the main differentiated feature of *F. hidakana* shared only with allopatric *F. breviseta*, the two species are combined in the formal subgroup *'hidakana'* by us. From '*macrochaetosa*' group *F. hidakana* differ by more setae on body and more lateral position of accp1-s on Abd.V (see Fig. 28 vs Figs 29, 32). Being often mixed with habitually similar species (often with *F. imparis* sp. n.), *F. hidakana* is normally easy to recognize by scattered pigment grains on body.

Specimens collected in Japan, both in Honshu and Hokkaido, differ from specimens from Russia by three (vs two) s-setae on Ant.I. In Japanese populations the individuals with two s rarely occur so we keep both variants within diagnosis of *F. hidakana*.

Distribution and ecology. Species was described from Hokkaido (Hidaka-Mombetsu) and subsequently listed in catalogues of Japanese Collembola (Yosii 1977; Furuno et al. 2000; Niijima and Hasegawa 2011). Known from Hokkaido (Suma 1997, 2008, Hishi et al. 2012), eastern Honshu (Ibaraki) (Hasegawa et al. 2009), Aomori Pref. (Yamauchi and Suma 1999, 2009). In Far East of Russia the species was previously recorded near Ussuriysk (Kutyreva 1988) and in Shikotan Island (as '*F.* sp.aff. *hidakana*' in Potapov and Marusik 2000).

As a whole, distributional range of the species appears to cover southern area of the Russian Far East, North Korea, and northern half of Japan (Fig. 90). It inhabits forest litter and decaying wood in low mountains, rare in higher altitudes.

Subgroup '*macrochaetosa*'

***Folsomia amurica* Potapov & Kuznetsova, sp. n.**
http://zoobank.org/3F726CE9-BE32-46F1-88E9-BC0FBED96F0E
Figs 4, 29–31, 33–39, 90

Type material. Holotype, female, Far East of Russia, Amurskaya Region, Zeysky Reserve, ~50 km W Zeya, near "Gol'tsy" station, subalpine dwarf wood (*Pinus pumila*), ~ 1300 m alt., coniferous litter, 20.viii.2014., Ten paratypes from the same biotope and five paratypes from the same location, litter of mixed forest at 700 m alt., 21.viii.2014, coll. M. Potapov and N. Kuznetsova. Deposited in MSPU.

Other material. Far East of Russia, Amurskaya Region, various biotopes nearby type locality: litter and rotten wood in mountain tundra, spruce and larch forests at different altitudes (from 400 to 1400 m alt.); Amurskaya Region, ~ three km W Arkhara, oak-forest, litter, 17.viii.2014, coll. M. Potapov and N. Kuznetsova.

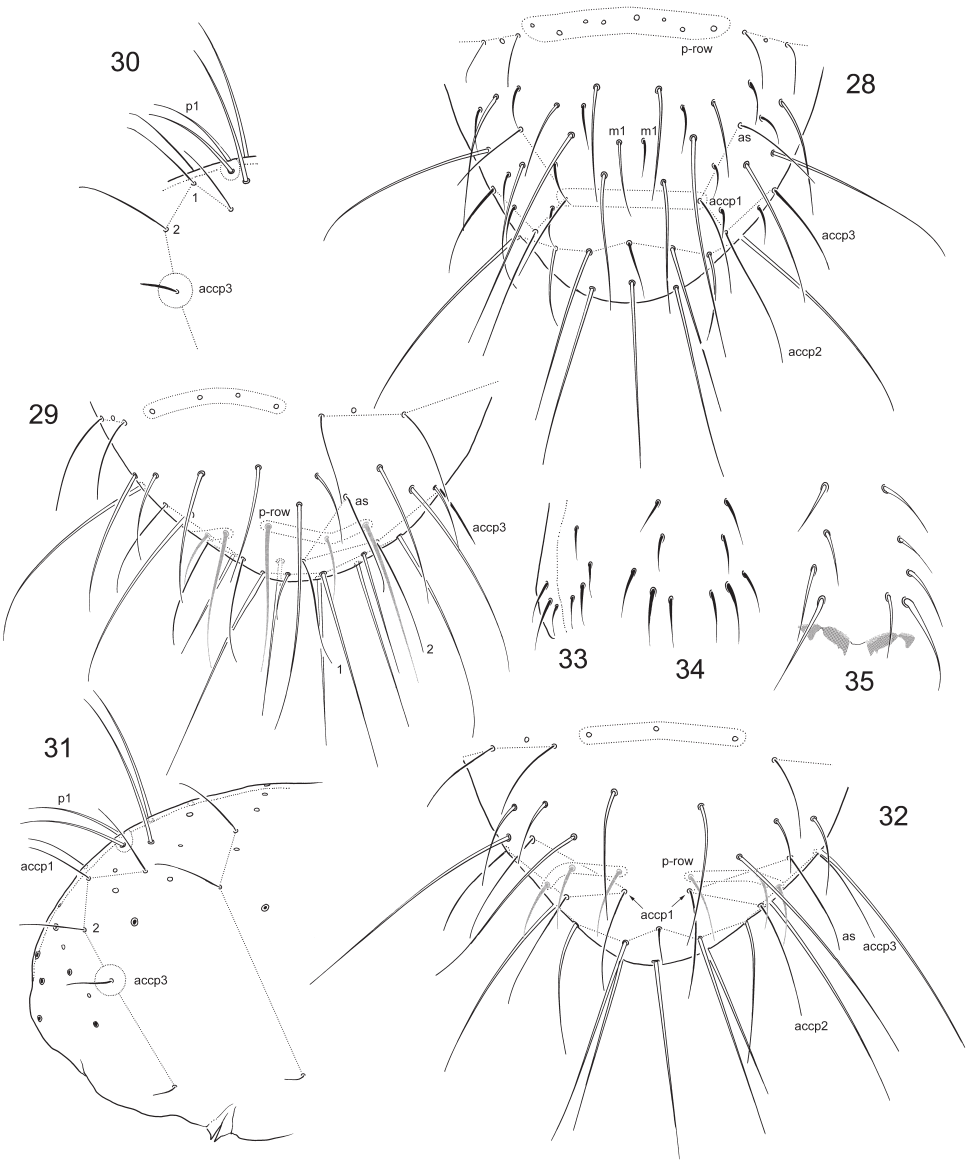
China, Inner Mongolia Province, Da Hinngan Ling Mts, ~ 25 km W BaLin, young tussocky wet birch forest, litter, 12.viii.2014, coll. M. Potapov.

Diagnosis. Blind. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula complete (43/22235; 10/100). Medial s-setae on body tergites long, set in p-row. Ventral setae on Th.III present. Manubrium on anterior side with 4–6+4–6 setae, no unpaired axial setae, dens with 23–27 anterior setae. Mucro bidentate.

Description. Body size from 1.0 to 1.5 mm. Body without pigmentation, relatively tubular (Fig. 39). Cuticle with fine, hexagonal primary granulation ("smooth"). Ocelli absent. PAO slender, constricted, 1.3–1.7 as long as width of Ant.I and 1.6–2.0 as long as inner unguis length. Labium with five usual papillae (*A*–*E*), guard setae e7 absent, three proximal and four basomedian setae. Ventral side of a head with 4+4 postlabial setae. Ant.I with 15 common setae as a rule, two (rarely three) ventral s-setae (s) and three bms, two of which small, dorsal and ventral, the former set together with long seta-form third bms, Ant.II with three bms and one latero-distal s, Ant.III with one bms and with five distal s (including one lateral), without additional s-setae. Several tubular s-setae on Ant.IV. Organite large, rounded.

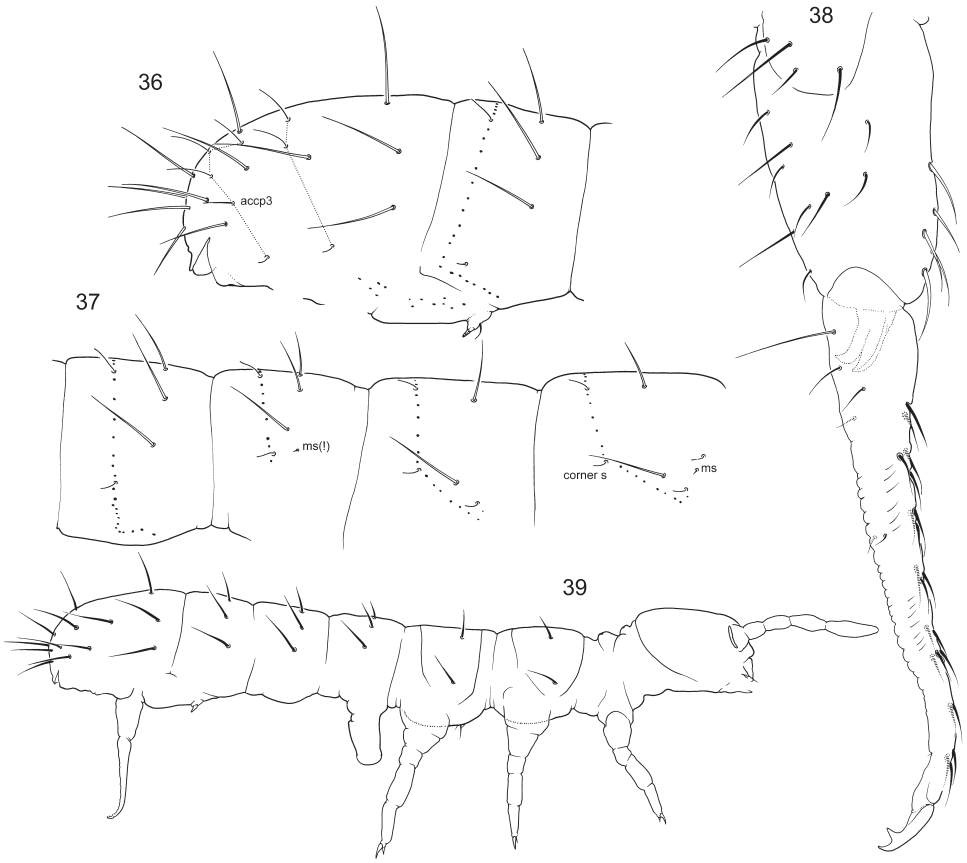
Common setae long. Sensillary formula as 43/22235 (s), 10/100 (ms) (Figs 36, 37). The most tergal s-setae thin and long. Medial s-setae on Th.II–Abd.III situated in posterior position, on Abd.I–III between Md and Mdl. Latero-ventral s-setae on abdominal tergites shorter than medial (Fig. 37). Abd.V with five s-setae arranged as three dorsal ones (as, accp1, accp2), long and slender, one lateral (accp3), clearly shorter (accp2 : accp3 = 1.8–2.3), and one latero-ventral, short ('3+1+1' pattern) (Figs 29–31). p1-setae on Abd.V long (see Table 2). Macrosetae smooth and long, 2,2/3,3,3 in number, medial ones on Abd.V 1.5–1.8 times shorter than dens and 4.7–6.2 times longer than mucro. Axial chaetotaxy as 10–11,6,/3–4,3–4,3–4. Metathorax with 3+3 ventral setae of which one long and two short.

Unguis of normal shape, without lateral and inner teeth. Empodial appendage as long as 0.5–0.6 unguis. All tibiotarsi with additional setae: 26–29 on legs I–II and > 35



Figures 28–35. *Folsomia* spp. **28** *F. hidakana*, end of abdomen, dorsal view **29–31** *F. amurica* sp. n., end of abdomen, specimens from Amurskaya Region, dorsal (**29**) and lateral views (**31**), specimen from Inner Mongolia Province, lateral view (**30**) **32** *F. imparis* sp. n., end of abdomen **33–35** *F. amurica* sp. n., chaetotaxy of anterior side of manubrium, variations.

on leg III. Upper and lower subcoxae of legs I–III with 0,1/3,8–9/5–6,8–10 setae, respectively. Coxae of leg I with three front setae. Tibiotarsal tenent setae pointed, some setae on distal half of tibiotarsi thickened. Ventral tube with 4+4 latero-distal and 7–8 posterior setae (four in distal transversal row and 3–4 in more proximal position), an-



Figures 36–39. *F. amurica* sp. n. **36–37** Position of macrosetae, setae of p-row, and s-setae on posterior (**36**) and anterior (**37**) half of corpus **38** Furca, lateral view **39** Appearance.

teriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 8–9, posterior one with five setae. Anterior side of manubrium with 4–6+4–6 setae, their position vary, unpaired setae absent (Figs 33–35). Posterior side of manubrium with 4+4 latero-basal, two apical setae (ap), 3+3 setae in distal transversal row (M1, ml1, L1), two pairs of lateral setae, and 3–4+3–4 in central part (Fig. 38). Dens with 19–24 anterior setae. Posterior side of dens crenulated and with six normal setae (four basal and two at the middle) and usually one rudimentary minute seta at the base of mucro (Fig. 38). Mucro bidentate. Ratio of manubrium : dens : mucro = 4.5–6.2 : 7.2–9.3 : 1. Males present.

Remarks. The species most resembles *F. macrochaetosa* and *F. imparis* sp. n. and is characterized by the absence of unpaired setae on anterior side of manubrium, short accp3-s-setae and long p1 setae on Abd.V (Table 2).

Distribution and ecology. Known from three neighboring localities of inner part of East Asia (Fig. 90). The species occurs in forest litter at different altitudes.

Derivatio nominis. The species is common in areas around Amur River lowlands.

Folsomia brevisensilla Potapov & Babenko, 2000

Material. Far East of Russia, Magadanskaya Region, Ten'kinsky District, village Kulu, 04.ix.1995, coll. S. Bukhkalo.

Remarks. The species resembles *F. inoculata* sharing with the latter species a middle-sized furca, short s-setae on body, their position on tergites, and undifferentiated ventral setae on Th.III. Nevertheless, *F. brevisensilla* does not possess several unique characteristics of the latter species, e.g., large and tubular accp3-s on Abd.V and the absence of subapical seta on posterior side of dens.

Distribution. It is the most northern species of the '*inoculata*' group since known so far only in the basin of Kolyma River (NE Asiatic part of Russia).

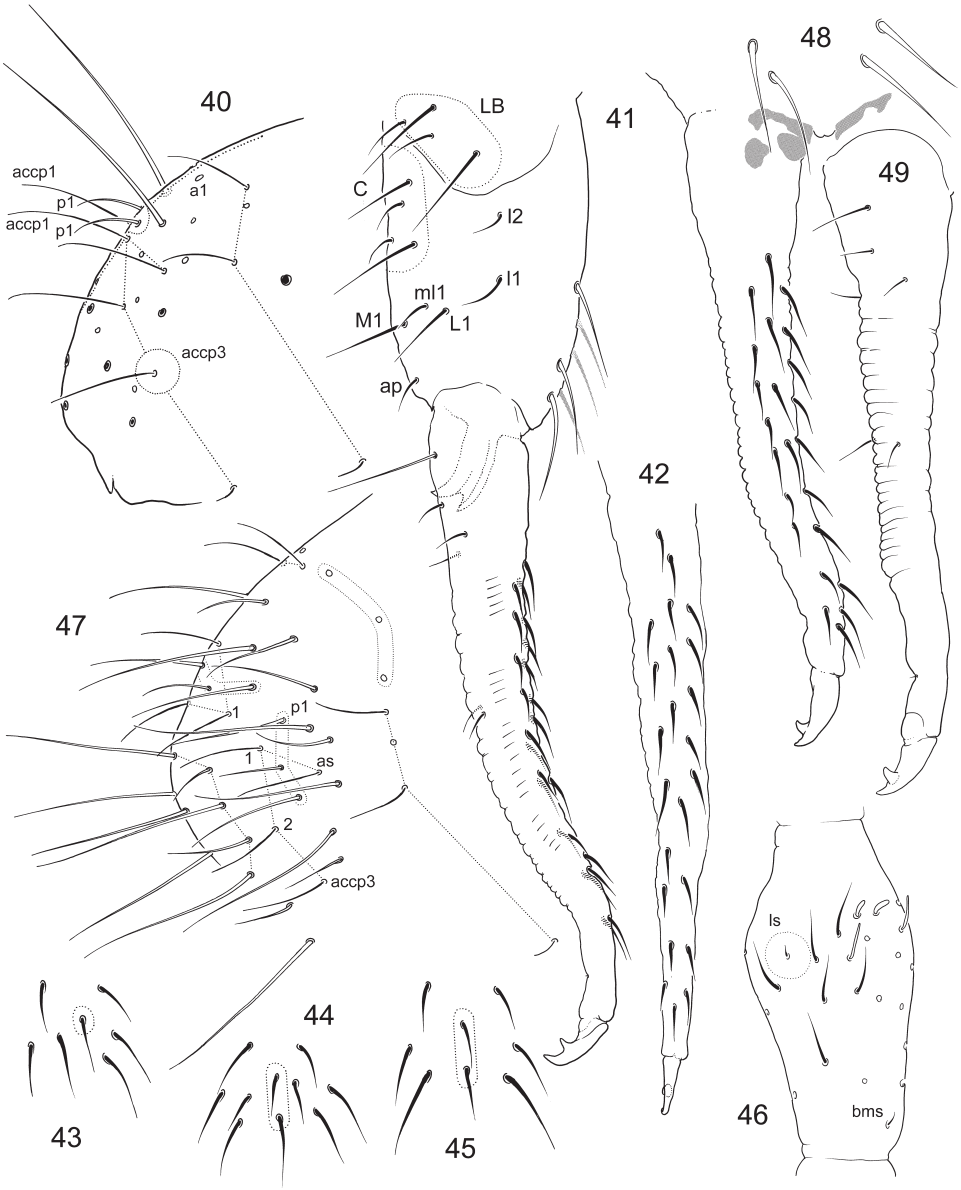
Folsomia imparis Potapov & Hasegawa, sp. n.

http://zoobank.org/695BD340-E77E-43FF-B561-05E42B1FE6B8
Figs 32, 40–46, 90

Type material. Holotype, female, Japan, Hokkaido Island, Shiretoko Peninsula, trail to Mont. Rausu, deciduous forest (*Acer*, *Quercus*, *Sorbus*, *Magnolia*, *Daphniphillum macropodium*), litter, 19.viii.2016, 354 m alt., 44.1083°N, 145.0893°E, coll. M. Potapov and N. Kuznetsova. Paratypes, 12 specimens from the same location; three specimens from Russia, Far East, S Primorye, Ussuriysky Reserve, Komarovskoye Forest District, Turova Nipple, Khripunovsky Pass, mixed forest with *Pinus koraiensis* on slope, rotten wood, 22.vii.2016, coll. M. Potapov and N. Kuznetsova; four specimens from same region, but Shkotovsky District, trail to Mont. Khualaza, deciduous forest, rotten wood and litter, 21.vii.2016, coll. M. Potapov and N. Kuznetsova. The material from Japan and Russia is deposited in TPM and MSPU, respectively.

Other material. Far East of Russia, Primorsky Krai, Bikin River near confluence to Amba River, mixed forest litter, 29.ix.2009, coll. O. Smirnova; Ussuriyski District, Ussuriyski Reserve, decaying wood, 5.x.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; Shkotovsky District, trail to Khualaza Mount, rotten wood, 21.vii.2016, coll. M. Potapov and N. Kuznetsova; Partizansky District, vicinities of Ekaterinovka, Chondalaz (= Lazovy) Range, oak litter, 26.ix.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; Khasansky District, vicinities of Barabash, oak litter, 200–400 m alt., 27.ix.2004, coll. M. Potapov; Sakhalin, Kholmsky District, South Kamysh Ridge, Spamberg Mt., moss in mixed and coniferous forests, 14–15. vi.2017, coll. A. Kuprin; Korsakovsky District, vicinities of Korsakov, forest litter, 16.vi.2017, coll. A. Kuprin; Khabarovsky Krai, suburbs of Khabarovsk, Voronez highlands, leaf litter near river bank. 26.iv.2010, coll. M.Potapov; Verkhnebureinsky District, western part of Badjal Range, upper flow of Irungda River (tributory of Amgun' River), 1900 m alt., subalpine litter and moss, 23.vi.2014, coll. A. Brinev.

North Korea. Hamgyong-namdo Province (= South Hamgyong), SW from Tanchon, 30.v.1987, coll. A. Szeptycki; Yanggang-do Province, Rimjong-su Waterfall, litter, 7.vii.1985, coll. A. Szeptycki.



Figures 40–49. *F. imparis* sp. n. (**40–46**) and *F. macrochaetosa* (**47–49**) **46** End of abdomen, lateral view **41** Furca, lateral view (unpaired setae marked with grey) **42** Anterior side of dens **43–45** Chaetotaxy of anterior side of furca, variations **46** Ant.III **47** End of abdomen **48** Furca, anterior view **49** Dens, posterior view. Notation of setae of posterior and lateral sides of manubrium: ap, M1, ml1, L1, l1, l2; LB–latero-basal setae, C–setae of central area.

Material of *F.* sp. aff. *imparis*. Khabarovsky Krai (western part), Bureyskoye Reservoir, Nizny Mel'gin Bay, 50.5539°N, 131.3970°E, 12.ix.2009, coll. M. Babykina; Amurskaya Region, ~3 km N Zeya, oak litter, 22.viii.2014, coll. M. Potapov and N. Kuznetsova.

Diagnosis. Blind. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula complete (43/22235; 10/100). Medial s-setae on body tergites long, set in p-row. Ventral setae on Th.III present. Manubrium on anterior side with 3–5+3–5 paired and 2–3 unpaired axial setae, dens with 23–27 anterior setae. Mucro bidentate.

Description. Body size from 0.9 to 1.4 mm. Body without pigmentation, its shape as in *F. amurica* sp. n. Cuticle with fine hexagonal primary granulation ("smooth"). Ocelli absent. PAO slender, constricted, 1.4–1.7 as long as width of Ant.I and 1.7–1.9 as long as inner unguis length. Labium with five usual papillae (*A*–*E*), guard setae e7 absent, three proximal and four basomedian setae. Ventral side of a head with 4+4 postlabial setae. Ant.I with 15–17 common setae, two ventral s-setae (s) and three bms, one long (inseparable from common setae) and two short, Ant.II with three bms and one latero-distal s, Ant.III with one bms and with five distal s (including one lateral), without additional s-setae (Fig. 46). Several tubular s-setae on Ant.IV. Organite stick-like, small.

Common setae long and sparse. Sensillary formula as 43/22235 (s), 10/100 (ms). Tergal s-setae thin and long. Medial s-setae on Th.II–Abd.III situated in posterior position, on Abd.I–III between Md and Mdl. Abd.V with five s-setae arranged as four ones (as, accp1, accp2, accp3), long and slender, and one latero-ventral, short ('4+1' pattern) (Figs 32, 40), accp3 s-setae almost as long as accp2 (accp2 : accp3 = 1.0–1.2). p1-setae on Abd.V short (see also the Discussion and Table 2). Macrosetae smooth and long, 2,2/3,3,3 in number, medial ones on Abd.V 1.5–2.0 times shorter than dens and 4.8–7.7 times longer than mucro. Metathorax with 3+3 (rarely, 4+3) ventral setae, as in *F. amurica* sp. n.

Unguis of normal shape, without lateral and inner teeth. Empodial appendage as long as 0.4–0.5 unguis. Tibiotarsi with 26–28 setae on legs I–II and 33–37 on leg III. Upper and lower subcoxae of legs I–III with 0,1/3,~7/5–6,7–8 setae, respectively. Coxae of leg I with three front setae. Tibiotarsal tenent setae pointed, some setae on distal half of tibiotarsi thickened. Ventral tube with 4+4 latero-distal and seven posterior setae (four in distal transversal row and three in more proximal position), anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 10–12, posterior one with five setae. Anterior side of manubrium with 3–5+3–5 pair setae, and 2–3 (rarely one) axial unpaired setae (Figs 43–45). Posterior side of manubrium with 4+4 latero-basal, two apical setae (ap), 3+3 setae in distal transversal row (M1, ml1, L1), two pairs of lateral setae, and 3–4+3–4 in central part (Fig. 41). Dens with 23–27 anterior setae (Figs 41, 42). Posterior side of dens crenulated and with six normal setae (four basal and two at the middle) and one rudimentary seta at the base of mucro. Mucro bidentate. Ratio of manubrium : dens : mucro = 5.2–6.6 : 9.4–11.7 : 1. Males present.

Remarks. *Folsomia imparis* sp. n. is well defined by the presence of unpaired setae on anterior side of manubrium shared only with *F. hidakana* (belongs to another subgroup) and *F. setifrontalis* (has anterior setae on ventral tube). Main differences from the other species of the subgroup '*macrochaetosa*' are shown in Table 2.

A typical form, called preliminary as f. 1 (Fig. 32) has short p1-setae on Abd.I. In Japan and Primorsky Krai we often recorded specimens with long p1, as long as a1 (f. 2 in Table 2) which was not mixed with f. 1 by samples even if reported in the same areas.

Additionally, a closely related form was also recorded in two more eastern localities (see the Material part, *F.* sp. aff. *imparis*). It differs from all species listed in Table 2 having much more setae on body tergites: particularly, posterior row of Abd.IV has seven (vs. 3–4) p-setae between medial s-setae. The final decision on the status of these polychaetotic specimens was not made by us and calls for more information on their ecology and distribution.

Distribution and ecology. The species is widely distributed in Far East of Russia, Korea and in the most northern part of Japan (Fig. 90). We suppose some records of *F. fimetaria* in Hokkaido refer to this species. *F. imparis* sp. n. is rather common in different forest litter, often in rotten wood.

Derivatio nominis. The species has unpaired setae on anterior side of manubrium.

Folsomia macrochaetosa Martynova in Martynova, Berman & Chelnokov, 1977

Figs 47–49, 90

Type Material. Three paratypes labelled as "Magadanskaya Region, vicinities of Magadan, Snow Valley, dwarf-wood belt. 18.ix.1974. coll. Berman." Kept in Zoological Institute (S.-Petersburg).

Other material. Far East of Russia, Khabarovsky Krai, Vicinities of Nikolaevskna-Amure, lower flow of Amgun' River, larch and birch forests, 1.vii.1990, coll. N. Ryabinin; Primorsky Krai, Ussuriysky Reserve, Komarovskoye Forest District, mixed forest, 22.vii.2016, coll. M. Potapov and N. Kuznetsova; Terneysky District, Sikhote-Alinski Reserve, Kabany station, hardwood with *Rhododendron*, litter, 08.viii.2017, coll. N. Kuznetsova, A. Geras'kina, A. Kuprin; South Kuril Islands, Kunashir Isl., Krugly Cape and 5 km E Yu-Kuril'sk, viii–ix.1997, coll. Y. Marusik.

South Korea, Gangwon-do, Palsan Mt., mixed forest in foothills, litter, 09.ix.2017, coll. A. Kuprin.

Description. Body size from 0.9 to 1.5 mm. Body without pigmentation, cuticle with fine primary granulation. Ocelli absent. PAO slender, constricted, 1.4–1.6 as long as width of Ant.I and 1.4–2.2 as long as inner unguis length. Labium with five usual papillae (*A–E*), guard setae e7 absent, three proximal and four basomedian setae. Ventral side of a head with 4+4 postlabial setae. Ant.I with 15–16 common setae, s-setae of antennae as in *F. imparis* sp. n. Organite stick-like, small.

Common setae long. Sensillary formula as 43/22235 (s), 10/100 (ms). Tergal s-setae long, medial ones on Th.II–Abd.III situated in posterior position. Abd.V with five s-setae arranged as four ones (as, accp1, accp2, accp3), long and slender, and one latero-ventral, short ('4+1' pattern), accp3 s-setae somewhat shorter than accp2 (accp2 : accp3 = 1.1–1.5). p1-setae on Abd.V long (Fig. 47, see also the Discussion and Table 2). Macrosetae smooth and long, 2,2/3,3,3 in number, medial ones on Abd.V 1.3–1.7 times shorter than dens and 4.6–6.4 times longer than mucro. Metathorax with 3+3 ventral setae, one long.

Unguis of normal shape. Empodial appendage as long as 0.50–0.55 of unguis. Chaetotaxy of tibiotarsi and subcoxae similar to *F. amurica* sp. n. and *F. imparis* sp. n.

Number of front setae on coxae of leg I varies (2–3), variant with two setae common for specimens from Magadan and Kunashir. Ventral tube with 4+4 latero-distal and 6–8 posterior setae, anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 11–12, posterior one with five setae. Anterior side of manubrium with 2–3+2–3 pairs of setae (2+2 usually in males), without axial unpaired setae (Figs 48–49). Dens with 21–30 anterior setae. Posterior side of dens crenulated and with six normal setae and one rudimentary at the base of mucro. Mucro bidentate. Ratio of manubrium : dens : mucro = 4.3–5.7 : 6.4–10.0 : 1. Males present.

Remarks. *F. amurica* sp. n., *F. imparis* sp. n., *F. macrochaetosa*, and *F. setifrontalis* combine a group of species with long macrosetae and furca, sparse setae covering, and posterior position of median s-setae on all tergites. The differences between the species of this subgroup are shown in Table 2.

Distribution. Scattered records all over the coastal areas from Magadan (Russian Far East) to South Korea (Fig. 90).

Folsomia setifrontalis Potapov & Marusik, 1977

Material. Far East of Russia, Primorsky Krai, Partizansky District, vicinities of Ekaterinovka, Chondalaz (=Lazovy) Range, oak litter, 26.ix.2004, coll. M. Potapov, L. Deharveng, R. Pomorski, and A. Bedos; Shkotovsky District, vicinities of Anisimovka and near trail to Khualaza Mount, forest litter, 10-12.ix.2001, coll. M. Potapov, Y. Bu and H. Cheng-Wang; Terneysky District, Sikhote-Alimski Reserve, Blagodatny station, oak wood on slope, rotten wood, 07.viii.2017, coll. N. Kuznetsova, A. Geras'kina, A. Kuprin.

Remarks. *Folsomia setifrontalis* is sharply defined by the presence of anterior setae on ventral tube that is a unique character for the genus. Populations from Primorsky Krai differ from the type specimens (South Kuril Islands) by the presence of unpaired setae on manubrium and longer accp3-s on Abd.V. Considering this variability, a wider diagnosis is proposed for the species. So far, the chaetotaxy of ventral tube remain a key characteristic of this species.

Distribution and ecology. Less common than the sympatric *F. imparis* sp. n. and *F. macrochaetosa*. Rare records in forest litter of southern part of Far East of Russia.

Table 2. Differentiated characters of three species of the '*macrochaetosa*' subgroup.

Species	Abd.V : accp3-s	Abd.V : a1:p1	Paired setae on manubrium	Unpaired setae on manubrium
F. amurica sp. n.	short	0.9–1.1	4–6+4–6	absent
F. imparis sp. n.	long	f.1: 1.4–2.3 f.2: 1.0–1.2	3–5+3–5	2–3 (1)
F. macrochaetosa	long	1.1–1.3	2(3)+2(3)	absent
F. setifrontalis	long	1.6–2.3	3–5+3–5	0–2

Subgroup '*laconica*'

***Folsomia laconica* Potapov & Kuznetsova, sp. n.**
http://zoobank.org/D39223CD-C85B-478F-9392-AB44DF1C64A9
Figs 6, 51, 52, 54, 55–57, 90

Type material. Holotype, female, Far East of Russia, Amurskaya Region, Khingansky Reserve, near (~6 km W) Kundur, valley of Karapcha River, northern steep slope, mixed forest with *Abies*, litter, 19.viii.2014, coll. M. Potapov and N. Kuznetsova. 15 paratypes from the same location and ten paratypes from Khingansky Reserve, ~10 km E Uril, coniferous forest (*Pinus koraiensis*, *Abies*, *Picea*), 7.x.2009, coll. M. Babykina. Deposited in MSPU.

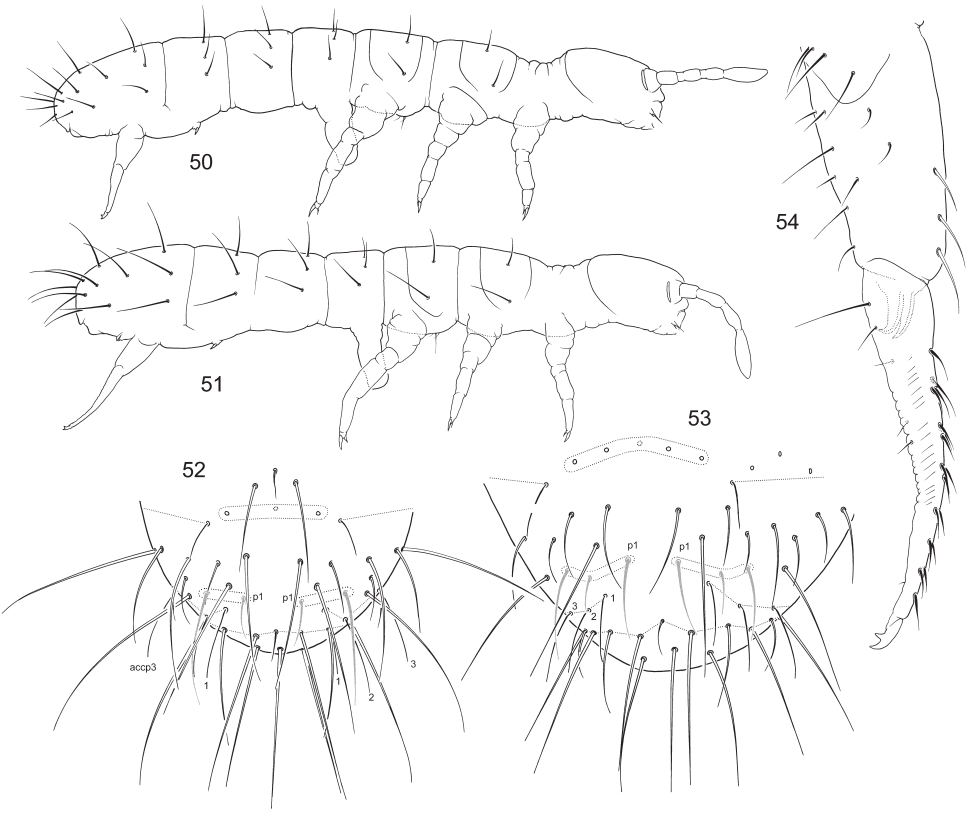
Other material. Amurskaya Region, Khingansky Reserve, ~15–20 km SE Uril, oak wood litter, 8.x.2009, coll. M. Babykina. North Korea, Yanggang-do Province, ~1.5 km SE Mupho, litter under *Rhododendron* and *Alnus*, 5.vii.1985, coll. A. Szeptycki.

Diagnosis. Blind. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula incomplete (33/22224; 10/000). Medial s-setae on body tergites long, set in p-row. Ventral setae on Th.III present. Anterior side of manubrium with 3+3 setae, no unpaired axial setae present. Dens with 17–20 anterior setae, its posterior side with three setae in basal part. Mucro bidentate.

Description. Body size approximately 1.3 mm (Fig. 51). Without pigmentation. Cuticle with fine primary granulation ("smooth"). Ocelli absent. PAO slender, not constricted or slightly constricted, 1.5–1.7 as long as width of Ant.I and 1.7–2.0 as long as inner unguis length. Labium complete, guard setae e7 present, three proximal and four basomedian setae. Ventral side of head with 4+4 postlabial setae. Ant.I with 16–17 common setae, two ventral s-setae (s) and three basal micro s-setae (bms): two dorsal (short and long) and one ventral. Ant.II with three bms and one latero-distal s, Ant.III with one bms and with five distal s (including one lateral), without additional s-setae. Ant.IV with stick-like organite.

Common setae sparse, macrosetae long (Fig. 51). Sensillary formula as 33/22224 (s), three s-setae lost: corner accp-s on Th.II, one of dorsal accp-s on Abd.IV, and as-s on Abd.V (Figs 55–56). Micro s-setae as 10/000 (ms). Tergal s-setae thin and long, lateral s-setae on abdomen shorter. Medial s-setae on Th.II–Abd.III situated in posterior position, on Abd.I–III between Md and Mdl. Abd.V with four s-setae arranged as three long and slender (accp1, accp2, accp3) and one latero-ventral, short ('3+1' pattern) (Figs 52, 57), accp3 s-setae as long as accp2 (ratio accp2 : accp3 = 1.0–1.2). Macrosetae smooth and very long, 2,2/3,3,3 in number, medial ones on Abd.V slightly shorter than dens (dens: Md = 1.0–1.3) and 7.3–9.3 times longer than mucro. Metathorax with 3+3 ventral setae.

Unguis of normal shape, without lateral and inner teeth. Empodial appendage as long as ~0.5 of unguis. All tibiotarsi with additional setae: 28–29 on legs I–II and >35 on leg III. Upper and lower subcoxae of legs I–III with 0,1/3,7/6,8 setae, respectively. Coxae of leg I with three front setae. Tibiotarsal tenent setae pointed, few setae on dis-



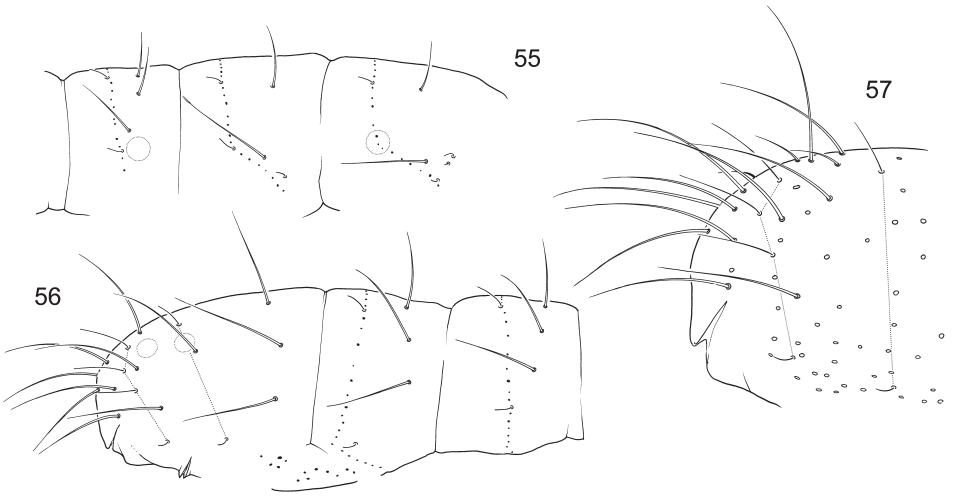
Figures 50–54. *F. trisensilla* sp. n. (**50, 53**) and *F. laconica* sp. n. (**51, 52, 54**) **50–51** Appearance **52–53** End of abdomen, dorsal view **54** Furca, lateral view.

tal half of tibiotarsi III slightly thickened. Ventral tube with 4+4 latero-distal and 6–7 posterior setae (4 in distal transversal row), anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 12–14, posterior one with five setae. Anterior side of manubrium with 3+3 setae (Fig. 54). Posterior side of manubrium with 5+5 latero-basal, two apical setae (ap), 2+2 setae in distal transversal row (M1, ml1), two pairs of lateral setae, and 4+4 in central part (Fig. 54). Dens with 17–20 anterior setae. Posterior side of dens crenulated and with six setae: three basal, two at the middle, and one subapical (Fig. 54). Subapical seta often hardly visible. Mucro bidentate. Ratio of manubrium : dens : mucro = 5.4–7.2 : 7.8–9.3 : 1.

Remarks. *Folsomia laconica* sp. n. most resembles *F. trisensilla* sp. n. but differs having three (vs four) basal setae on posterior side of dens) (Figs 54, 63–64) and fewer common setae at the end of abdomen. The latter character is expressed in 2+2 dorsal p-setae on Abd.V (vs 3+3 in *F. trisensilla* sp. n.) and 2–3 p-setae between s-setae on Abd.IV (vs 4–5) (Figs 52, 53).

Distribution and ecology. Known from three locations in Russian Far East and North Korea (Fig. 90). It occurs in forest litter.

Derivatio nominis. The species shows the most laconic chaetotaxy of p-row on Abd.V.



Figures 55–57. *F. laconica* sp. n. **55–56** Position of macrosetae, setae of p-row, and s-setae on anterior (**55**) and posterior (**56**) half of corpus **57** End of abdomen, lateral view.

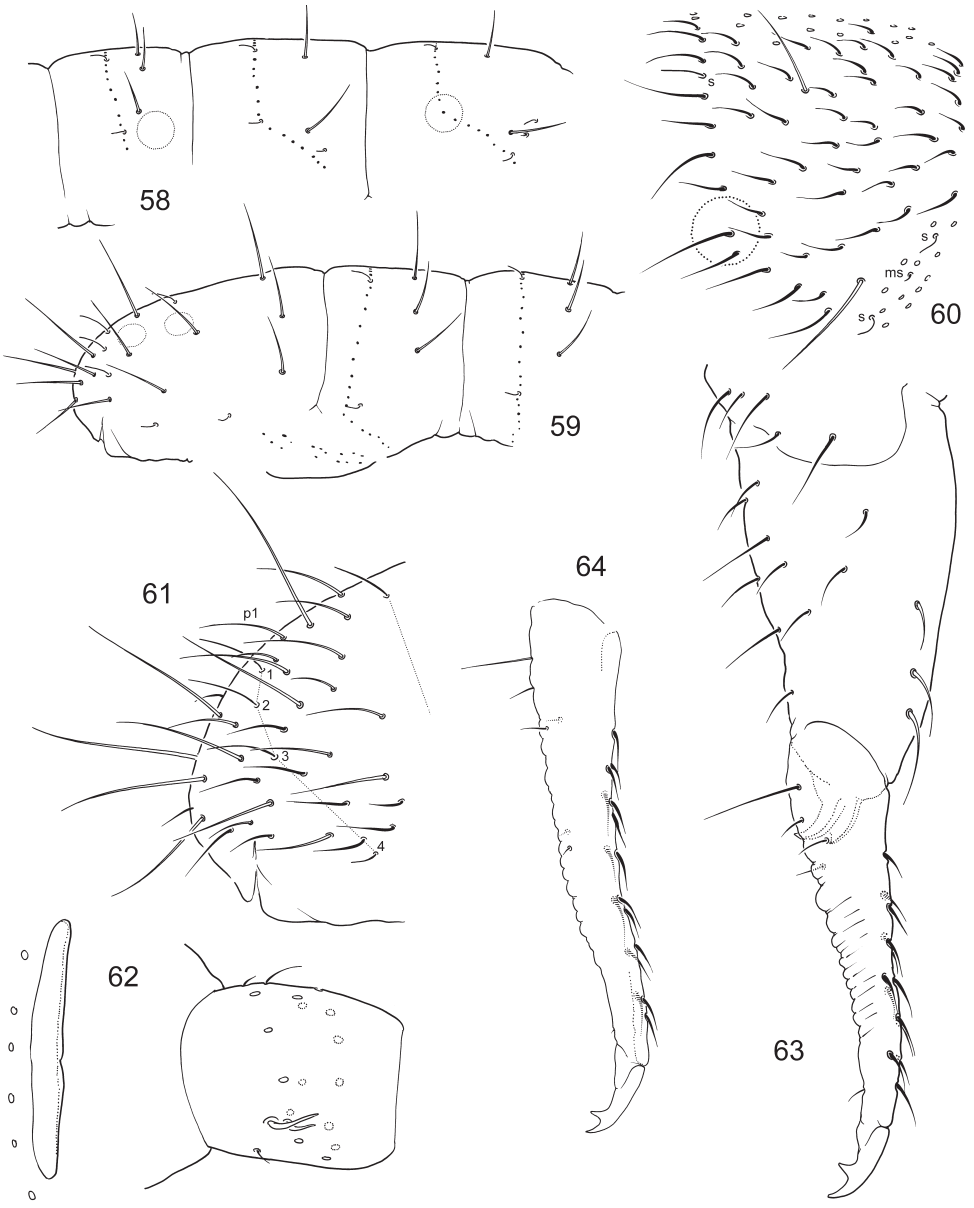
***Folsomia trisensilla* Potapov, sp. n.**
http://zoobank.org/004AE2D2-2ED2-4C31-AB69-BD8792B7FBAD
Figs 50, 53, 58–64, 90

Type material. Holotype, female, Far East of Russia, Khabarovsky Krai, Vaninsky District, 10 km N Vysokogorny, valley of Mulinka River, closed *Picea* and *Abies* forest on NE slope, litter, ~ 750 m alt., 29.ix.2011, coll. M. Potapov. Ten paratypes from the same location and six paratypes from the nearly same location, in litter of coniferous forests at different altitudes (600 and 900 m alt.), 29.ix.2011, coll. M. Potapov. Deposited in MSPU.

Other material. Far East of Russia, Khabarovsky Krai. Different sites of type locality, litter and rotten wood, 29.ix.2011, coll. M. Potapov; Kamchatka. Nearby Anavgai and Esso settlements, different larch forests, litter and rotten wood, ~ 500 m alt., 4.vii.2012, coll. M. Potapov; Primorsky Krai. Terneysky District, Sikhote-Alimski Reserve, Kabany station, forest litter, 08.viii.2017, coll. N. Kuznetsova, A. Geras'kina, A. Kuprin; East Siberia: Chitinskaya Region, near foothills of Daursky Range, valley of Ilya River, ~ three km station Ara-Ilya, 50.9253°N, 113.1783°E, 887 m alt., mixed forest with *Betula* and *Larix*, 11.vii.2014, coll. A. Gulgenova.

Diagnosis. Blind. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula incomplete (33/22224; 10/000). Medial s-setae on body tergites long, set in p-row. Ventral setae on Th.III present. Anterior side of manubrium with 3+3 paired setae, no unpaired axial setae present. Dens with 12–16 anterior setae, its posterior side with four setae in basal part. Mucro bidentate.

Description. Body size from 1.0 to 1.3 mm, rather tubular (Fig. 50). Without pigmentation. Cuticle "smooth". PAO slender, slightly constricted, 1.5–1.7 as long as width of Ant.I and 1.7–2.0 as long as inner unguis length (Fig. 62). Labium complete,



Figures 58–64. *F. trisensilla* sp. n. **58–59** Position of macrosetae, setae of p-row, and s-setae on anterior (**58**) and posterior (**59**) half of corpus **60** Th.II **61** End of abdomen **62** PAO and Ant.I **63** Furca, lateral view (type population) **64** Dens, lateral view (Kamchatka).

guard setae e7 present, three proximal and four basomedian setae. Ventral side of head with 4+4 postlabial setae. Ant.I with 15–16 common setae, two ventral s-setae (s) and three basal micro s-setae (bms): two dorsal (short and long) and one ventral. Ant.II with three bms and one latero-distal s, Ant.III with one bms and with five distal s (including one lateral), without additional s-setae. Several s-setae on Ant.IV tubular. Organite middle-sized, roundish.

Common setae long. Sensillary formula as 33/22224 (s), three s-setae lost (as described for the '*laconica*' subgroup (Figs 58, 59). Corner s-setae on Th.II absent (Fig. 60). Micro s-setae as 10/000 (ms). Tergal s-setae thin and long, lateral s-setae on abdomen shorter. Medial s-setae on Th.II–Abd.III situated in posterior position, on Abd.I–III between Md and Mdl. Abd.V with four s-setae arranged as three long and slender (accp1, accp2, accp3) and one latero-ventral, short ('3+1' pattern) (Figs 53, 61), accp3 s-setae as long as accp2 (0.9–1.1). Macrosetae smooth and long, 2,2/3,3,3 in number, medial ones on Abd.V slightly shorter than dens (1.0–1.3) and 3.5–4.6 times longer than mucro. Metathorax with 3+3 ventral setae.

Empodial appendage as long as 0.5–0.6 of unguis. All tibiotarsi with additional setae: 24–26 on legs I–II and 30–35 on leg III. Upper and lower subcoxae of legs I–III with 0,1/3,7–8/6–7,7–8 setae, respectively. Coxae of leg I with three (rarely two on one side) front setae. Tibiotarsal tenent setae pointed, some setae of distal whorl of tibiotarsi thickened. Ventral tube with 4+4 latero-distal and 7–8 posterior setae (four in distal transversal row and 3–4 in more proximal position), anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 8–10, posterior one with four setae. Anterior side of manubrium with 3+3 setae (rarely 2+3) (Fig. 63). Posterior side of manubrium with 5(4)+5(4) latero-basal, two apical setae (ap), 2+2 setae in distal transversal row (M1, ml1), two pairs of lateral setae, and 4–6+4–6 in central part (Fig. 63). Dens with 12–16 anterior setae. Posterior side of dens crenulated and with five setae (4 basal and one shorter one at the base of mucro), two setae at the middle present or absent (Figs 63, 64, see also the Discussion part). Mucro bidentate. Ratio of manubrium : dens : mucro = 4.1–5.0 : 3.9–5.2 : 1.

Remarks. Two setae at the middle of posterior side of dens are always absent in the type populations (Fig. 63, Khabarovsky Krai). Specimens from Kamchatka possess these setae (always rudimentary and one sometimes asymmetrically lost) (Fig. 67). We accept a wide diagnosis of the new species considering both variants.

An odd population was found near Uril (Amurskaya Region) differing from the typical ones by having 4+4 (vs 3+3) anterior setae on manubrium (left out of diagnosis of the new species so far).

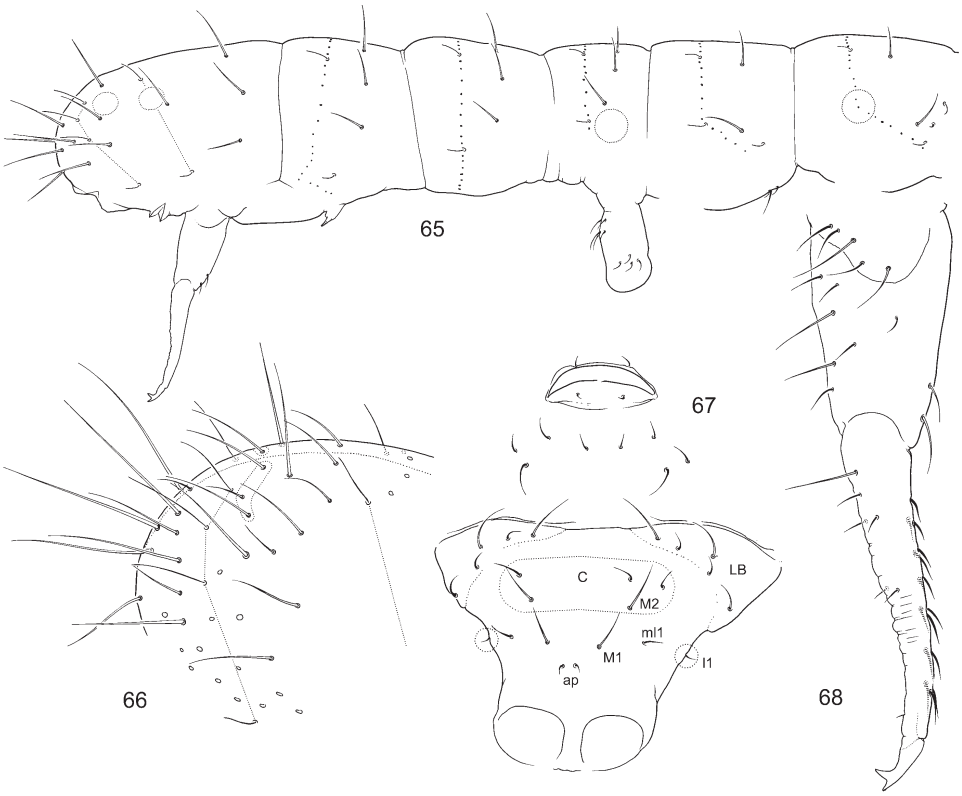
For difference between *F. trisensilla* sp. n. and *F. laconica* sp. n. see Remarks to the latter.

Distribution and ecology. Known from forest litter in three localities in Eastern Asia (Fig. 90).

Derivatio nominis. The new species name reflects the presence of three (vs four, as common for the genus) s-setae on dorsal side of Abd.V that is characteristic of the '*laconica*' subgroup.

***Folsomia tertia* Potapov, sp. n.**
http://zoobank.org/6294599B-3CEA-4971-8B72-6B28918EA511
Figs 65–68

Type material. Holotype, female, Far East of Russia, Khabarovsky Krai, vicinities of Khabarovsk, Bol'shoy Khekhtsyr Range, ~10 km N Korfovsky, mixed forest litter, 28.vi.2007, coll. E. Sokolova. Ten paratypes from the same location. Deposited in MSPU.



Figures 65–68. *F. tertia* sp. n. **65** Position of macrosetae, setae of p-row, and s-setae on corpus **66** End of abdomen **67** Posterior side of manubrium and genital area in adult female **68** Furca, lateral view. Notation of setae of posterior and lateral sides of manubrium: ap, M1, ml1, M2, l1; LB–latero-basal setae, C–setae of central area.

Diagnosis. Blind. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula incomplete (33/22224; 10/000). Medial s-setae on body tergites long, set in p-row. Ventral setae on Th.III present. Anterior side of manubrium with 2+2 setae, no unpaired axial setae present. Dens with 13–16 anterior setae, its posterior side with four setae in basal part. Mucro bidentate.

Description. Body size from 0.9 to 1.2 mm, shape of corpus rather tubular, slender. Without pigmentation. Cuticle with fine hexagonal primary granulation ("smooth"). PAO slender, insignificantly constricted, 1.6–1.8 as long as width of Ant.I and 2.1–2.2 as long as inner unguis length. Labium complete, guard setae e7 present, three proximal and four basomedian setae. Ventral side of head with 4+4 postlabial setae. Ant.I with 14–15 common setae, two ventral s-setae (with one thick) and three basal micro s-setae (bms): two dorsal (short and long) and one ventral. Ant.II with three bms and one latero-distal s, Ant.III with one bms and with five distal s (including one lateral), without additional s-setae. Organite normal, small.

Sensillary formula as 33/22224 (s), three s-setae lost (as in other species of the subgroup, Fig. 65). Micro s-setae as 10/000 (ms). Tergal s-setae thin and long, lateral s-setae

on abdomen shorter. Medial s-setae on Th.II–Abd.III situated in posterior position, on Abd.I–III between Md and Mdl. Abd.V with four s-setae arranged as three ones (accp1, accp2, accp3), long and slender, and one latero-ventral, shorter ('3+1' pattern) (Fig. 66), accp3 s-setae almost as long as accp2 (accp3 : accp2 = 0.8–1.0). With 3+3 medial p-setae on Abd.V: p1 and p3 long, p2 short. Seta p1 somewhat longer than a1 and accp1-s on Abd.V (a1 : p1 = 0.7–0.8, accp1 : p1 = 0.8–0.9). Macrosetae smooth and rather long, 2,2/3,3,3 in number, medial ones at the end of abdomen slightly shorter than dens (0.8–0.9) and 2.8–3.9 times longer than mucro. Metathorax with 3+3 ventral setae.

Empodial appendage as long as 0.55–0.60 of unguis. Tibiotarsi with few additional setae: 22–24 on legs I–II and ~29 on leg III. Upper and lower subcoxae of legs I–III with 0,1/3,7/3–5,~8 setae, respectively. Coxae of leg I with two front setae. Tibiotarsal tenent setae pointed, few setae of whorl of tibiotarsi insignificantly thickened. Ventral tube with 4+4 latero-distal and 5–7 posterior setae (four in distal transversal row and 1–3 in more proximal position), anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 7–9, posterior one with 5–6 setae. Anterior side of manubrium with 2+2 setae (Fig. 68). Posterior side of manubrium with 5+5 latero-basal, two apical setae (ap), 2+2 setae in distal transversal row (M1, ml1), one pair of lateral setae, and 3(2) +3(2) in central part (Fig. 67). Dens with 13–16 anterior setae. Posterior side of dens crenulated and with seven setae (four basal, two at the middle, and one very short at the base of mucro) (Figs 68). Two setae at the middle of dens often very short, one sometimes absent. Subapical seta often hardly visible. Mucro bidentate. Ratio of manubrium : dens : mucro = 3.1–4.1 : 3.3–4.5 : 1. Males present.

Remarks. The new species belongs to the '*laconica*' subgroup due to incomplete s-set on body. It differs from two other members, *F. laconica* sp. n. and *F. trisensilla* sp. n., by reduced chaetotaxy on anterior (2+2 instead of 3–4+3–4 setae) and posterior sides (1+1 vs 2+2 lateral setae) of manubrium. *F. tertia* sp. n. has the shortest macrosetae among species of the subgroup and somewhat resembles members of the '*tatarica*' subgroup.

Distribution. Known only from type locality.

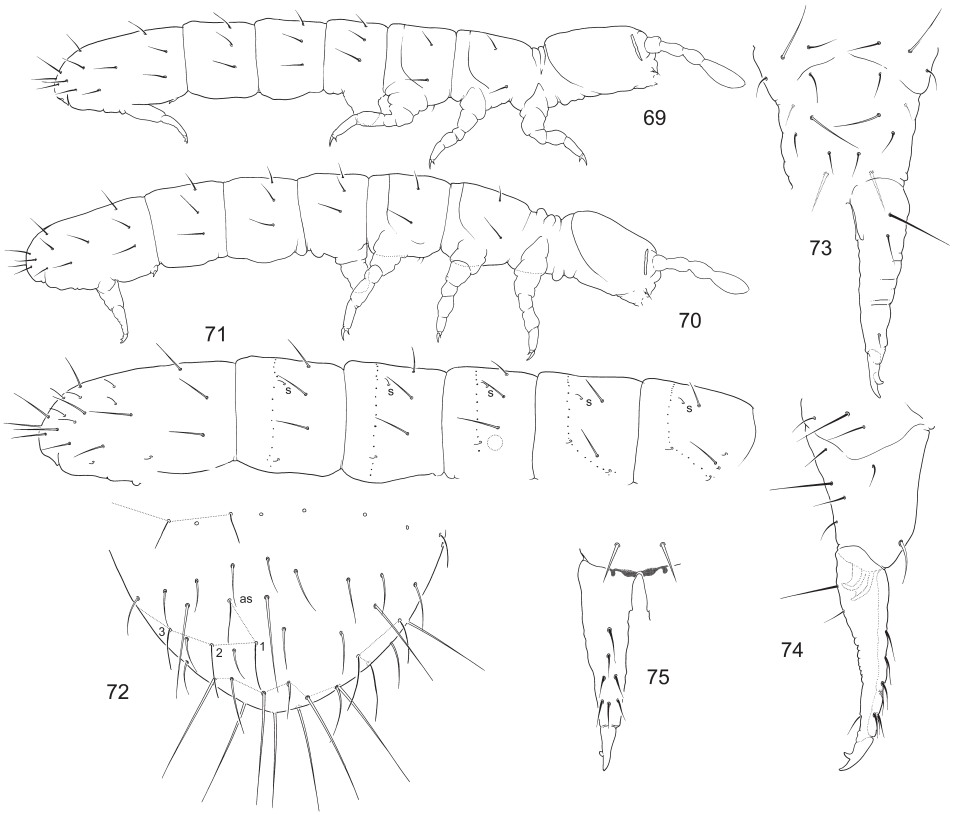
Derivatio nominis. The new species is the third (*tertius* in Latin) species of the '*laconica*' subgroup.

Subgroup '*tatarica*'

***Folsomia calcarea* Potapov, sp. n.**
http://zoobank.org/E4AB1B52-2108-4802-BC00-A8843C5F3372
Figs 69, 71–75

Type material. Holotype, female, Russia, European part, Samarskaya District, Samarskaya Luka National Park, calcareous stone-pit, soil, 02.v.2010, coll. Y. Shveenkova. Six paratypes from the same location and maple forest nearby. Deposited in MSPU.

Diagnosis. Blind. Body slender. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula incomplete (43/22235; 10/000). Medial s-setae on body



Figures 69–75. *F. calcarea* sp. n. (**69, 71–75**) and *F. tubulata* sp. n. (**70**) **69–70** Appearance **71** Position of macrosetae, setae of p-row, and s-setae on corpus **72** End of abdomen, dorsal view **73–75** Furca, posterior (**73**), lateral (**74**), and anterior (**75**) views.

tergites in anterior position. Th.III with 1+1 ventral setae. Anterior side of manubrium with 1+1 setae, dens with 6–7 anterior setae. Mucro bidentate.

Description. Body size near 1.1 mm (for the largest subadult female). Body slender, tubular (Fig. 69). Cuticle with fine hexagonal primary granulation ("smooth"). Ocelli absent. PAO slender, constricted, 1.8–2.5 as long as width of Ant.I and 2.3–2.7 as long as inner unguis length. Labium with five usual papillae (*A–E*), guard setae e7 absent, three proximal and four basomedian setae. Ventral side of head with 3+3 postlabial setae. Ant.I with 11–12 common setae, two ventral s-setae (s) and three basal micro s-setae (bms), two dorsal (middle-sized and short) and one ventral (short), Ant.II with three bms and one latero-distal s, Ant.III with one bms and with four distal s (lateral s absent), without additional s-setae. Organite short and small.

Common setae short. Sensillary formula as 43/22235 (s), 10/000 (ms) (Fig.71). Tergal s-setae thin and hardly differ from common seta, longer on dorsal side of Abd.V. Medial s-setae on Th.II–Abd.III situated in mid-tergal position, on Abd.I–III between Md and Mdl. Abd.V with five s-setae arranged as four ones (as, accp1, accp2, accp3), long and slender, and one latero-ventral, short ('4+1' pattern) (Fig. 72), accp3 s-setae

almost as long as accp2 (0.9–1.2). Macrosetae smooth, 2,2/3,3,3 in number, medial ones on Abd.V as long as 0.8–1.3 of dens and 2.6–3.3 times longer than mucro. Metathorax with 1+1 ventral setae.

Unguis of normal shape, without lateral and inner teeth. Empodial appendage as long as 0.4–0.5 of unguis. Tibiotarsi with few setae: 21–22 on legs I–II and 24–27 on leg III. Upper and lower subcoxae of legs I–III with 0,1/3,5–7/4–5,6–6 setae, respectively. Coxae of leg I with two front setae. Ventral tube with 4+4 latero-distal and 4–5 posterior setae (four in distal transversal row), anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 3–4, posterior one with three setae. Anterior side of manubrium with 1+1 setae (Fig. 75). Posterior side of manubrium with 3+3 latero-basal, 4+4 on main part, and 1+1 setae on lateral side (Fig. 73). Dens with seven (rarely six) anterior setae (Figs 74 and 75). Posterior side of dens slightly crenulated and with three setae (two basal and one at the base of mucro. Mucro bidentate. Ratio of manubrium : dens : mucro = 2.8–3.9 : 2.6–3.4 : 1.

Remarks. Two key characters, short furca and anterior position of medial s-setae on body tergites, are shared with only *F. torpeda*. *F. calcarea* sp. n. differs by ms-setae on Abd.I missing (vs present in *F. torpeda*) and fewer number of setae on posterior side of manubrium. The absence of lateral s on Ant.III is shared only with *F. breviseta* sp. n. but value of this characteristic requires further study.

Distribution and ecology. Known only from the type locality. The species possibly belongs to calciphilous fauna.

Derivatio nominis. The species was recorded in calcareous soil.

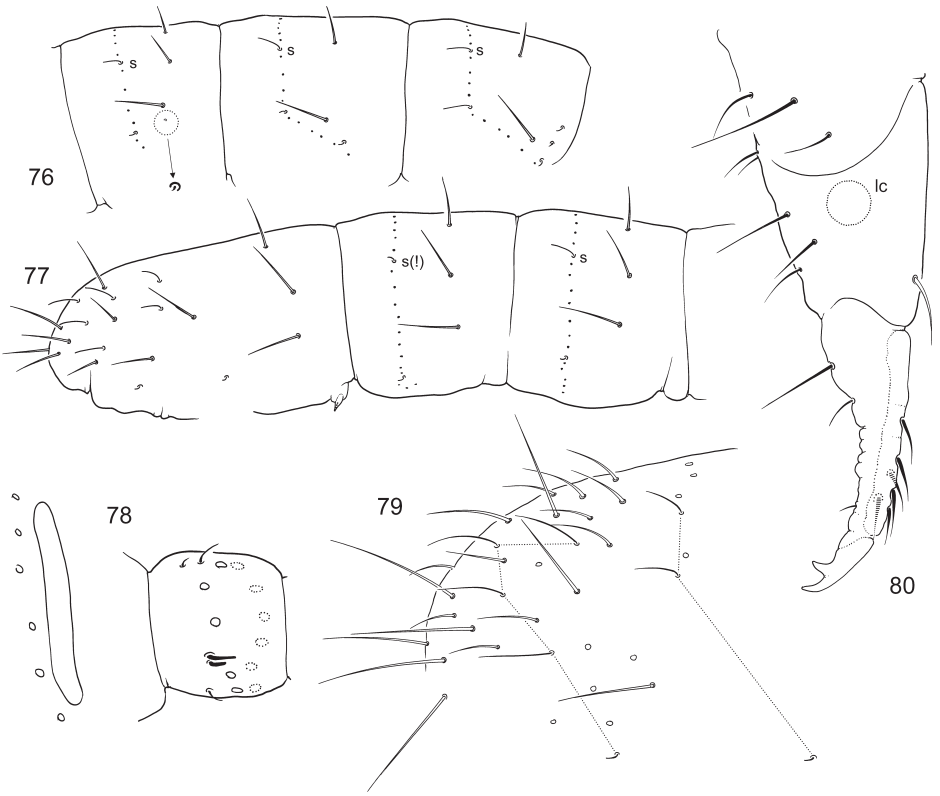
Folsomia tubulata Potapov & Babenko, sp. n.

http://zoobank.org/854D6C06-9C07-4F55-A31D-50E5DA94D4D4
Figs 70, 76–80

Type material. Holotype, adult male, Russia, East Siberia, Yakutia (Sakha Republic), Lensky District, Chayandinsky allotment, July of 2011, coll. V. Boeskorov. Two paratypes from the same location. Deposited in MSPU.

Diagnosis. Blind. Body slender. Dorsal macrosetae (Md) present on both Th.II and Th.III. Sensillary formula complete (43/22235; 10/100). Medial s-setae on body tergites set in p-row. Th.III with 2+2 ventral setae. Anterior side of manubrium with 1+1 setae, dens with 5–7 anterior setae. Mucro bidentate.

Description. Body size 0.8–0.9 mm. Body slender, tubular (Fig. 70). Cuticle orthogonal, finely reticulated. Ocelli absent. PAO slender, not constricted or slightly constricted, 1.5–1.8 as long as width of Ant.I and 2.3–2.4 as long as inner unguis length (Fig. 78). Labium with five usual papillae (*A*–*E*), guard setae e7 present, three proximal and four basomedian setae. Ventral side of head with 3–4+3–4 postlabial setae. Ant.I with eleven common setae, two ventral s-setae (s) and three basal micro s-setae (bms) (Fig. 78), two dorsal (middle-sized and short) and one ventral (short), Ant.II with three bms and one latero-distal s, Ant.III with one bms (not found in one



Figures 76–80. *F. tubulata* sp. n. **76** Position of macrosetae, setae of p-row, and s-setae on anterior (**76**) and posterior (**77**) half of corpus **78** PAO and Ant.I **79** End of abdomen, lateral view **80** Furca, lateral view (potential area of latero-central setae on manubrium marked).

specimen) and with five distal s (including one lateral), without additional s-setae. Organite short and small.

Common setae short. Sensillary formula as 43/22235 (s). Medial s-setae on Th.II–Abd.III situated in p-row, on Abd.I–III between Md and Mdl (Figs 76, 77). Tergal s-setae vary in length depending on position. Long s-setae: two accp-s on Th.II, medial accp-s on Th.III–Abd.II. Short s-setae: all as-s on Th.II–III, corner accp-s on Th.III, lateral accp-s on Abd.I–III, medial accp-s on Abd.III. Two dorsal accp-s on Abd.IV long, latero-ventral short. Abd.V with five s-setae arranged as four (as, accp1, accp2, accp3), long and slender, and one latero-ventral short ('4+1' pattern) (Figs 76, 77, 79), accp3 s-setae as long as accp2. Micro s-formula as 10/100 (ms), but ms-setae of Abd.I very small and hardly visible (Fig. 76). Macrosetae smooth and short, 2,2/3,3,3 in number, medial ones on Abd.V as long as 0.9–1.0 dens and 2.4–2.9 times longer than mucro. Metathorax with 2+2 ventral setae.

Empodial appendage as long as 0.4–0.5 of unguis. Tibiotarsi with 22 setae on legs I–II and 25–27 on leg III. Upper and lower subcoxae of legs I–III with 0,1/1,6–7/3–4,5–6 setae, respectively. Coxae of leg I with two front setae. Ventral tube with 4+4

latero-distal and three (seen in only one specimen) posterior setae, anteriorly without setae. Tenaculum with 4+4 teeth and a seta. Anterior furcal subcoxae with 6–7, posterior one with three setae. Anterior side of manubrium with 1+1 setae (Fig. 80). Posterior side of manubrium with 3+3 latero-basal, 4–5+4–5 on main part, and without setae on lateral sides (Fig. 80). Dens with 5–7 anterior setae. Posterior side of dens slightly crenulated and with three setae (two basal and one at the base of mucro. Mucro bidentate. Ratio of manubrium : dens : mucro = 3.0–3.5 : 2.3–2.5 : 1. Males present.

Remarks. Within '*tatarica*' group, only *F. baida* (Ural Mts.) has medial s-setae in posterior position on all tergites. *F. tubulata* sp. n. shows more reduced furca: one pair of anterior setae on manubrium (vs two pairs in *F. baida*), latero-central setae on manubrium absent (vs present), 5–7 setae on anterior side of dens (vs 9–10). Similar structure of furca is known for *F. tatarica* (steppe zone of Eastern Europe) which has another s-pattern on tergites (Table 1). Strong reduction of ms-setae on Abd.I is uncommon while calls for further study.

Distribution. Known from the type locality.

Derivatio nominis. The species is named after tubular shape of body.

Folsomia inoculata **Stach, 1947**

Figs 7, 81–90

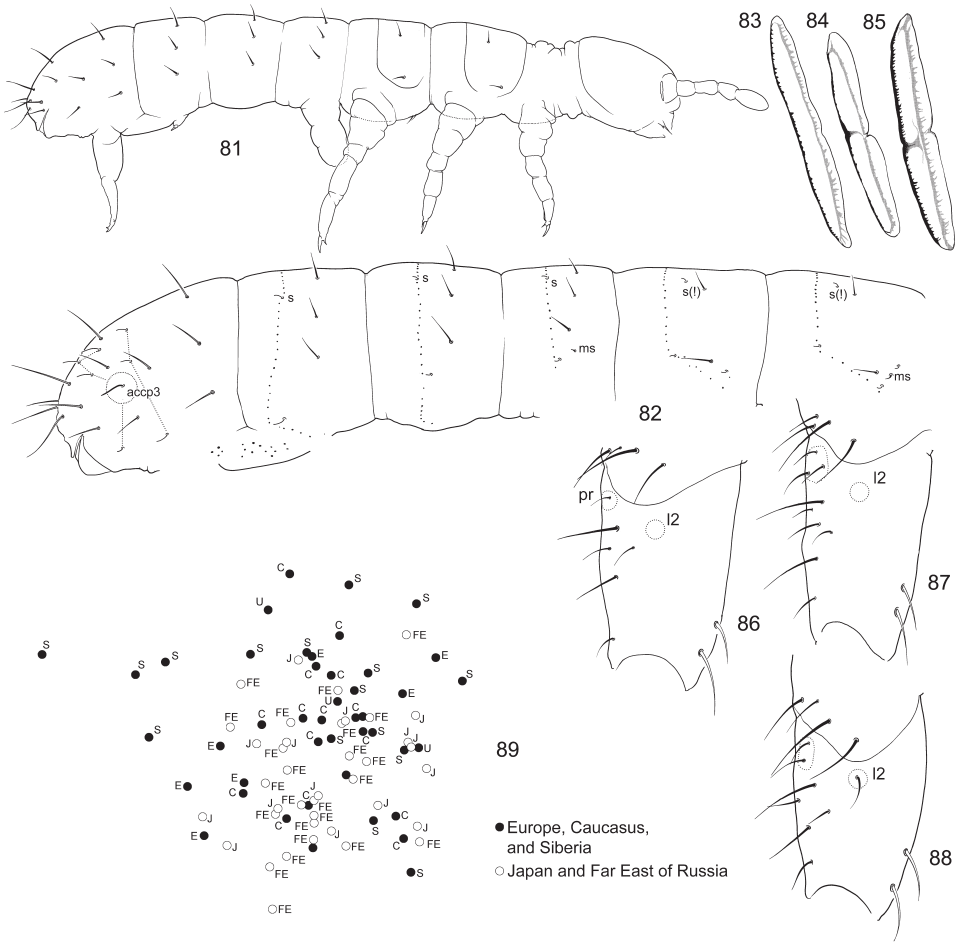
Syn.: *Folsomia ezoensis* Yosii, 1965

Type material of J. Stach. Two adult females from the collection of J. Stach labelled as "Polonia, Czarhohora, 28.VI.1922, leg. Smraczynski. *F. inoculata*". Kept in the Institute of Systematics and Evolution of Animals, Polish Academy of Sciences in Krakow, Poland.

Additional material. East Asia. Japan, Honshu Island. Nagano Prefecture, E Chino city, Kitayama, surroundings of Mugikusa Hutte, 2255 m alt., 36.0404°N, 138.3679°E, coniferous green moss forest with *Tsuga*, north slope, litter, 10.viii.2016; ibidem, 36.0653°N, 138.3410°E, stony meadow, grass turf, 11.viii.2016, coll. M. Potapov and N. Kuznetsova; Hokkaido Island. Japan, Hokkaido Island, Shiretoko Peninsula, trail to Mont. Rausu, different forests, litter and rotten wood, 19.viii.2016, from 350 to 1100 m alt.; Shiretoko Peninsula, nearby Shiretoko Pass, 593 m alt., 44.0617°N, 145.0913°E, stony mixed forest with *Betula ermanii*, 17.viii.2016; Shiretoko Peninsula, surroundings of Utoro, 500-year mixed forest, rotten wood, 20.viii.2016, 97 m alt., 44.1006°N, 145.0584°E, coll. M. Potapov and N. Kuznetsova.

China: Jilin Province, 5.viii.2009, Nearby Tian Lake, Changbai Mts., 1718 m alt., coniferous forest, soil under tree, coll. D. Wu.

Far East of Russia, Primorsky Krai, Shkotovsky District, Pidan Mount, ~800 m alt., rotten wood, 20.ix.2004, coll. M.Potapov, L.Deharveng, R.Pomorski, and A. Bedos; Shkotovsky District, trail to Mont. Khualaza, deciduous forest, rotten wood. 21.vii.2016, coll. M. Potapov and N. Kuznetsova; Sakhalin, Kholmsky District, South Kamysh Ridge of the Western Sakhalin Mountains, Spamberg Mt., mixed forest on



Figures 81–89. *F. inoculata* **81** Appearance **82** Position of macrosetae, setae of p-row, and s-setae on corpus **83** PAO, variations (**83, 84** Japan **85** Caucasus) **86–88** Manubrium, lateral view (Germany: Helgoland, coll. J. Schulz (**86**), Caucasus: Aibga (**87**), Japan: central Honshu (**88**) **89** Scatterplot of 84 individuals from five large regions of Palearctic basing on nine length ratios (for explanations see the Methods part). Abbreviations: pr, l2–groups of setae on posterior side of manubrium (notation as in Fjellberg, 2007), C–Caucasus, E–Europe, FE–Far East of Russia, J–Japan, S–Siberia, U–Ural.

slope, litter, 15.vi.2017, coll. A. Kuprin; Yuzhno-Sakhalinsk, Susunaysky Range, Chekhov peak, litter on top, 16.vi.2017, coll. A. Kuprin; Khabarovsky Krai, Sikhote-Alin Range, Nanaisky District, ~ 15 km N road Khabarovsk-Sovetskaya Gavan, Golaya mount. massif, Studeny Pass, coniferous forest, rotten wood, 28.vi–07.vii.2017, coll. A. Brinev; Sikhote-Alin Range, Vaninsky District, nearby Vysokogorny, valley of Mulinka River, rotten wood, ~ 600 m alt., 29.ix.2011, coll. M. Potapov; Vaninsky District, nearby Datta, coastal larch-wood, 28.ix.2011, coll. M. Potapov; Kamchatka, Elizovsky District, vicinities of Malki, 53.3219°N, 157.5502°E, 260 m alt., *Betula ermanii* forest, litter and rotten wood, 26.vi.2012, coll. M. Potapov and N. Kuznetsova.

Additionally, specimens from 32 localities, i.e. Ukraine (Skolevskiye Beskids), Bosnia (Perucica), Germany (Helgoland Isl., Zittau Mts, and Bavarian Alps), France (Mont Blanc), Russia (Komi, Middle Ural Mts.), Caucasus (Teberda, Guzeripl, Tsey, Khosta, Krasnaya Polyana, Lagonaki, and several other locations in Western part of North Caucasus), Armenia (Dilizhan), Georgia (Batumi, Kutaisi), Turkey (one unprecise locality, coll. L. Deharveng), Kazakstan (West Altai), Russia, West Siberia (Altai Mts.) and East Siberia (Podkamennaya Tunguska, Shira, W Sayan Mts), were examined.

Description. Body stout, very characteristic, head massive, with swollen front (Fig. 81) and brown robust mouth parts. Size from 0.9 to 1.7 mm. Without pigmentation. Cuticle with fine hexagonal primary granulation. PAO slender, usually constricted, often with small "inner denticles" (Figs 83–85) (see also the Discussion part). PAO length 1.1–1.7 as long as width of Ant.I and 1.3–2.1 as long as inner unguis length. Labium complete, guard setae e7 present, three proximal and four basomedian setae. Mandible and maxillary head strongly sclerotized. Ventral side of head with 4+4 postlabial setae. Ant.I with 13–15 common setae, two ventral s-setae (s) and three basal short micro s-setae (bms). Ant.II with three bms and one latero-distal s, Ant.III with one bms and with five distal s (including one lateral), without additional s-setae.

Common setae short. Sensillary formula as 43/22235 (s). Micro s-setae as 10/100 (ms). Tergal s-setae short and distinct. Medial s-setae on Th.II–III in front of p-row, on Abd.I–III in posterior position, between Md and Mdl. Abd.V with five s-setae arranged as three short (as, accp1, accp2), one lateral long and tubular, and one latero-ventral, short ('3+1+1' pattern) (Fig. 82), accp3 s-setae much longer than accp2 (accp2:accp3=0.5–0.9). Macrosetae smooth and short, 2,2/3,3,3, medial ones on Abd.V shorter than dens, with the whole range of ratio Mac : dens as 0.6–1.1, and 1.9–3.1 times longer than mucro. Foil setae at the tip of abdomen absent. Thorax with 2–4+2–4 subequal setae at ventral line.

Unguis of normal shape, without lateral and inner teeth. Empodial appendage usually longer than half of unguis (0.5–0.7). All tibiotarsi with additional setae: 23–27 setae on legs I–II and >30 setae on leg III, as a whole. Upper and lower subcoxae of legs I–III with 0,1/5–7,8–12/7–9,8–10 setae, respectively. Coxae of leg I with two front setae. Ventral tube with 4–5+4–5 latero-distal and 6–7 posterior setae (with four in distal transversal row), anteriorly without setae. Tenaculum with 4+4 teeth and one or two setae. Anterior furcal subcoxae with 11–16, posterior one with four setae. Anterior side of manubrium with 2+2 setae (rarely 2+3 or 1+2). Posterior side of manubrium with 4–5+4–5 latero-basal, two apical setae (ap), 2+2 setae in distal transversal row, pair of lateral setae present or absent (see the Discussion part), and 4–5(3–6)+4–5(3–6) in central part. Dens normally with 10–14 anterior setae (the whole range is 8–16). Posterior side of dens crenulated and with four setae: three (very rarely two) basal and one at the middle, no subapical setae. Mucro bidentate. Ratio of manubrium : dens : mucro = 3.1–4.9 : 2.4–4.3 : 1.

Remarks. *Folsomia inoculata* is a rather peculiar species due to several characteristics. On Abd.V the differentiation of s-setae is unique: accp3-s is well-marked, tubular, and longer than three shortened and thin s-setae of "dorsal triplet" (shown in detail

on fig.14 in Potapov and Greenslade 2010). The furca is of middle size, in an intermediate position between short-furcated '*tatarica*' and long-furcated '*macrochaetosa*' subgroups; posterior chaetotaxy of the dens is uncommon: seta at the middle present whereas subapical one normally absent (fig. XIV, 6 in Stach, 1947), the latter, although often small, is present in all other species of the '*inoculata*' group. Appearance of the species is rather specific enabling its recognition under low magnification (Fig. 81).

Available vast material on this species shows a wide variation in several characters (chaetotaxy of manubrium and dens, shape of PAO, body length) which, however, are individual or population-dependent and does not indicate several species.

According to the original description, PAO is not constricted in *F. inoculata*, which was also shown in associated figures by Stach (1947, figs XIV, 7 and XIV, 8). This peculiarity was a reason for Niijima and Hasegawa (2011) to retain *F. ezoensis* Yosii, 1965 (described from Japan, PAO constricted) and *F. inoculata* Stach, 1947 (described from Poland, PAO not constricted) as two separate species. In our material, PAO is normally constricted in both western and eastern Palearctic (incl. Japan) while the character continuously varies depending on the specimen being, in fact, not constricted in an extreme variant (Fig. 83). A constricted PAO that is unlike the original description was also indicated for European populations by Martynova (1973), Schulz (1999), and Fjellberg (2007).

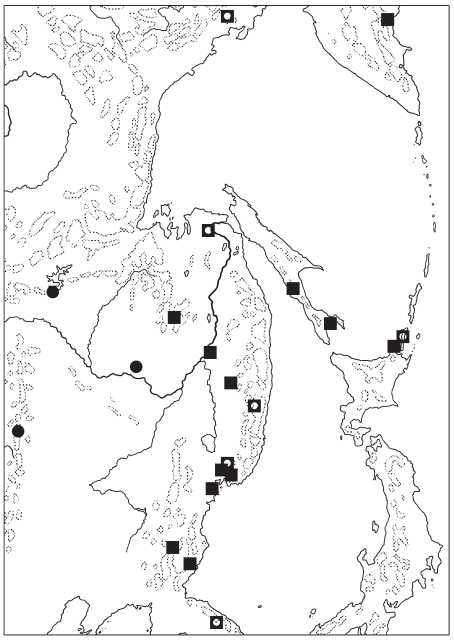
The modern detailed description of the species is given in Fjellberg (2007). Among other characteristics, a reduction of dorsal chaetom of manubrium was stressed, particularly lateral pair (l2) lost, only one pair of setae was shown in pr- and m-groups (fig. 23B–C in Fjellberg 2007). Such chaetotaxy was found by us only in specimens from Helgoland (NW Germany, coll. J. Schulz) (Fig. 86). Specimens from other localities normally have a pair of lateral setae and two or more pairs of setae at least in pr-group (Fig. 88). The presence of lateral setae l2 is not stable; few individuals missing them on both sides (sometimes asymmetrically) were recorded by us in the North Caucasus (Fig. 87), Germany, France, and Japan. Thus, a wide variation of chaetotaxy of posterior side of manubrium can be concluded for *F. inoculata*.

Size of the body ranges between 0.9 and 1.7. Specimens from eastern populations appears to be smaller than in western ones, but the whole variation is strongly overlapping (0.9–1.5 vs 1.1–1.7 mm, respectively).

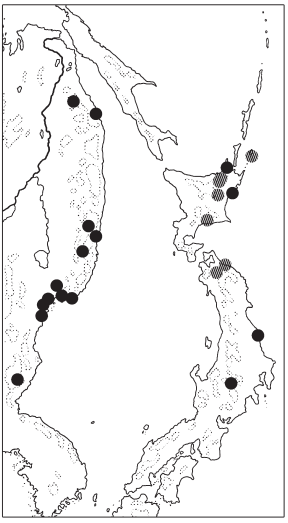
The performed multivariate analysis of metric morphology did not reveal any irregularities, and noticeable differences between eastern and western populations were not detected (Fig. 89). Nevertheless, individuals of a particular population often resemble each other and this may be partly explained by the same phenological condition.

The species is facultatively parthenogenetic and its populations mostly consist of females. Males were seen by us only in four "central" localities: in Middle Ural mountains (upper flow of Pechora River), East Siberia (Podkamennaya Tunguska), Caucasus (Aibga Range), Turkey, and Kazakstan (West Altai).

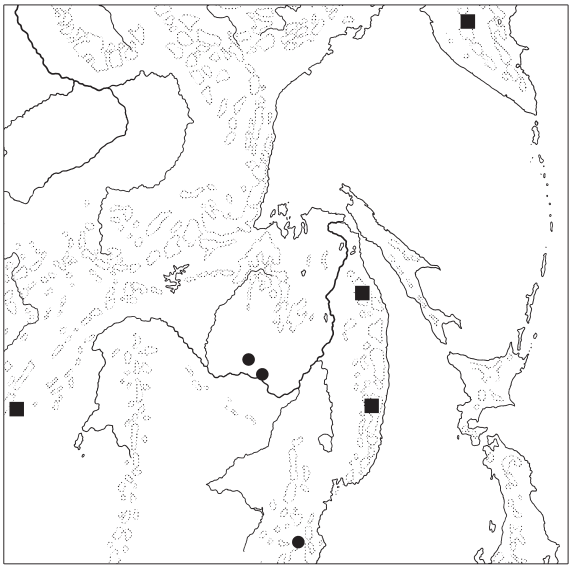
Distribution and ecology. The species is widely distributed in the region (Fig. 90) and was listed in catalogues of Japanese Collembola (Yosii 1977; Furuno et al. 2000), often as its junior synonym *F. ezoensis*. Known from Osaka (Natuhara et al. 1994), Tokyo (Iwanami et al. 1980), Hokkaido (Yosii 1965, Suma 1997, Hishi et al. 2012),



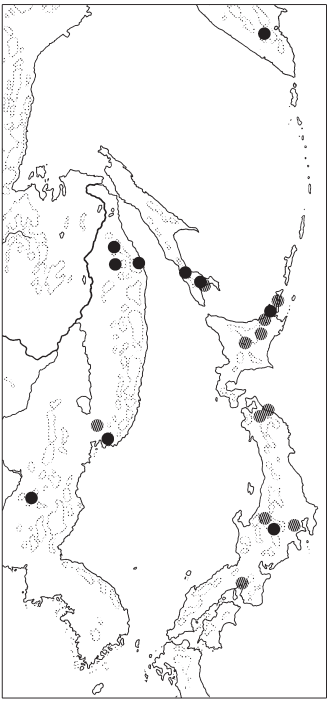
■ *F. imparis* sp.nov. ◘ *F. macrochaetosa*
● *F. amurica* sp.nov.



F. hidakana



● *F. laconica* sp.nov.
■ *F. trisensilla* sp.nov.



F. inoculata

Figure 90. Records of species of the *Folsomia inoculata* group in eastern Asia. Striped circles–literature records (for references see the Distribution parts to associated species).

Shigayama (Tamura and Chiba 1977), Kyoto (Takeda 1995; Fujii and Takeda 2012), Aomori Pref. (Yamauchi and Suma 1999, 2009). For Russia, *F. inoculata* was recorded in Sakhalin (Kurcheva 1977; Solntseva and Molodova 1979), Ussuriyski Reserve and Kaimanovka (Kutyreva 1979, 1984, as *F. ezoensis*), Ussuriysk (Kutyreva 1988), and Kunashir Island (Potapov and Marusik 2000). In the revision of *Folsomia* of Russia the species was recorded in the Caucasus and the south of West Siberia (Martynova 1973).

Distributional range of *F. inoculata* appears to be restricted to the Holarctic. In the Palearctic we still have not seen specimens from the eastern areas of East Siberia, such as Buryat Republic and Amurskaya District, despite intensive collections in appropriate sites. Thus, all populations can probably be divided to 'western' and 'eastern' which are inseparable by morphology for the present. In Scandinavia and the westernmost part of Europe *F. inoculata* is very rare and appears to be an alien species (absent, for example, in the Iberian Peninsula). In the Nearctic, the species is also infrequent although it occurs at least on the Pacific coast of USA (Oregon, Cascade Range, coll. A. Smolis, our identification, new record). *Folsomia inoculata* does not occur in the Arctic; the northernmost record is north-east corner of Komi Republic (67.50°N, NE European part of Russia) (Babenko et al. 2017).

The species often occurs in forest litter while apparently preferring rotten wood where it can be very abundant. *Folsomia inoculata* is the most dendrophilous species of the *'inoculata'* group and, very likely, in the genus, having associated shape of body and crushing mouth parts. The species is also sporadically recorded in specific sites enriched by organic matter.

A key to the species of *Folsomia* of the *'inoculata'* group

1 Laterally positioned accp-3 s-seta much longer than three dorsal s-setae on Abd.V (Figs 7, 82). 8–16 setae on anterior side of dens..... ***inoculata* Stach, 1947** (Holarctic)

– Accp-3 s-seta as long as or shorter than three dorsal s-setae on Abd.V (Figs 4–6). Anterior side of dens with 5–27 setae..... **2**

2 More than eleven setae on anterior side of dens **7**

– Fewer than eleven setae on anterior side of dens..... **3**

3 Medial s-setae in front of p-row on Th.II–III and Abd.I–II (Fig. 3) **4**

– Medial s-setae in p-row on Th.II–III and Abd.I–II (Fig. 1) **5**

4 Abd.I without ms-setae (Fig. 71). Posterior side of manubrium with 3+3 latero-basal and 4+4 setae on main part (Fig. 73)..... .....***calcarea* sp. n.** (south-east of European part of Russia)

– Abd.I with ms-setae (as in Fig. 76). Posterior side of manubrium with 3+3 latero-basal and 6–7+6–7 setae on main part.....***torpeda* Potapov, 2006** (north and east of European part of Russia, north-west of Siberia)

5 Medial s-setae in front of p-row on Abd.III (as in Fig. 71) .... ***tatarica* Martynova, 1964** (European part of Russia)

– Medial s-setae in p-row on Abd.III (Fig. 77) **6**

6 Dens with 5–7 anterior setae. Manubrium with one pair of setae on anterior side (Fig. 80) ..... ***tubulata* sp. n.** (Yakutia)

– Dens with 9–10 anterior setae. Manubrium with two pairs of setae on anterior side ..... ***baida* Potapov, 2006** (north and north-east of European part of Russia)

7 Medial setae on ventral side of Th.III present (Fig. 9) **8**

– Medial setae on ventral side of Th.III absent (Fig. 10) **16**

8 Medial s-setae on Th.III–Abd.II absent (s-formula: 42/11235) ..... ***bashkira* Potapov, 2006** (Ural)

– Medial s-setae on Th.III–Abd.II present (s-formula: 43/22235 or 33/22224) ... **9**

9 Medial s-setae in front of p-row on Th.II–III (Fig. 2) ..... ***brevisensilla* Potapov & Babenko, 2000** (North-East of Russia)

– Medial s-setae within p-row on Th.II–III (Fig. 1) **10**

10 One and three dorsal s-setae on Abd.IV and V, respectively (Fig. 6), corner s-setae on Th.II absent (Fig. 58): s-formula 33/22224. Ms-setae on Abd.I absent (Fig. 58) **11**

– Two and four dorsal s-setae on Abd.IV and V, respectively (Fig. 4), corner s-setae on Th.II present: s-formula 43/22235. Ms-setae on Abd.I present (Fig. 37) **13**

11 Manubrium with 2+2 setae on anterior side and no more than 3+3 setae in central part of posterior side (Figs 67, 68) ..... ***tertia* sp. n.** (Far East of Russia)

– Manubrium with 3+3 or more setae on anterior side and more than 3+3 setae in central part of posterior side (Fig. 54) **12**

12 Abd.V with p1-setae shorter than accp1 s-setae (Fig. 52). Three setae on basal part of posterior side of dens (Fig. 54) ..... ***laconica* sp. n.** (Amurskaya District (Far East of Russia), North Korea)

– Abd.V with p1-setae as long as accp1 s-setae (Fig. 53). Four setae on basal part of posterior side of dens (Figs 63–64) ..... ***trisensilla* sp. n.** (East Siberia, Far East of Russia)

13 Setae on anterior side of ventral tube absent **14**

– Setae on anterior side of ventral tube present ..... ***setifrontalis* Potapov & Marusik, 2000** (south of Far East of Russia)

14 Anterior side of manubrium with 2–3+2–3 setae (Fig. 48) ..... ***macrochaetosa* Martynova, 1977** (Far East of Russia)

– At whole, seven or more setae on anterior side of manubrium (Figs 33–35, 43–45) **15**

15 Unpaired setae on anterior side of manubrium absent (Figs 33–35). Lateral accp3 s-seta clearly shorter and thicker than accp2 and accp1 on Abd V (Figs 30–31) ..... ***amurica* sp. n.** (Amurskaya District (Far East of Russia), Inner Mongolia Province (North China))

– Unpaired setae on anterior side of manubrium present (Figs 43–45). Lateral accp3 s-setae as long and as thick as accp2 and accp1 on Abd V (Fig. 40) ..... ***imparis* sp. n.** (Japan, south of Far East of Russia)

16 Medial s-setae in front of p-row on Abd.I–III (Figs 3, 17). Body with short macrosetae ..... ***breviseta* sp. n.** (North-East Asia)

– Medial s-setae within p-row on Abd.I–III (Figs 2, 21, 22). Body with long macrosetae..... ***hidakana* Uchida & Tamura, 1968** (Japan, Korea, south of Far East of Russia)

Acknowledgements

We would like to express our sincere thanks to Drs Vasily Alpatov, Marina Babykina, Anne Bedos, Vasily Boeskorov, Alexey Brinev, Yun Bu, Sergey Bukhkalo, Huang Chen-Wang, Louis Deharveng, Tatyana Dobrolyubova, Wolfram Dunger, Arne Fjellberg, Saori Fujii, Anna Geraskina, Natalia Goloschapova, Ayuna Gulgenova, Ryo Kitagawa, Anastasia Korotkevich, Nikolay Kozlov, Alexander Kremenitsa, Arkady Lelej, Andrey Matalin, Igor Melnik, Akira Mori, Taizo Nakamori, Keiko Niijima, Kei-ichi Okada, Andrey Ptashinsky, Seikoh Saitoh, Juergen Schulz, Maxim Shashkov, Dmitry Shitikov, Yulia Shveenkova, Olga Sleptsova, Olga Smirnova, Yelena Sokolova, Sofia Stebaeva, Yasuhiko Suma, Anastasia Taskaeva, Lilia Vanyavina, Ivan Vtorov, Wanda Weiner, and Dong-Hui Wu, for kindly providing material on Collembola or for field assistance.

The authors are grateful to the management and staff of the Shiretoko National Park (Japan, Hokkaido), Ussurisky Nature Reserve (Russia, Primorsky Krai), "Land of Leopard" National Park (Primorsky Krai), Sikhote-Alin Nature Reserve (Primorsky Krai), State Reserve of Laso (Primorsky Krai), Alkhanai National Park (Russia, Zabaikal'sky Krai), Khingansky State Nature Reserve (Russia, Amurskaya Region), Zeysky State Nature Reserve (Amurskaya Region), Caucasian Biosphere Reserve (Russia, North Caucasus), who provided the collecting permit and the favorable conditions to our field work. Our special thanks are to Taizo Nakamori (Yokohama National University) whose hospitality was very helpful during our stay in Japan. We also indebted to Javier Arbea and an anonymous reviewer for their critical comments.

The study was partly supported by Japan–Russia Research Cooperative Program of RFBR (project No. 16-54-50068) for M.Potapov, N.Kuznetsova, A.Babenko, and A. Kuprin.

References

Babenko AB, Potapov MB, Taskaeva AA (2017) The collembolan fauna of the East European tundra. Russian Entomological Journal 26(1): 1–30.

Fjellberg A (2007) The Collembola of Fennoscandia and Denmark. Part II: Entomobryomorpha and Symphypleona. Fauna Entomologica Scandinavica 42: 1–264. https://doi.org/10.1163/ej.9789004157705.i-265

Fujii S, Takeda H (2012) Succession of collembolan communities during decomposition of leaf and root litter: Effects of litter type and position. Soil Biology & Biochemistry 54: 77–85. https://doi.org/10.1016/j.soilbio.2012.04.021

Furuno K, Hasegawa M, Hisamatsu M, Ichisawa K, Itoh R, Niijima K, Suma Y, Tamura H, Tanaka S (2000) List of collembolan species recorded from Japan and their Japanese names. Edaphologia 66: 75–88. [In Japanese with English summary]

Hasegawa M, Fukuyama K, Makino S, Okochi I, Tanaka H, Okabe K, Goto H, Mizoguchi T, Sakata T (2009) Collembolan community in broad-leaved forests and in conifer stands of *Cryptomeria japonica* in Central Japan. Pesquisa Agropecuária Brasileira 44: 881–890. https://doi.org/10.1590/S0100-204X2009000800012

Hishi T, Tashiro N, Maeda Y, Inouei S, Cho K, Yamauchi K, Ogata T, Mabuchi T (2012) Soil depth distribution and the patterns of alpha- and beta-diversity of families of soil Collembola in cool-temperate deciduous natural forests and larch plantations of northern Japan. Edaphologia 91: 9–20.

Iwanami M, Tsuchiya D, Niijima K (1980) Density and species composition of Acarina and Collembola in Tama, Tokyo, in relation to forest types and soil properties. Japanese Journal of Ecology 30: 145–154. [In Japanese with English summary]

Kurcheva GF (1977) Soil invertebrates of Soviet Far East. Nauka, Moscow, 131 pp. [In Russian]

Kutyreva LT (1979) Fauna and population of collembolans in soils of spruce-broadleaf forests of South Primorye. In: Chernova NM (Ed.) Fauna i Ekologiya bespozvonochnykh. MGPI, Moscow, 53–60. [In Russian]

Kutyreva LT (1984) Springtails in secondary oak forests of Primorsky Krai. In: Gilyarov MS, Chernova NM (Eds) Fauna i Ekologiya nogokhvostok. Nauka, Moscow, 118–123. [In Russian]

Kutyreva LT (1988) Complexes of springtails in anthropogenic forests. In: Izmeneniye rastitelnogo i zhivotnogo mira pod vliyaniyem anthropogennoi deyatelnosti v usloviyakh Dal'nego Vostoka. KGPI, Khabarovsk, 142–148. [In Russian]

Lee BH (1973) Étude de la faune Coréenne des Collemboles. I. Liste des Collemboles de Corée et description de trois espèces. Revue d'Ecologie et de Biologie du Sol 10: 435–449.

Martynova EF (1973) To diagnostics of springtails of the genus *Folsomia* Willem (Collembola, Isotomidae) occurring on the territory of the USSR. Fauna of Siberia. 16. Nauka, Novosibirsk, 7–23. [In Russian]

Natuhara Y, Imai C, Takeda H (1994) Classification and ordination of communities of soil arthropods in an urban park of Osaka City. Ecological Research 9: 131–141. https://doi.org/10.1007/BF02347488

Niijima K, Hasegawa M (2011) Classification of the Family Isotomidae Börner, 1913 (Apterygota: Collembola) from Japan 1. Anurophorinae Borner, 1906 and Proisotominae Stach, 1947. Edaphologia 89: 29–69. [In Japanese]

Potapov M (2001) Isotomidae. In: Dunger W (Ed.) Synopses on Palearctic Collembola. Vol. 3, Abhandlungen und Berichte des Naturkundemuseums Gorlitz 73: 1–603.

Potapov MB, Greenslade P (2010) Redescription of *Folsomia loftyensis* Womersley with notes on the sensillary arrangement of the genital segment in the genus (Collembola: Isotomidae). Zoologischer Anzeiger 249: 13–20. https://doi.org/10.1016/j.jcz.2010.01.004

Potapov M, Marusik Yu (2000) New and little known *Folsomia* Willem, 1902 (Collembola: Isotomidae) from South Kuriles. Russian Entomological Journal 9: 99–102.

Schulz HJ (1999) Bemerkenswerte sächsische Collembolenfunde, insbesondere aus Heidemooren der Oberlausitz, und eine Aktualisierung des Verzeichnisses der Springschwänze für Sachsen (Collembola). Entomologische Nachrichten und Berichte 43: 233–236.

Solntseva EL, Molodova LP (1979) Springtails of South Sakhalin. In: Chernova NM (Ed.) Fauna i Ekologiya bespozvonochnykh. MGPI, Moscow, 34–37. [In Russian]

Stach J (1947) The Apterygotan fauna of Poland in relation to the world-fauna of this group of insects. Family Isotomidae. Polska Akademia Umiejętności, Acta Monographica Musei Historiae Naturalis, Krakow, 488 pp.

Suma Y (1997) Collembolan fauna of 'heat islands', Akan National Park. Sylvicola 15: 19–28. [In Japanese]

Suma Y (2008) Collembolan fauna of Mt. Shari Prefectural natural Park, Eastern Hokkaido. Jezoensis 34: 79–86. [In Japanese]

Takeda H (1995) Changes in the collembolan community during the decomposition of needle litter in a coniferous forest. Pedobiologia 39: 304–317.

Tamura H, Chiba S (1977) Collembola. In: Kitazawa Y (Ed.) JIBP Synthesis 15. Ecosystem analysis of the subalpine coniferous forest of the Shigayama IBP Area, Central Japan, University of Tokyo Press, Tokyo, 88–97.

Tanaka M (1970) Ecological studies on communities of soil Collembola in Mt. Sobo, southwest Japan. Japanese Journal of Ecology 20(3): 102–110.

Uchida H, Tamura H (1968) Descriptions and records of Collembola from Hokkaido. II. Kontyu 36: 1–13.

Yamauchi S, Suma Y (1999) Collembola fauna of the Towada Mountain Range and Mts. Hakkoda-san, Aomori Pref., Japan. Journal of Natural History of Aomori 4: 51–57. [In Japanese]

Yamauchi S, Suma Y (2009) Collembolen Fauna in Mt. Hashikami-dake, Hashikami-machi Town, Aomori Prefecture, northern Japan. Bulletin of the Aomori Prefectural Museum 38: 9–16. [In Japanese]

Yosii R (1939) Isotomid Collembola of Japan. Tenthredo 2: 348–391.

Yosii R (1965) On some Collembola of Japan and adjacent countries. Contributions from the Biological Laboratory, Kyoto University 19: 1–71.

Yosii R (1977) Critical check list of the Japanese species of Collembola. Contributions from the Biological Laboratory, Kyoto University 25: 141–170.

ZooKeys 750: 41–44 (2018)
doi: 10.3897/zookeys.750.24529
http://zookeys.pensoft.net

RESEARCH ARTICLE

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

Wecomedon Jarrett & Bousfield, 1982, a replacement name for the amphipod genus *Psammonyx* Bousfield, 1973 (Crustacea, Amphipoda, Tryphosidae), preoccupied by *Psammonyx* Döderlein, 1892 (Foraminifera, Astrorhizida, Ammovolummidae)

Tammy Horton[1]

1 *National Oceanography Centre, Southampton, European Way, Southampton SO14 3ZH, UK*

Corresponding author: *Tammy Horton* (tammy.horton@noc.ac.uk)

Academic editor: *C.O. Coleman* | Received 18 February 2018 | Accepted 30 March 2018 | Published 16 April 2018

http://zoobank.org/E9B6A23A-C8E2-4C38-A597-B2D107F5190C

Citation: Horton T (2018) *Wecomedon* Jarrett & Bousfield, 1982, a replacement name for the amphipod genus *Psammonyx* Bousfield, 1973 (Crustacea, Amphipoda, Tryphosidae), preoccupied by *Psammonyx* Döderlein, 1892 (Foraminifera, Astrorhizida, Ammovolummidae). ZooKeys 750: 41–44. https://doi.org/10.3897/zookeys.750.24529

Abstract

Wecomedon Jarrett & Bousfield, 1982 is reintroduced as a replacement name for *Psammonyx* Bousfield, 1973 (Crustacea: Amphipoda: Tryphosidae) which is a junior homonym of *Psammonyx* Döderlein, 1892 (Foraminifera: Astrorhizida: Ammovolummidae).

Keywords

Psammonyx, *Wecomedon*, Amphipoda, Foraminifera, homonym

Introduction

Psammonyx Bousfield, 1973 was established as a new genus of lysianassid amphipod (now in the family Tryphosidae) with its type species, *Anonyx nobilis* Stimpson, 1853. It was recently discovered to be a junior homonym of *Psammonyx* Döderlein, 1892, a genus of ammovolummid foraminiferan (Foraminifera: Astrorhizida: Ammovolummidae). *Psammonyx* Döderlein, 1892 is a valid name in current use and contains the type species *Psammonyx vulcanicus* Döderlein, 1892 along with two further fossil species; *Psammonyx campbelli* Browne & Schott, 1963 and *Psammonyx maxwelli* Ireland, 1939 (Hayward et al. 2018).

Systematics

Wecomedon Jarrett & Bousfield, 1982, re-established

Psammonyx Bousfield, 1973: 144 (Crustacea: Amphipoda: Tryphosidae); type species: *Anonyx nobilis* Stimpson, 1853, original designation by Bousfield 1973; preoccupied.

Wecomedon Jarrett & Bousfield, 1982: 113 (Crustacea: Amphipoda: Tryphosidae); type species: *Hippomedon wecomus* J.L. Barnard, 1971, original designation by Jarrett and Bousfield 1982.

non *Psammonyx* Döderlein, 1892: 146 (Foraminifera: Astrorhizida: Ammovolummidae); type species: *Psammonyx vulcanicus* Döderlein, 1892, original designation by Döderlein 1892.

Psammonyx – Budnikova, 2005: 179 (*Wecomedon* Jarrett & Bousfield, 1982 reduced to the rank of junior synonym of *Psammonyx* Bousfield, 1973).

Type species. *Hippomedon wecomus* J.L. Barnard, 1971, original designation by Jarrett and Bousfield (1982).

Remarks. *Psammonyx* Bousfield, 1973 currently contains eleven species (Horton et al. 2018). The genus was established by Bousfield in 1973, for the single species *Psammonyx nobilis* (Stimpson, 1853), designated as the type of the genus (as *Anonyx nobilis* Stimpson, 1853). A second species (*P. terranovae* Steele, 1979) was added by Steele in 1979, and in 1982, Jarrett and Bousfield described a third species (*Psammonyx longimerus* Jarrett & Bousfield, 1982) and transferred the fourth species *Psammonyx kurilicus* (Gurjanova, 1962) from the genus *Hippomedon*.

In 2005, Budnikova added two further species (*Psammonyx kudrjaschovi* Budnikova, 2005 and *Psammonyx tzvetkovae* Budnikova, 2005) and placed the genus *Wecomedon* Jarrett & Bousfield, 1982 in synonymy with *Psammonyx*, transferring the five species it contained to *Psammonyx* (*P. boreopacificus* (Gurjanova, 1962); *P. minusculus* (Gurjanova, 1938) *P. similis* (Jarrett & Bousfield, 1982); *P. wecomus* (J.L. Barnard, 1971); and *P. wirketis* (Gurjanova, 1962)).

According to ICZN article 60.2 the oldest available and potentially valid synonym of the rejected junior homonym becomes the valid name of the taxon (see ICZN Article 23.3.5), and takes its own authorship and date. Therefore, the replacement name for *Psammonyx* Bousfield, 1973 is *Wecomedon* Jarrett & Bousfield, 1982, with *Hippomedon wecomus* J.L. Barnard, 1971 as the type species of the genus.

Wecomedon is now comprised of the following eleven species:

Wecomedon boreopacificus (Gurjanova, 1962), **comb. n.** Original name *Hippomedon boreopacificus*;

Wecomedon kudrjaschovi (Budnikova, 2005), **comb. n.** Original name *Psammonyx kudrjaschovi;*

Wecomedon kurilicus (Gurjanova, 1962), **comb. n.** Original name *Hippomedon kurilicus*;

Wecomedon longimerus (Jarrett & Bousfield, 1982), **comb. n.** Original name *Psammonyx longimerus*;
Wecomedon minusculus (Gurjanova, 1938), **comb. n.** Original name *Paratryphosites minusculus*;
Wecomedon nobilis (Stimpson, 1853), **comb. n.** Original name *Anonyx nobilis*;
Wecomedon similis Jarrett & Bousfield, 1982, **comb. n.** Original name *Wecomedon similis*;
Wecomedon terranovae (Steele, 1979), **comb. n.** Original name *Psammonyx terranovae*;
Wecomedon tzvetkovae (Budnikova, 2005), **comb. n.** Original name *Psammonyx tzvetkovae*;
Wecomedon wecomus (J.L. Barnard, 1971), **comb. n.** Original name *Hippomedon wecomus*;
Wecomedon wirketis (Gurjanova, 1962), **comb. n.** Original name *Hippomedon wirketis.*

Acknowledgements

I would like to thank Cedric D'Udekem D'Acoz for bringing the homonym to my attention and for improvements to the manuscript during review, and Andrew Gooday for assistance with the validity of the foraminiferan name. This work was funded by the UK Natural Environment Research Council (NERC), and contributes to the Porcupine Abyssal Plain – Sustained Observatory (NERC National Capability programme).

References

Barnard JL (1971) Gammaridean Amphipoda from a deep-sea transect off Oregon. Smithsonian Contributions to Zoology 61: 1–86. [48 figs]

Bousfield EL (1973) Shallow-water gammaridean Amphipoda of New England. Cornell University Press, Ithaca, 312 pp.

Browne RG, Schott VJ (1963) Arenaceous foraminifera from the Osgood Formation at Osgood, Indiana. Bulletins of American Paleontology 46(209): 187–243.

Budnikova LL (2005) Two New Species of *Psammonyx* and the Identity of the Genus *Wecomedon* (Amphipoda, Gammaridea). Publications of the Seto Marine Biological Laboratory 40(3–4): 179–197. https://doi.org/10.5134/176321

Döderlein L (1892) No official title (Demonstration: *Petrostroma schulzei*, *Psammonyx vulcanus*). Verhandlungen der Deutschen Zoologischen Gesellschaft 1892: 143–146.

Gurjanova E (1938) Amphipoda, Gammaroidea zalikov Siaukhu i Sudzukhe (Yaponskoe More). Amphipoda, Gammaroidea of Siaukhu Bay and Sudzukhe Bay (Japan Sea). Reports of the Japan Sea Hydrobiological Expedition of the Zoological Institute of the Academy of Sciences USSR in 1934 1: 241–404. [59 figs]

Gurjanova EF (1962) Bokoplavy severnoi chasti Tikhogo Okeana (Amphipoda, Gammaridea) chast' 1. Opredeliteli po faune SSSR, Zoologicheskiy Institute Akademii Nauk SSSR 74: 1–440.

Hayward BW, Le Coze F, Gross O (2018) World Foraminifera Database. *Psammonyx* Döderlein, 1892. http://www.marinespecies.org/aphia.php?p=taxdetails&id=737404 [accessed on 2018–02–14]

Horton T, Lowry J, De Broyer C, Bellan-Santini D, Coleman CO, Corbari L, Daneliya M, Dauvin J-C, Fišer C, Gasca R, Grabowski M, Guerra-García JM, Hendrycks E, Hughes L, Jaume D, Jazdzewski K, Kim Y-H, King R, Krapp-Schickel T, LeCroy S, Lörz A-N, Mamos T, Senna AR, Serejo C, Sket B, Souza-Filho JF, Tandberg AH, Thomas J, Thurston M, Vader W, Väinölä R, Vonk R, White K, Zeidler W (2018) World Amphipoda Database. *Psammonyx* Bousfield, 1973. http://www.marinespecies.org/amphipoda/aphia.php?p=taxdetails&id=158139 [accessed on 2018–02–18]

Ireland HA (1939) Devonian and Silurian Foraminifera from Oklahoma. Journal of Paleontology 13(2): 190–202.

Jarrett NE, Bousfield EL (1982) Studies on the amphipod family Lysianassidae in the Northeastern Pacific region. *Hippomedon*: and related genera: Systematics and distributional ecology. National Museums of Canada, Publications in Biological Oceanography 10: 103–128.

Stimpson W (1853) Synopsis of the marine Invertebrata of Grand Manan: or the region about the mouth of the Bay of Fundy, New Brunswick. Smithsonian Contributions to Knowledge 6: 1–66. [pls 1–3]

Steele DH (1979) A new species of *Psammonyx* (Crustacea, Amphipoda, Lysianassidae) from the Northwestern Atlantic. Canadian Journal of Zoology 57(6): 1215–1221. https://doi.org/10.1139/z79-155

ZooKeys 750: 45–58 (2018)
doi: 10.3897/zookeys.750.23874
http://zookeys.pensoft.net

RESEARCH ARTICLE

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

High-speed duetting – latency times of the female acoustic response within the bush-cricket genera *Leptophyes* and *Andreiniimon* (Orthoptera, Phaneropteridae)

Klaus-Gerhard Heller[1], Olga Korsunovskaya[2], Bruno Massa[3], Ionuț Ștefan Iorgu[4]

1 *Department of Biology, Humboldt-Universität zu Berlin, Berlin; postal address: Grillenstieg 18, 39120 Magdeburg, Germany* **2** *Department of Entomology, Faculty of Biology, Moscow State University, 119234, Moscow, Leninskie Gory 1-12, Russia* **3** *Department of Agricultural, Food and Forest Sciences, University of Palermo, Viale Scienze Bd 4A, 90128 Palermo, Italy* **4** *"Grigore Antipa" National Museum of Natural History, Kiseleff Blvd. 1, Bucharest, Romania*

Corresponding author: *Klaus-Gerhard Heller* (heller.volleth@t-online.de)

Academic editor: *F. Montealegre-Z* | Received 25 January 2018 | Accepted 21 March 2018 | Published 16 April 2018

http://zoobank.org/CCD78A14-76CA-4740-BA73-2579055B100D

Citation: Heller K-G, Korsunovskaya O, Massa B, Iorgu IȘ (2018) High-speed duetting – latency times of the female acoustic response within the bush-cricket genera *Leptophyes* and *Andreiniimon* (Orthoptera, Phaneropteridae). ZooKeys 750: 45–58. https://doi.org/10.3897/zookeys.750.23874

Abstract

To find a mate, male and female bush-crickets of the family Phaneropteridae typically engage in duets. The male sings and the female responds. For mutual recognition, the amplitude pattern of the male song and the species-specific timing of the female response have been shown to be very important. In the seven studied species, belonging to the genera *Leptophyes* and *Andreiniimon*, these duets are extremely fast and nearly completely in the ultrasonic range. The females produce very short sounds by fast closing movements of the tegmina. They respond with species-specific delays of 20 to 150 ms after the beginning of the male song. The different latency times are probably not important for species recognition, since in sympatric species they are quite similar.

Keywords

Phaneropterinae, katydid, female acoustic signals, duet, stridulatory movement

Introduction

In bush-cricket (katydid) species of the family Phaneropteridae (or subfamily Phaneropterinae, depending on author) not only the males produce songs, but typically the females respond acoustically to these signals (for a review, see Heller et al. 2015). Exchanging sounds, males or females or both approach the other sex phonotactically. Using this bi-directional communication system, the insects may meet faster and safer than in a system where the male signals continuously without knowing if there is an interested receiver. However, here not only the female must recognise the male song; the male must also know which sounds represent answers to his song. While the male songs exhibit species-specific temporal patterns of amplitude modulation and sometimes even last for many seconds (e.g., *Ducetia japonica* group; Heller et al. 2017), the female response is typically a short click or a series of clicks. Sometimes, these sounds are difficult to discriminate from similarly structured environmental noise.

At the end of the last century, three groups of scientists studied simultaneously and independently this communication system (Heller and Helversen 1986; Robinson et al. 1986; Zhantiev and Korsunovskaya 1986) and discovered that the males use 'auditory time windows' for recognition. A female response must be heard within a certain time interval after the male song, otherwise it is disregarded. As discussed by Heller and Helversen (1986), in this way the male increases his signal to noise ratio for the detection of female signals and, at the same time, these windows might be used for species recognition. Different species have indeed different female latency times and different male time windows (Heller and Helversen 1986), but the tested species were not closely related. In the meantime, many different male song patterns have been detected, and even cryptic species, differing mainly in male song (e.g., Heller and Reinhold 1992: *Poecilimon paros*; Iorgu 2012b: *Isophya dochia*) have been found. The acoustic behaviour of the females, however, has received less attention. According to some studies, auditory time windows do not seem to be important for female species recognition. The females of all four *Barbitistes* species tested have quite similar latency times (Stumpner and Meyer 2001). Also in the subgenus *Hamatopoecilimon*, all studied species were similar in this respect (Heller et al. 2011). In both groups, the male songs differ clearly and contain marker syllables to trigger the female response. In the species-rich genus *Isophya*, however, the situation is different. Some species also possess trigger elements in the male song, and the females respond shortly after these markings (e.g., *I. bucovinensis*; Iorgu et al. 2017, see Iorgu 2012b for similar examples), but in others the female response seems to be triggered by any syllable of the male song (e.g., *I. sicula*; Orci et al. 2010), and in still others the female response occurs invariably with a fixed and relatively long delay after the end of the male song (e.g., *I. stepposa;* Zhantiev and Korsunovskaya 1986).

In the present paper we focus on the genus *Leptophyes* Fieber, 1853 and the monotypic genus *Andreiniimon* Capra, 1937. Both genera are closely related to *Isophya* (Ullrich et al. 2010). *Andreiniimon* and most of the nine European *Leptophyes* species have simple songs, which are quite similar to each other (see review in Kleukers et al. 2010; Ingrisch and Pavicevic 2010; the species *L. asamo* Pavićević & Ivković, 2014

is considered as a presumed synonym of *L. punctatissima*, following Chobanov et al. 2016). However, some species occur sympatrically over large parts of their range, so that acoustical discrimination would seem to be useful. Within the genus, large differences in mating behaviour have been observed [e.g., in spermatophore size and sperm number (Vahed and Gilbert 1996) and sexual refractory period (Vahed 2007)], which may theoretically also affect the acoustic communication between the sexes. The male calling songs are known from all species; the female response behaviour, however, is so far known from only three. We present additional data on these three species (*A. nuptialis, L. albovittata, L. punctatissima*) and describe the female acoustic behaviour of another four species (*L. discoidalis*, *L. laticauda*, *L. lisae*, *L. sicula*) for the first time.

Material and methods

The female response behaviour was studied in the laboratory using virgin females, collected as nymphs (or from a laboratory culture, only some *L. punctatissima* females). We studied the following species (number of females studied in brackets): *Andreiniimon nuptialis* (3)*, Leptophyes albovittata* (4)*, L. punctatissima* (6), *L. discoidalis* (1), *L. laticauda* (5), *L. lisae* (4), *L. sicula* (1). The duets were recorded – mostly in the evening – using a Racal store 4-D tape recorder (Racal Electronics plc, Weybridge, United Kingdom) and modified tape-recorder Yupiter 202-Stereo (Komunist Works, Kiev, USSR/Ukraine), with microphones Brüel & Kjær 4133 and 4135 (B&K, Nærum, Denmark; frequency response flat up to 40 and 70/100 kHz respectively; distance to microphone 50 to 100 mm). *Leptophyes discoidalis* was recorded using a digital audio recorder EDIROL R-09HR (Roland Corporation US, Los Angeles, USA; frequency response flat 20 Hz – 40 kHz; sampling rate 96 kHz). Wing movements were registered by an optoelectronic device (Helversen and Elsner 1977; modified as in Heller 1988). Additionally, duets were recorded directly on computer using a sound card (M-Audio transit; M-Audio, Cumberland, Rhode Island, United States; sampling rate was mostly set to 64 or 96 kHz) and the microphones Uher M 645 (Munich, Germany) and Sony ECM-121 (Sony, Tokyo, Japan). A male and a female were placed separately into two plastic tubes (*Drosophila* tubes 28.5×95 mm, Biosigma, Cona (VE), Italy) standing side by side, with one microphone placed inside or on top of each vial. Both microphones typically picked up male and female sounds, but with different amplitudes. In a comparison of these signals no distortions in time or frequency domain were found. The output of each microphone was registered as one track of a stereo recording. After digitising the songs on a computer, oscillograms (after high pass filtering, typically around 1 kHz) and sound analyses were made using the programs Turbolab (TL 4.0, Stemmer, Puchheim, Germany), Amadeus (Amadeus II, Martin Hairer, http://www.hairersoft.com) and Audacity (Audacity 2.1.0; http://audacity.sourceforge.net) on Apple. Each data point is based on not less than 10 independent measurements of latency time of a female (except for one female of *L. lisae* with only seven measurements and two females of *A. nuptialis*, with five measurements), given as mean ± standard deviation (SD). For the frequency

measurements given in the Results, recordings made with a digital bat-detector (Pettersson D1000X; Pettersson Elektronik AB, Uppsala, Sweden; frequency response flat 5–235 kHz: sampling rate 100 or 192 kHz) and with the R-09HR (see above) were evaluated using fast fourier transformation (FFT) analysis with hanning window, 512 points per frame, from one frame or the mean of several overlapping frames.

Song terminology — Latency time: interval between beginning of male song/song model to beginning of female response. Calling song: song produced by an isolated male. Syllable: the sound produced by one complete up (opening) and down (closing) stroke of the wing. Echeme: a first-order assemblage of syllables. Impulse: a simple, undivided, transient train of sound waves (here: the highly damped sound impulse arising as the impact of one tooth of a stridulatory file).

Measurements of body and spermatophore mass follow McCartney et al. (2009).

Results

The females of all species studied here (*Leptophyes punctatissima* (Bosc, 1792), *L. albovittata* (Kollar, 1833), *L. laticauda* (Frivaldszky, 1868), *L. discoidalis* (Frivaldszky, 1868), *L. lisae* Heller & Willemse, 1989, *L. sicula* Kleukers, Odé & Fontana, 2010, *Andreiniimon nuptialis* (Karny, 1918)) responded to male songs with very short signals consisting of one to three loud impulses and occasionally of some more soft ones. Rarely, up to five loud impulses were observed. In all species studied in this respect, the loud impulses were produced by a closing movement of the tegmina. The peak of the carrier frequency of the females' responses was mostly similar to that of the males, with the notable exception of *A. nuptialis* (Table 1). Timing and latency of the responses are described below.

Table 1. Peak frequencies of male and female song and body and spermatophore mass in European *Leptophyes* and *Andreiniimon* species.

Species	Male (kHz)	Source	Female (kHz)	Source	Body mass male/female (mg)	Spermatophore mass (% male body mass; n)	Source
L. punctatissima	40	F	40	F	172/302	5.8; 2	B
L. albovittata	50–57	C, G, H	67	D	124/255	6.3; 9	B
L. laticauda	20–23	C, D	22	D	423/668	24.6; 21	B
L. discoidalis	32–35	A, E	35	A	–	–	–
L. lisae	27(–30)	C, D	30	D	177/297	4.5; 6	B
L. sicula	29	A	30	A	203/354	–	A
A. nuptialis	61	C, D	44	D	354/494	9.8; 2	B

A this paper
B Dagmar von Helversen, unpublished
C Heller (1988)
D Heller et al. (2015)
E Iorgu (2012a)
F Robinson et al. (1986)
G Zhantiev and Korsunovskaya (1986)
H Zhantiev and Korsunovskaya (2015)

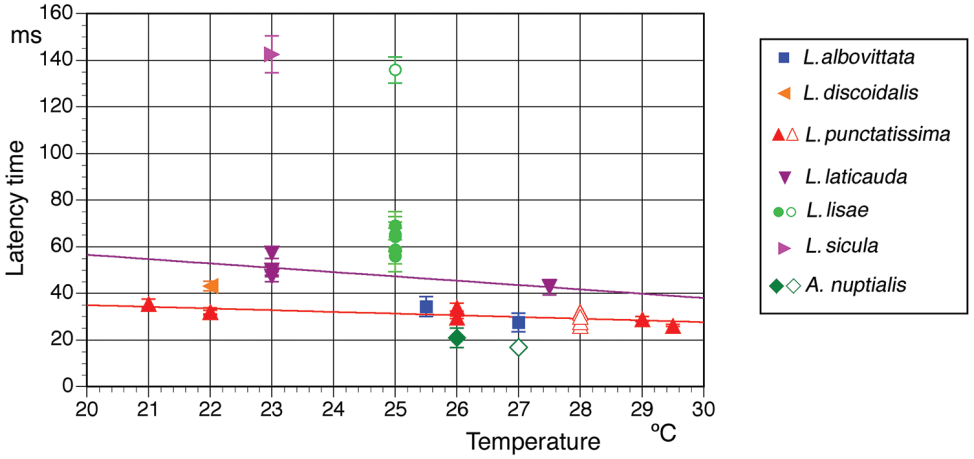


Figure 1. Latency times of the female response. The times refer to the beginning of the male song with temperature in European *Leptophyes* species and *Andreiniimon nuptialis*. Open symbols: *L. punctatissima* from Robinson et al. 1986; *L. lisae*, see text; *A. nuptialis* from Heller and Helversen 1986. Error bars indicate SD, regression lines based on own data (for details, see text).

Leptophyes punctatissima

Specimens studied: 5 females, GREAT BRITAIN: laboratory culture, 1 ix–31 x 1983, leg. C. Hartley; 1 female, GERMANY: Nürnberg (49°27'N, 11°3'E), 1 x–31 xii 1987, leg. K. Reinhold.

The male calling song consists of single, short syllables presented at intervals of several seconds. The acoustical response behaviour of the female was studied intensively by Hartley and Robinson (1976), Robinson (1980), Robinson et al. (1986) and Zimmermann et al. (1989). Robinson et al. (1986) gave detailed information about the latency times. Here we add data on the temperature dependency of this behaviour (Fig. 1; $f(x)=-0.7299x+49.53$; $r^2=0.6336$) and demonstrate that the female reaction can be elicited by crude, click-like models of the male song. Females responded very reliably to fingernail snips (Fig. 2A) – acoustically an impulse of about 1 ms or less in duration with most energy in the ultrasonic range. This behaviour is well known in the laboratories working with this species. Rectangularly-modulated pulses of white noise with a duration of 15 ms were responded to with about the same latency, measured from the beginning of the pulse (Fig. 2B).

Leptophyes albovittata

Specimen studied: 1 female, GREECE: N. Drama, valley of river Nestos, above Paranestion, (41°17'N, 24°29'E), 5 m, 17 vi 1984, leg. v. Helversen; 3 males, 3 females, RUSSIA, Kursk distr.: Centralno-Chernozemny reserve (51°09'N, 36°26'E), 10–13 viii 1985, leg. O. Korsunovskaya.

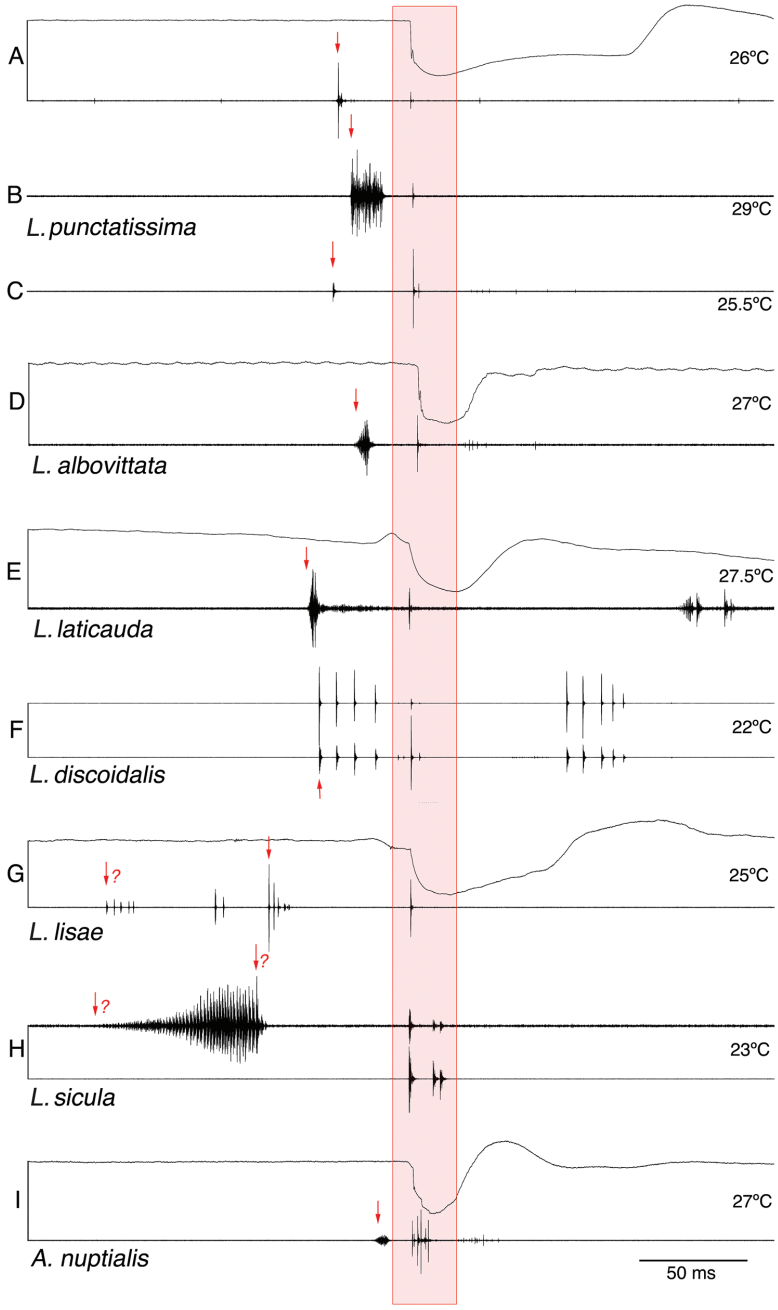


Figure 2. Oscillograms of male-female-duets. Stridulatory movement of female *Leptophyes* and *Andreiniimon* together with male-female duet (sound **A, D, E, G, I**) or male-female duet, sound only (**B, C, F, H**). Oscillograms of stridulatory movement and song [synchronous registration of left tegmen movement and sound (upper line: upward deflection represents opening, downward closing; lower line: sound)]. **A–C** female reaction to model of male song **D** female reaction to heterospecific male song (see text) **E–I** female reaction to conspecific male song. Female responses in box highlighted in red, proposed trigger point marked with red arrow.

The male calling song consists of single, short syllables presented at intervals of several seconds. The acoustic response behaviour of the female was first studied by Zhantiev and Korsunovskaya (1986, 1990, 2015). They showed that the female latency time is constant with reference to the beginning of the song. The females responded to song models independently of the duration of the model (tested from 10 ms up to 100 ms). Here we show that even very short signals (see *L. punctatissima*) are answered (Fig. 2C). It was therefore not surprising to see that calling songs of other species with the appropriate spectral properties were also answered (here *Andreiniimon nuptialis*; Fig. 2D). The female responses are produced during closing movements of the tegmina. However, during the re-opening of the tegmina soft impulses were sometimes observed (Fig. 2D).

Leptophyes laticauda

Specimens studied: 1 male, 1 female, ITALY: Medeazza near Trieste (45°55'N, 13°25'E), 1–10 vii 1995, leg. v. Helversen; 1 male, 1 female, MONTENEGRO: Petrovac (42°12'N, 18°56'E), 9 vi 2017, leg. M. Heller; 3 females, MONTENEGRO: Lovcen pass above Kotor (42°24'N, 18°45'E), 4 vi 2017, leg. M. and K.-G. Heller; 1 male, MONTENEGRO: Zabljak (42°19'N, 16°9'30"E), 8 vi 2017, leg. M. Heller.

The male calling song of *L. laticauda* is more variable and the song units (see below) are produced in a much faster rhythm (Heller 1988; Ragge and Reynolds 1998) than in the two previously described species. Each song unit consisted sometimes of one short, compact syllable only. Sometimes, this part was followed by an isolated impulse ('after-click'; see e.g., fig. 23G in Heller 1988). In the most often observed combination (echeme), one loud syllable (with or without after-click) was combined with a soft second syllable of variable internal structure (see male sound in Fig. 2E; see also Heller 1988; Fontana et al. 2002). Occasionally, several such soft syllables followed each other in short intervals (see description and figures in Roesti and Keist 2009). The females responded nearly exclusively in a fixed interval after the first and loudest syllable (Fig. 1). The impulses were produced during a closing movement, but in the movement track it can be observed that the female reacted a few ms earlier with a small tegmen or body movement (Fig. 2E). The latency time is slightly longer than in *L. punctatissima* and similarly, it depended on temperature ($f(x)=-1.8556x+93.63$; $r^2=0.502$).

Leptophyes discoidalis

Specimens studied: 1 male, 1 female, ROMANIA: Telciu (47°24'N, 24°23'E), 7 vii 2017, leg. I. Ș. Iorgu.

In contrast to all other European *Leptophyes* species, the male calling song consists not of single syllables (or very short echemes), but of a series of six up to 30 syllables (Ingrisch and Pavicevic 2012; Iorgu 2012a). The amplitude modulation of the echeme is decreasing with the loudest syllables at the beginning. The female answered after

a fixed time interval after the beginning of the first syllable (=after beginning of an echeme). The female never answered to another syllable of an echeme, but only to the first syllable after a larger gap (interval between last syllable of previous echeme and beginning of the next, 817 ± 151 ms; n=10).

Leptophyes lisae

Specimens studied: 1 male, 1 female, GREECE: N. Korinthia, southeast of Korinth (37°50'N, 23°2'E), 1–30 iv 1984, leg. E. Blümm; 1 male, 3 females, GREECE: Chios, 2 km west of Mesta (38°16'N, 25°54'E), 24 v 1995, leg. K.-G. Heller.

The male calling song consists of single syllables, but these syllables are much longer (ca. 150 ms at 20 °C; Heller and Willemse 1989) than in the species mentioned above and contain three groups of impulses. The last group is the loudest and decreasing in amplitude. The females answered with a fixed delay of about 60 ms after the last syllable group. Judging from the female reaction to the male song it would have been difficult to determine the trigger point for the response, but all three females tested answered to click-like song models with the same latency as to the beginning of the last group of impulses in the male song. Interestingly, one of these females had a bi-modal distribution of latency times. It switched irregularly between 'normal' response times (69±6 ms, range 58–78 ms, n=10) and much longer ones (136±6 ms, range 128–143 ms, n=10; see Fig. 1, open symbol).

Leptophyes sicula

Specimens studied: 1 male, 1 female, ITALY: Sicily, 1–31 viii 2015, leg. Bruno Massa.

The male calling song consists of relatively long (Kleukers et al. 2010: 40–50 ms), crescending single syllables. The female answered 142.5±8 ms (range 127–160 ms; n=30) after the beginning of this syllable, or 69±7 ms (range 53–81 ms; n=30) if measured from its end.

Andreiniimon nuptialis

Specimens studied: 1 male, 1 female, FYR MACEDONIA: 10 km w Miravci, Vardar near Demir Kabija (41°24 N, 22°9'E), 21 vi 1984, leg. D. and O. v. Helversen; 2 males, 2 females, GREECE: N. Ilia, Peloponnesos, valley of river Erimanthos, 6 km east of Koumanis (37°48'N, 21°47'E), 1–30 vi 1997, leg. K.-G. Heller.

The male calling song consists of single, very short syllables presented at intervals of several seconds. The female response occurred only about 20 ms later (see also Heller and Helversen 1986), typically consisting of several impulses. Its peak frequency was clearly lower than that of the male song (Table 1).

Discussion

The females of *Andreiniimon* and all six *Leptophyes* species studied here responded acoustically to the male calling song with very short signals, consisting of a few sound impulses only, produced by a closing movement of the tegmina (Fig. 2). These sounds were produced after quite short latency times, less than 200 ms after the beginning of the male signal (Fig. 1).

Latency times

Five species are grouped together with reaction times shorter than 60 ms. The fastest species, with a latency of about 20 ms or lower, was *Andreiniimon nuptialis.* It is thus the species with the fastest known duet in insects world-wide (see Bailey and Hammond 2003; their latency times refer to the end of the song). Only slightly slower are *L. punctatissima* and *L. albovittata* with latencies between 20 and 40 ms. In these two species the male calling songs and the peak frequency of the male and female are similar making acoustic discrimination difficult. Western *L. punctatissima* and eastern *L. albovittata* populations overlap in large parts of Central and Eastern Europe – both species are typically not found syntopically – but their ecological separation is strong enough to make acoustic differentiation unnecessary. The range of a fourth species, *L. laticauda*, lies nearly completely inside the area of one of the two others or even in that part where these overlap. Concerning the latency of the female response, it is slower than the others, but probably not enough to prevent misidentifications completely, at least by males of the faster species. The phonotactic reaction of males of *L. punctatissima* stops at about 45 ms (Robinson et al. 1986), so they might be attracted by fast *L. laticauda* females. However, the different spectra (Table 1) and the much faster rhythm in which the syllables/echemes of *L. laticauda* are produced will make acoustical problems unlikely. The long intervals between the syllables in *L. punctatissima* are probably not attractive for *L. laticauda* females. The fifth species, *L. discoidalis*, seems also to occur sympatrically with three others (*L. albovittata, L. boscii, L. punctatissima* and perhaps even *L. laticauda*; see Kleukers et al. 2010). Its females reacted even faster than *L. laticauda*, but the structure of the male calling song is very different (see below).

The last two species, *L. lisae* and *L. sicula*, have longer latency times than the five discussed above. Both are morphologically most similar to each other and then to *L. punctatissima*, but none occurs sympatrically with any other according to present knowledge. Otherwise, the three species would present a nice example of the importance of latency times. Males of *L. punctatissima* will certainly not accept the slow *L. lisae* females (see Zimmermann et al. 1989), and for *L. lisae* males the same might be assumed concerning *L. sicula* females. However, especially for *L. sicula* the possible mechanism of triggering the female response has to be discussed.

Why do the females use such short latency times? If the male phonotactically approaches a responding female, he may prefer the nearest one. The sound needs three milliseconds to travel one metre, so by answering rapidly a female can get an advan-

tage. In *L. punctatissima* the males even did not walk towards a female whose response they received later than 55 ms and with an intensity lower than 50 dB SPL. Successful duetting started only at distances lower than four metres (Zimmermann et al. 1989). Such narrow male time windows, however, exist probably only in species with extremely short female latency times (see fig. 8, Heller and Helversen 1986). If latencies become larger, variability will increase, assuming a similar coefficient of variation.

Song recognition

In species in which the females respond to song models which differ from the species-specific song pattern, artificial signals nevertheless contain the information necessary for species recognition and for triggering the female acoustic response. The females of some *Leptophyes* species do not seem to be very selective concerning species recognition. They responded to signals much shorter and much longer than the song (see above, Zhantiev and Korsunovskaya 1986). The same non-selective behaviour was also found in *Poecilimon ornatus*, a species from a related phaneropterid genus (Heller et al. 1997). However, this does not necessarily mean that all species with females responding to the beginning of the male song are non-selective. They may evaluate previous signals and then decide to answer to the next signal. In a stereotyped form this situation is found in species where the male song contains trigger syllables (e.g., in *Ancistrura nigrovittata*, see Dobler et al. 1994). Also in non-European *Leptophyes* species male calling songs with distinct trigger syllables have been described (e.g., *Leptophyes helleri*; Sevgili 2004). In a less stereotyped form, the female may use the intervals between male songs. The longer and the more variable the intervals between the male songs are, the less likely is this effect. It is certainly weak in *L. punctatissima* and *L. albovittata*, but may be more important in *L. laticauda* and, of course, in *L. discoidalis*. In some recordings of *L. discoidalis* made by Ingrisch (recording 0373 in Cigliano et al. 2018) and in some echemes studied here, the first syllable of an echeme is separated from the rest by an unusually long interval, perhaps the first step towards a real trigger syllable. In principle, *L. lisae* could also belong in this category with the first parts of the male syllable used for evaluating. However, the females unexpectedly answered to click-like song models. Possibly they switched to a general 'answering mode' after having heard some male songs. The long latency times observed irregularly in one female could indicate that she sometimes 'assumed' to have heard the first impulses of a syllable and is able to adapt to this situation. Although this unusual timing of *L. lisae* looks similar to the reaction of *L. sicula*, this species may use a completely different triggering process. In contrast to most other *Leptophyes* species with known male signals, it has a song with crescending syllable beginning, making exact timing of the female difficult. Depending on distance and/or noise, a female cannot easily recognise the start of the male syllable. On the other side, the end of the relatively long male syllable is clearly marked, serving as a better trigger point. Responding with a constant interval after the end of the male song was proven in *Isophya stepposa* by using song models (Zhantiev and Korsunovskaya 1986).

Of course, more studies are necessary to understand the differences in the female response behaviours between the species. There is, however, no evidence that the mating behaviour affects the acoustical response (see Table 1). For example, *L. laticauda* with spermatophores of ca. 25–30% male body weight and *L. punctatissima*, *L. albovittata* and *L. lisae* with spermatophores of 4–8% male body weight (Table 1; similar data also in Vahed 1994) do not group into acoustical response behaviours according to spermatophore nor body mass (Table 1). The same is true for carrier frequency. The large *L. laticauda* had clearly the lowest peak frequency, but *A. nuptialis*, next in body mass (Table 1), had the highest peak frequency.

So neither sexual selection (as far as the known differences in mating behaviour are concerned) nor species recognition play an easily understandable role for the evolution of female latency times. In both contexts male calling songs are probably more important. However, for the coexistence of different species ecological adaptations should not be underestimated. *Leptophyes punctatissima* and *L. albopunctata*, for example, occur sympatrically, but not syntopically over large parts of Europe (Kleukers et al. 2010) with nearly identical acoustical communication systems.

Acknowledgements

We are indebted to Dr. J. C. Hartley of Nottingham University and Dr. J. Rheinlaender for providing some animals of *L. punctatissima*, to Drs. G. and A. Lehmann for help in organising the transport of *L. sicula* and to E. Blümm, M. Heller, Drs. D. and O. v. Helversen and Dr. K. Reinhold for collecting specimens. Dr. Holger Braun and Dr. Thorin Jonsson gave helpful comments to a previous version of the manuscript. Some investigations were supported by the Russian Science Foundation (14–50–00029 – Scientific basis of the national biobank – depository of the living Systems).

References

Bailey WJ, Hammond TJ (2003) Duetting in insects – does call length influence reply latency? Journal of Zoology 260: 267–274. https://doi.org/10.1017/S0952836903003728

Chobanov DP, Hochkirch A, Iorgu IS, Ivkovic S, Kristin A, Lemonnier-Darcemont M, Pushkar T, Sirin D, Skejo J, Szövenyi G, Vedenina V, Willemse LPM (2016) *Leptophyes asamo*. The IUCN Red List of Threatened Species. e.T74780837A74780849. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T74780837A74780849.en

Cigliano MM, Braun H, Eades DC, Otte D (2018) Orthoptera Species File. Version 5.0/5.0. http://Orthoptera.SpeciesFile.org [01.1.2018]

Dobler S, Heller KG, Helversen Ov (1994) Song pattern recognition and an auditory time window in the female bushcricket *Ancistrura nigrovittata* (Orthoptera: Phaneropteridae). Journal of Comparative Physiology A 175: 67–74. https://doi.org/10.1007/BF00217437

Fontana P, Buzzetti FM, Cogo A, Odé B (2002) Handbook to the Grasshoppers and Allied Insects of the Veneto Region: Blattaria, Mantodea, Isoptera, Orthoptera, Phasmatodea, Dermaptera, Embiidina. Museo Naturalistico Archaeologico di Vicenza, Vicenza, 592 pp.

Hartley JC, Robinson DJ (1976) Acoustic behavior of both sexes of the speckled bush cricket *Leptophyes punctatissima*. Physiological Entomology 1: 21–26. https://doi.org/10.1111/j.1365-3032.1976.tb00882.x

Heller KG (1988) Bioakustik der europäischen Laubheuschrecken. Margraf, Weikersheim, 358pp.

Heller KG, Helversen Dv (1986) Acoustic communication in phaneropterid bushcrickets: species-specific delay of female stridulatory response and matching male sensory time window. Behavioral Ecology and Sociobiology 118: 189–198. https://doi.org/10.1007/BF00290822

Heller KG, Helversen Ov, Sergejeva M (1997) Indiscriminate response behaviour in a female bushcricket: sex role reversal in selectivity of acoustic mate recognition? Naturwissenschaften 84: 252–255. https://doi.org/10.1007/s001140050391

Heller KG, Hemp C, Ingrisch S, Liu CX (2015) Acoustic communication in Phaneropterinae (Tettigonioidea) – a global review with some new data. Journal of Orthoptera Research 24: 7–18. https://doi.org/10.1665/034.024.0103

Heller KG, Ingrisch S, Liu CX, Shi FM, Hemp C, Warchalowska-Sliwa E, Rentz DCF (2017) Complex songs and cryptic ethospecies: the case of the *Ducetia japonica* group (Orthoptera: Tettigonioidea: Phaneropteridae: Phaneropterinae). Zoological Journal of the Linnean Society 181: 286–307. https://doi.org/10.1093/zoolinnean/zlw019

Heller KG, Reinhold K (1992) A new bushcricket from the Greek islands, *Poecilimon paros* sp. nov., (Orthoptera: Phaneropterinae). Tijdschrift voor Entomologie 135: 163–168.

Heller KG, Willemse F (1989) Two new bush-crickets from Greece, *Leptophyes lisae* sp. nov. and *Platycleis tenuis* sp. nov. (Orthoptera: Tettigoniidae). Entomologische Berichten, Amsterdam 49: 10: 144–156.

Heller KG, Willemse L, Odé B, Volleth M, Feist R, Reinhold K (2011) Bioacoustics and systematics of the *Poecilimon hamatus* group (Tettigonioidea: Phaneropteridae: *Poecilimon: Hamatopoecilimon* n. subg.). Journal of Orthoptera Research 20: 81–95. https://doi.org/10.1665/034.020.0108

Helversen Ov, Elsner N (1977) The stridulatory movements of acridid grasshoppers recorded with an opto-electronic device. Journal of Comparative Physiology 122: 53–64. https://doi.org/10.1007/BF00611248

Ingrisch S, Pavicevic D (2010) Seven new Tettigoniidae (Orthoptera) and a new Blattellidae (Blattodea) from the Durmitor area of Montenegro with notes on previously known taxa. Zootaxa 2565: 1–41. https://doi.org/10.5281/zenodo.197230

Ingrisch S, Pavicevic D (2012) Faunistics, distribution and stridulation of orthopteroid insects of the Durmitor plateau and the surrounding canyons. Fauna Balkana (University of Novi Sad, Serbia) 1: 13–120.

Iorgu IŞ (2012a) Orthoptera fauna (Insecta) of Piatra Cloşani Mountain (The Southern Carpathians, Romania). Studii şi comunicări. Ştiinţele Naturii (Muzeul Olteniei Craiova. Oltenia) 28: 55–62.

Iorgu IŞ (2012b) Acoustic analysis reveals a new cryptic bush-cricket in the Carpathian Mountains (Orthoptera, Phaneropteridae). ZooKeys 254: 1–22. https://doi.org/10.3897/zookeys.254.3892

Iorgu IŞ, Iorgu EI, Szövényi G, Orci KM (2017) A new, morphologically cryptic bush-cricket discovered on the basis of its song in the Carpathian Mountains (Insecta, Orthoptera, Tettigoniidae). ZooKeys 680: 57–72. https://doi.org/10.3897/zookeys.680.12835.

Kleukers RMJC, Odé B, Fontana P (2010) Two new cryptic *Leptophyes* species from southern Italy. Zootaxa 2506: 26–42. https://doi.org/10.5281/zenodo.195953

McCartney J, Potter MA, Robertson AW, Telscher K, Lehmann G, Lehmann A, Helversen Dv, Reinhold K, Achmann R, Heller KG (2009) Understanding nuptial gift size in bush-crickets: an analysis of the genus *Poecilimon* (Tettigoniidae; Orthoptera). Journal of Orthoptera Research 17(2) (2008): 231–242. http://www.jstor.org/stable/25473446

Orci KM, Szövenyi G, Nagy B (2010) *Isophya sicula* sp. n. (Orthoptera: Tettigonioidea), a new, morphologically cryptic bush-cricket species from the Eastern Carpathians (Romania) recognized from its peculiar male calling song. Zootaxa 2627: 57–68. https://doi.org/10.5281/zenodo.198254

Ragge DR, Reynolds WJ (1998) The Songs of the Grasshoppers and Crickets of Western Europe. Harley Books, Colchester, Essex, 591 pp.

Robinson DJ (1980) Acoustic communication between the sexes of the bush cricket *Leptophyes punctatissima*. Physiological Entomology 5: 183–190. https://doi.org/10.1111/j.1365-3032.1976.tb00882.x

Robinson DJ, Rheinlaender J, Hartley JC (1986) Temporal parameters of male-female sound communication in *Leptophyes punctatissima*. Physiological Entomology 11: 317–324. https://doi.org/10.1111/j.1365-3032.1986.tb00419.x

Roesti C, Keist B (2009) Die Stimmen der Heuschrecken. Haupt Verlag, Bern, Stuttgart, Wien, 144 pp. [with DVD]

Sevgili H (2004) Review of the genus *Leptophyes* of Turkey with the description of a new species (Orthoptera, Phaneropterinae). Transactions of the American Entomological Society (Philadelphia) 130: 95–112. http://www.jstor.org/stable/25078840

Stumpner A, Meyer S (2001) Songs and the function of song elements in four duetting bushcricket species (Ensifera, Phaneropteridae, *Barbitistes*). Journal of Insect Behavior 14: 511–534. https://doi.org/10.1023/A:1011176106943

Ullrich B, Reinhold K, Niehuis O, Misof B (2010) Secondary structure and phylogenetic analysis of the internal transcribed spacers 1 and 2 of bush crickets (Orthoptera: Tettigoniidae: Barbitistini). Journal of Zoological Systematics and Evolutionary Research 48: 219–228. https://doi.org/10.1111/j.1439-0469.2009.00553.x

Vahed K (1994) The evolution and function of the spermatophylax in bushcrickets (Orthoptera: Tettigoniidae). PhD Thesis, Nottingham University, Nottingham.

Vahed K (2007) Comparative evidence for a cost to males of manipulating females in bushcrickets. Behavioral Ecology 18, 499–506. https://doi.org/10.1093/beheco/arm021

Vahed K, Gilbert FS (1996) Differences across taxa in nuptial gift size correlate with differences in sperm number and ejaculate volume in bushcrickets (Orthoptera: Tettigoniidae). Proceedings of the Royal Society London B, Biological Sciences 263: 1257–1265. https://doi.org/10.1098/rspb.1996.0185

Zhantiev RD, Korsunovskaya OS (1986) Sound communication in bush crickets (Tettigoniidae, Phaneropterinae) of the European Part of the USSR. Zoologicheskii Zhurnal 65: 1151–1163. [In Russian, with English summary]

Zhantiev RD, Korsunovskaya OS (1990) Sound communication of Phaneropteridae (Orthoptera). In: Gribakin FG, Wiese K, Popov AV (Eds) Advances in Life Sciences: Sensory System and Communication in Arthropods. Birkhäuser, Basel etc., 403–406.

Zhantiev RD, Korsunovskaya OS (2015) Acoustic signals of the bush-crickets of tribe Barbitistini (Orthoptera: Tettigoniidae: Phaneropterinae) from Eastern Europe and Caucasus. II. *Leptophyes* Fieber, 1853, *Euconocercus* Bey-Bienko, 1950, *Barbitistes* Charpentier, 1825, *Polysarcus* Fieber, 1853. Russian Entomological Journal 24: 201–210.

Zimmermann U, Rheinlaender J, Robinson D (1989) Cues for male phonotaxis in the duetting bushcricket *Leptophyes punctatissima*. Journal of Comparative Physiology A 164: 621–628. https://doi.org/10.1007/BF00614504

ZooKeys 750: 59–130 (2018)
doi: 10.3897/zookeys.750.23536
http://zookeys.pensoft.net

RESEARCH ARTICLE

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

A taxonomic study of Costa Rican *Leptodrepana* with the description of twenty-four new species (Hymenoptera, Braconidae, Cheloninae)

Samin D. Dadelahi[1], Scott R. Shaw[1],
Helmuth Aguirre[1], Luis Felipe V. de Almeida[2]

1 *U.W. Insect Museum, Department of Ecosystem Science & Management (3354), University of Wyoming, 1000 East University Avenue, Laramie, Wyoming 82071, U.S.A.* **2** *Universidade Federal de São Carlos, Departamento de Ecologia e Biologia Evolutiva, Rod. Washington Luis, km 235, CEP 13565-905, São Carlos SP, Brazil*

Corresponding author: *Helmuth Aguirre* (helmuthaguirre@gmail.com)

Academic editor: *J. Fernandez-Triana* | Received 10 January 2018 | Accepted 19 February 2018 | Published 16 April 2018

http://zoobank.org/E60BAC2F-51D5-4788-8825-BD2113035CE0

Citation: Dadelahi SD, Shaw SR, Aguirre H, De Almeida LFV (2018) A taxonomic study of Costa Rican *Leptodrepana* with the description of twenty-four new species (Hymenoptera, Braconidae, Cheloninae). ZooKeys 750: 59–130. https://doi.org/10.3897/zookeys.750.23536

Abstract

The genus *Leptodrepana* Shaw was described in 1983, but prior to the current study only one Neotropical species had been described from Mexico and none were named from Costa Rica. In this paper twenty-four new species are described and named from Costa Rica: *L. alexisae* Dadelahi & Shaw, **sp. n.,** *L. atalanta* Dadelahi & Shaw, **sp. n.**, *L. conda* Dadelahi & Shaw, **sp. n.**, *L. conleyae* Dadelahi & Shaw, **sp. n.**, *L. demeter* Dadelahi & Shaw, **sp. n.**, *L. eckerti* Dadelahi & Shaw, **sp. n**., *L. gauldilox* Dadelahi & Shaw, **sp. n.**, *L. hansoni* Dadelahi & Shaw, **sp. n.**, *L. kimbrellae* Dadelahi & Shaw, **sp. n.,** *L. lorenae* Dadelahi & Shaw, **sp. n.**, *L. munjuanae* Dadelahi & Shaw, **sp. n.**, *L. ninae* Dadelahi & Shaw, **sp. n.**, *L. pamelabbas* Dadelahi & Shaw, **sp. n.**, *L. ronnae* Dadelahi & Shaw, **sp. n.**, L. *rosanadana* Dadelahi & Shaw, **sp. n.**, *L. schuttei* Dadelahi & Shaw, **sp. n.**, *L. scottshawi* Dadelahi, **sp. n.**, *L. shriekae* Dadelahi & Shaw, **sp. n.**, *L. sohailae* Dadelahi & Shaw, **sp. n.**, *L. sorayae* Dadelahi & Shaw, **sp. n.,** *L. soussanae* Dadelahi & Shaw, **sp. n.**, *L. stasia* Dadelahi & Shaw, **sp. n.**, *L. strategeri* Dadelahi & Shaw, **sp. n.**, and *L. thema* Dadelahi & Shaw, **sp. n.** A key to Costa Rican species of *Leptodrepana* is provided. The flagellum of all female *Leptodrepana* described in this work is reduced to only 17 flagellomeres. This character state is also found in two North American species described by Shaw (1983), *L. opuntiae* Shaw and *L. oriens* Shaw. It is hypothesized that a female antenna with 17 flagellomeres is a synapomorphy for a species-group comprising all the Costa Rican *Leptodrepana* species as well as two of the Mexican and North American species, *L. opuntiae* and *L. oriens*.

Keywords
Carapace, egg-larval parasitoids, Malaise traps, Neotropical Region

Introduction

The braconid subfamily Cheloninae is large and cosmopolitan with more than 1500 described species (Shaw 1997, Yu et al. 2012, Kittel and Austin 2014). Here, the subfamily Adeliinae is considered part of the Cheloninae, in agreement with the results of Kittel et al. (2016). All chelonines are characterized by the presence of a metasomal carapace formed by the fusion of the first three metasomal terga into a rigid structure, dorsally covering the abdomen (Dudarenko 1974). Carapace formation is not unique to the Cheloninae and can be found in many other braconid subfamilies e.g., Microgastrinae, Sigalphinae, Ichneutinae, Rogadinae, and Helconinae (Dudarenko 1974, Shaw 1997). The inclusion of Adeliinae left no obvious morphological synapomorphies to define the Cheloninae. However, it is hypothesized that egg-larval parasitism is a trait unifying the subfamily, though such a characteristic is only inferred in Adeliinae based on morphological similarities between Adeliinae and the remaining chelonines (Čapek 1971 and Nixon 1965, cited by Shaw and Huddleston 1991).

The genus *Leptodrepana* Shaw was first described in 1983 and is represented by four species (Shaw 1983). Prior to that time *Leptodrepana* species were placed in the genus *Ascogaster* Wesmael. A taxonomic study of *Ascogaster*, however, resulted in the discovery of the genus *Leptodrepana* (Shaw 1983). *Leptodrepana* is separated from *Ascogaster* based on 13 diverging morphological characters (Shaw 1983). In *Leptodrepana,* the ocellar triangle is equilateral. The occipital carina, while complete, tends to be weak dorsally. Evenly scattered minute setae are present over the eyes. The median frontal carina is often weak. The scutellar disc is generally flat and polished. The ovipositor is long, slender, and tends to be curved upward. The carapace apex is often flared above the ovipositor. In females, the flagellum often consists of 17 segments, the apical flagellomeres tend to be longer than wide, and the ventral cavity is as long as the carapace. The scutellar sulcus has 7–10 well-defined depressions. The propodeal tubercles are usually short or indistinct. The metatibial spurs are less than half the length of the metabasitarsus. And, where host associations are known, members of the genus are associated with plutellid hosts (Lepidoptera: Plutellidae). *Leptodrepana* species are distributed across Central and South America (Shaw 1997).

In contrast, *Ascogaster* has an isosceles-shaped ocellar triangle. The occipital carina is strong. The eyes are consistently glabrous. The median frontal carina is often present. The scutellar disk is bulging and often sculptured. The ovipositor tends to be short and retracted under the carapace. The carapace apex is not flared above the ovipositor. In females, the flagellum consists of 25 or more segments, the apical flagellomeres are often almost as long as wide, or shorter, in length than width and the ventral cavity is shorter than the length of the carapace. The scutellar sulcus generally bears 4–6 well-defined depressions. The propodeal tubercles are well-developed. The metatibial spurs tend to be greater than half the length of the metabasitarsus. And, hosts consist primarily of tortricids (Lepidoptera: Tortricidae).

The best characters for distinguishing between the two genera are the shape of the ocellar triangle, shape and number of flagellomeres in the female, and degree of convexity in the scutellar disc.

Despite these noticeable character differences the generic designation of *Leptodrepana* is still debated. This is largely due to the presence of a few intermediate forms of the genera in other regions. Some species examined in the Palearctic region have characters intermediate to the states mentioned above making it difficult to identify them as either *Leptodrepana* or *Ascogaster* (Tang and Marsh 1994, Achterberg 1990). Some European taxonomists accept *Leptodrepana* as a valid genus (Zettel 1990). Others do not. For example, Huddleston's (1984) revision of the Palearctic *Ascogaster* did not address the complication created by the presence of intermediate forms; instead the work completely ignored the new genus. In 1990, the problem was discussed by Achterberg and he synonymized the genus, albeit without an adequate explanation or formal examination of the group. Although accepting Achterberg's (1990) synonymy appears to solve the problem of chelonine morphs that fall somewhere between *Ascogaster* and *Leptodrepana*, it maintains another conceptual problem; *Ascogaster* would become a clearly paraphyletic group. A phylogenetic analysis of chelonine wasps, based on 16s rDNA, supports Shaw's (1983) recognition of the genus *Leptodrepana* as separate from *Ascogaster* (Chen 1999). A more recent analysis by Kittel et al. (2016), based on three molecular markers (*COI*, *EF1a*, *28S*) and 37 morphological characters, recovered *Ascogaster* into two separated clades, one mostly Australian and one mostly North American. The genera *Austroascogaster* Kittel & Austin, 2014, *Leptodrepana*, and *Megascogaster* Baker, 1926 are located between the two clades, thus rendering *Ascogaster* paraphyletic. Kittel et al. propose two scenarios to solve the paraphyly: one considers *Ascogaster sensu lato*, i.e., to group all the clades into *Ascogaster*; the other considers *Ascogaster sensu stricto*, i.e., to restrict the genus to the North American clade. The last scenario provides some insight about the patterns of biogeographic divergence among the clades, recognizes documented morphological differences among the genera, and maintains the monophyly of each genus. Moreover, an eventual nomenclatural change supporting the first scenario requires a more comprehensive data set (Kittel et al. 2016).

The Cheloninae are egg-larval endoparasitoids of microlepidoptera (Shaw and Huddleston 1991). Shaw (1995, 1997) has suggested that exploiting the exposed and vulnerable egg stage of a host may be a means of simplifying the host location and oviposition process. Chelonines are koinobionts, so parasitized eggs are allowed to develop and mature during the larval stage. The third instar larva of the wasp emerges from the last larval stage of the host within the host pupation chamber (Shaw and Huddleston 1991). After emergence, the wasp larva feeds externally before spinning a cocoon and pupating while still inside the pupation chamber of the host (Shaw 1995). There has been little biological study of *Leptodrepana*. Shaw (1983) was able to associate *L. opuntiae* with a plutellid host but no other host information is available for other described *Leptodrepana* species or those treated in this paper.

The present work is a taxonomic study of Costa Rican *Leptodrepana.* Due to the unique efforts of the Malaise Network in place in Costa Rica, the country is especially well-sampled and a surprising number of *Leptodrepana*, normally rare species, have been collected (see Materials and methods).

Materials and methods

Approximately 292 specimens were examined for this study. This number includes all identified Neotropical *Leptodrepana* available in the collections of the following institutions: Natural History Museum, London, England (**BNHM**), California Academy of Sciences, San Francisco, California (**CAS**), Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (**INBio**), University of Wyoming Insect Museum, Laramie, Wyoming (**UWIM**).

Most of the specimens examined in this study were collected by Malaise traps that are part of the Malaise Network. The Malaise Network is a sampling program originally supported by the Natural History Museum to aid in the inventory of Costa Rican Hymenoptera. The Malaise traps in the program were initially set up by Ian Gauld and Paul Hanson. Eventually, more than 45 sites were sampled in seven different provinces. The collected material was sorted to the family level at the Insect Museum of the University of Costa Rica. Sorted samples were then sent off to experts for further study. According to Hanson (pers. comm. 1995), the purpose of the Malaise Network is two- fold: to encourage taxonomic study and to eventually build a synoptic collection of Costa Rican Hymenoptera.

The majority of the specimens in this study were prepared at the UWIM. Prior to point mounting, specimens were immersed in 100 % ethanol for a 24-hour period. After immersion in the ethanol the specimens were briefly allowed to air-dry for a period of approximately 15 minutes. At this point, specimens were immersed in chloroform for 15 minutes (minute individuals) to 45 minutes (larger bodied individuals) and then allowed to air-dry.

In some instance, specimens were riddled with debris and required cleaning. To clean the specimen it was removed intact on the point from the pin and placed in a small mesh basket. A solution was prepared of approximately 1/2 teaspoon dry dishwasher detergent to 500 mL of warm tap water. The basket and enclosed specimen were submerged in the warm soapy solution and gently agitated for 1 minute. The specimen was allowed to stand in the solution for approximately 2 hours gently agitated 2–3 more times during this period. It was then removed from the soapy solution and immersed in three changes of warm clean water. The specimen without the point was removed from the basket and allowed to dry before being prepared in the manner given above.

A calibrated ocular micrometer was used for all measurements. For the sake of consistency, the same microscope and micrometer were used for all measurements. Images were captured with a Leica M205C stereomicroscope with digital Leica DFC295 camera kit and processed with Leica Application Suite Version 3.8.0 auto-montage software. Unless otherwise noted in the figure captions, illustrated specimens were females. Also, unless otherwise indicated, all of the material examined was collected by use of a Malaise trap, originated in Costa Rica, and is presently located at the UWIM. In addition, due to the large amount of material collected by Paul Hanson his name as collector has also been omitted except in cases of holotype data records. Therefore, unless otherwise indicated, please acknowledge P. Hanson as collector of all of the ma-

terial used in this study. Collection data was recorded as it appears on the data label, although for purposes of organization some information may have been rearranged so as to follow the same sequential format of other labels.

This manuscript was developed from a master thesis written by SDD under the guidance of SRS. Authorship of the new species is attributed to SDD and SRS, with the exception of the patronymic species *L. scottshawi*, authorship of which is solely attributed to SDD. The coauthors HA and LFVA produced and arranged the images and plates for this publication, as well as contributing to the updating of the introduction, and refinement of the identification key and descriptions.

Taxonomic characters and terminology

Costa Rican specimens can be identified to subfamily Cheloninae and genus *Leptodrepana* using the keys and characters previously provided by Shaw (1995, 1997, 2006) and Wharton et al. (2017).

The morphological characters and terminology in this study follow the works of Shaw (1983), Huddleston (1991), Tang and Marsh (1994), and Sharkey and Wharton (1997). The term precoxal sulcus is employed instead of sternaulus accordingly to Wharton (2006). Microsculpture characteristics are described in accordance to Harris (1979). Wing venation is described according to the conventions used by Sharkey and Wharton (1997).

Head

To describe differences in head shape among species a simple width to length ratio was used. Width (HW) is expressed as the measurement of the maximum breadth of the head when the specimen is viewed anteriorly, in all cases the distance between the outer perimeters of the eyes. Length (HL) is expressed as the measurement of the maximum length of the head when the specimen is held in a lateral view, usually from the top of the ocellar triangle to the apical clypeal margin.

Female specimens in this study consistently had 17 flagellomeres with length of each segment decreasing apically. In almost all cases flagellomere length exceeded width, but in a few species length and width of the penultimate flagellomere is approximately equal and 0.5 the size of the ultimate flagellomere. Additionally, in some species the flagellum appears slightly dilated medially at flagellomeres 8–14. The number of flagellomeres in the antennae of males varied from 22–26. In males, the flagellum was always slender and long with all segments longer than wide and tapering apically.

Microsculpture and pubescence of the head is also a useful character for distinguishing between species, especially the depressed area of the frons, which may be obstructed from view by the position of the antennae. The median carina of the frons is a somewhat useful character but only insofar as it is either present or lacking.

Mesosoma

Microsculpture of the mesopleuron was especially important. The mesopleuron was generally characterized by the type of sculpture present medially and the type of sculpture at the precoxal sulcus. In some cases a deep groove with regularly shaped depressions is present at the precoxal sulcus and in this study is termed a scrobiculate groove. This character is contrasted by a foveate band or groove at the precoxal sulcus which consists of irregularly sized pits.

Other characters include degree of organization of linear lacunose grooves in the mesoscutum, type of sculpture on the mesonotal lobes, the number of well-defined depressions in the scutellar sulcus, type of sculpture present on the lateral pronotum, and comparisons between the median and lateral propodeal tubercles.

Wings

Wing venation patterns are very similar among the known Costa Rican species, and of little value for distinguishing species. However, fore wing color does have utility for species recognition, including the degree of pigmentation, presence of infuscate bands or obfuscate areas, and, in some cases, density of setae (see Figs 126–128). The length of the fore wing is abbreviated as FWL.

Metasoma

Many characters of the metasoma are useful. Shape is expressed in terms of length to width ratios and both measurements are made in lateral view. Shape of the carapace apex in lateral, dorsal, and posterior views is also used to discriminate between species. The carapace apex may be rounded, squared, terminating in a single point, or terminating in two points. Microsculpture of the carapace is another useful character. Although basally areolate-rugose in all cases, species differed in microsculpture types apically. The length and width of the carapace are abbreviated as CL and CW respectively.

Size and color

In many species body size (body length, BL) proves to be a useful character. In this study, species are considered small if range in size falls below 2.5 mm and large if range in size is above 3.0 mm. In species of intermediate size, size is not used as part of the species diagnosis. The wide gap between what are considered small and large species should serve to remove some of the problems in length ascribed to various positions of the head, and metasoma.

In this study, color patterns of specimens examined were useful characters. Shaw (1983) notes that although color may vary widely within a species, it still has diagnostic

value. Indeed in examining series of material in this study, color is a fairly consistent character for distinguishing the Costa Rican species. Several *Leptodrepana* species exhibit a black/red/black body color pattern that is also shared by some Scelionidae and other insects, and may be part of a broader mimicry complex (P. Hanson, pers. comm.).

Taxonomic part

Genus *Leptodrepana* Shaw, 1983

Diagnosis. Head wider than long and sculptured; anterior tentorial pits distinct; frontoclypeal suture weak; apical clypeal margin rounded; mandibles bidentate with anterior tooth larger; maxillary palpi six-segmented; labial palpi four-segmented; antennae inserted high on face; scrobes carinate; ocelli prominent and arranged in an equilateral triangle; occipital carina complete and weak dorsally; female antennae with 17 flagellomeres, decreasing in length apically; male antennae with 22–26 flagellomeres, all longer than wide and tapering apically; mesosoma setose and sculptured: mesoscutum medially with roughly parallel lacunose grooves to areolate-rugose; notauli lacunose and often only visible anteriorly; mesonotal lobes varied; scutellar sulcus with 3–8 well-defined depressions; scutellar disc flat or slightly convex, polished-rugulose and punctate; anterior scutellar depression carinate, rarely foveolate; metanotum and posterior scutellar depression irregularly foveate; mesopleuron anteriorly rugose, medially varied, and indistinct to scrobiculate at precoxal sulcus; propodeum quadrate, areolate-rugose with median transverse carina raised into medial and lateral flanges; metatibial spurs shorter than half metabasitarsus length; wings setose, hyaline or infuscate; costa broken at base of stigma; three submarginal cells present in fore wing; veins RS+Mb, and r-m spectral; hind wing venation weak; metasoma dorsally setose and sculptured; tergites 1–3 fused to form a rigid carapace without transverse sutures, basally areolate-rugose; apically often flared above ovipositor; ventral cavity approximately the same length as carapace; ovipositor long slender and curved upwards; body color yellow, yellowish orange, orange, orangish brown, dark brown, brownish black, and black; body length 1.7–3.8 mm.

Remarks. Twenty-four new species of *Leptodrepana* are recorded from Costa Rica. Examinations of these species reveal some variation from the characters originally used by Shaw (1983) to separate the two genera. Shaw's (1983) diagnosis, based on North American species, states that the number of flagellomeres in females is sometimes reduced to 17, the scutellar sulcus has 7–10 depressions, and propodeal tubercles are usually short or indistinct. In Costa Rican *Leptodrepana,* the females consistently have 17 flagellomeres. The scutellar sulcus has anywhere from 3 to 8 depressions and the propodeal tubercles are often distinct, although sometimes the median flanges are much reduced in comparison to the lateral flanges. Reduction of the flagellum to just 17 flagellomeres is a character unique to only two of the N. American species described by Shaw (1983): *L. opuntiae, and L. oriens.* As all female Costa Rican *Leptodrepana* have 17 flagellomeres, this may be a synapomorphic character tying all Costa Rican *Leptodrepana* to *L. opuntiae* and *L. oriens*.

There is only one record of *Ascogaster* in the neotropics, *A. bugabensis* Cameron. This specimen was borrowed from the Natural History Museum (London) and upon examination proved to be a helconine in the genus *Urosigalphus* (Shaw and Dadelahi, 2002). However, based on our own vast experience sorting Costa Rican braconids, *Ascogaster* and *Leptodrepana* are easily distinguished with few, if any, of the intermediate forms that are (rarely) found in the Palearctic. Our examination of undescribed Costa Rican *Ascogaster* species found none with the number of flagellomeres reduced to 17.

Key to females of Costa Rican *Leptodrepana* species

1 Carapace apex appearing broadly or narrowly rounded in dorsal and posterior views (Figs 16, 18, 26, 28, 33, 59, 79, 123). Sometimes carapace ventral border slightly concave in posterior view (Figs 31, 109), but protuberances or tubercles absent..... **2**

– Carapace apex terminating in one (Figs 10, 11, 84, 86, 99, 101) or two points (tubercles) in dorsal and posterior view (Figs 4, 21, 23, 43, 71); apex may appear distinctly squared if tubercles are widely separated (Figs 54, 56)..... **10**

2 Head, mesopleuron, and metasoma entirely black in lateral view (as in Fig. 77); legs and antennae variable..... **3**

– Head, mesopleuron, and metasoma not entirely black in lateral view, sometimes metasoma basally white-yellow (Figs 72, 116) **4**

3 Wings with infuscate bands (Fig. 127); mesopleuron medially shiny and impunctate; antennae dark brown except for flagellomeres 2–4 (Fig. 77) .... ***L. rosanadana* sp. n.**

– Wings obfuscate or at most hyaline; mesopleuron medially densely foveate; antennae uniformly brown with distal ends of flagellomeres 1–4 yellowish white (Fig. 29) ..... ***L. eckerti* sp. n.**

4 Mesonotum yellowish orange (as in Fig. 58); mesopleuron mostly yellow to orange; propodeum black, orange, or orange and black; carapace black with basal third yellowish white or with medio-basal yellowish white patch..... **5**

– Mesosoma mostly black; carapace variable **7**

5 Antennae tri-colored (basally yellow, medially white and distally brown/black) (Fig. 57); mesonotum and metanotum yellow-orange with brown/black propodeum; scutellar sulcus with three well defined depressions; carapace apex with distinct ridge or carina in posterior view (Fig. 59)..... ..... ***L. munjuanae* sp. n.**

– Antennae uniformly brown or with scape, pedicel and first flagellomere yellowish white; mesonotum and metanotum orange or burnt orange; propodeum black or orange sometimes bearing black patches; scutellar sulcus with five well-defined depressions; carapace without distinct ridge in posterior view..... **6**

6 In lateral view, carapace no more than 3× as long as wide (Fig. 17); mesopleuron orange anteriorly and black posteriorly; propodeum black; carapace black with basal third yellowish white; fore leg, middle leg, and hind leg mostly yellowish white but hind leg with apical portions of coxa, tibia, and femur dark brown (Fig. 14)..... ***L. conda* sp. n.**

– In lateral view, carapace approximately 4× as long as wide (Fig. 27); mesopleuron orange or burnt orange; propodeum orange sometimes with small brownish black area over medial flanges; carapace black sometimes with media-basal yellowish white patch between dorsal carinae but not extending to lateral margin of carapace; fore leg, middle leg and hind leg mostly yellow to yellowish white, femur of hind leg with lateral patch of white and tibia with distinctive pattern: linear brown oval ring visible dorsally running most of tibia length (Fig. 24)..... ***L. demeter* sp. n.**

7 Mesopleuron medially punctate with deep regular foveate groove at precoxal sulcus; laterally pronotum smooth at propleural margin; carapace apex shiny and weakly punctate or shiny and rugulose with a transverse carina..... **8**

– Mesopleuron foveate to rugose with or without scrobiculate groove at precoxal sulcus; laterally pronotum rugose at propleural margin; carapace apex rugose to areolate-rugose and pubescent..... **9**

8 Carapace apex shiny and impunctate (Figs 117–118); smoothly rounded in lateral and posterior views; scutellar sulcus with 4–5 well-defined depressions..... ***L. strategeri* sp. n.**

– In posterior view, carapace apex rugulose and bearing a transverse carina (Figs 74–75); in lateral view, presence of apical carina gives carapace the appearance of terminating in a narrow point below midline; scutellar sulcus with 3 well-defined depressions..... ***L. ronnae* sp. n.**

9 Body size robust, more than 3.0 mm in length; coxae and trochanters of all legs yellowish white, femur, tibia, and tarsus dark brown, tibia with basal yellowish white band; carapace brown-black with basal quarter or less yellowish white in color (Figs 110, 111)..... ***L. soussanae* sp. n.**

– Body size small, less than 2.5 mm in length; legs yellow or light brown; carapace black with basal third yellowish white in color (Fig. 125)..... ***L. thema* sp. n.**

10 Carapace apex terminating in a single point or tubercle in dorsal and posterior views (Figs 10, 11, 84, 86, 99, 101)..... **11**

– In dorsal and posterior views, carapace apex terminating in two points or tubercles (Figs 4, 21, 23, 43, 71); tubercles may be greatly separated giving carapace apex a distinctly squared appearance (Figs 54, 56) or produced into flange visible in dorsal view (Fig. 6)..... **14**

11 In lateral view, carapace apex with lobe or rounded flange below or posterior to apical point (Fig. 105); carapace yellow-orange and with distinct pattern: in dorsal view, basal area yellowish white between dorsal carinae with lateral crescent shaped yellowish white patch posterior to basal third of carapace; head yellowish

orange; wings smoky except for white band across parastigma, and parts of veins 1RS, RS+M, 1m-cu and 2CU-a (Fig. 128)..... ***L. sorayae* sp. n.**

– In lateral view, carapace terminating in a single broad or narrow point (as in Fig. 12); carapace black, with or without yellowish white patch dorsally; head black; wings unpigmented or slightly dusky but no white band below parastigma **12**

12 Mesosoma and metasoma entirely brownish black (Figs 97–98); carapace apex shiny and weakly punctate; body size less than 2.0 mm..... ***L. sohailae* sp. n.**

– Mesosoma and metasoma not entirely blackish brown; carapace apex rugose to weakly areolate-rugose, body size greater than 2.0 mm **13**

13 Mesosoma orange, mesoscutum with wide shallow notauli; mesopleuron orange and medially foveate, deeply foveate rows forming grooved band at precoxal sulcus; carapace black, areolate-rugose, and often with white-yellow patch baso-medially covering dorsal carinae or restricted to two patches over dorsal carinae (Figs 9, 13) ..... ***L. atalanta* sp. n.**

– Mesonotum and metanotum orange, mesoscutum with narrow notauli; mesopleuron orange and often dark brown near posterior margin, foveate medially with deep regularly foveate groove at precoxal sulcus; propodeum black, carapace black, areolate-rugose, and basal third yellowish white in color (Figs 83, 86) ..... ***L. schuttei* sp. n.**

14 Apex of carapace with distinctly truncated appearance in dorsal view (Figs 54, 56); carapace black with diamond shape patch medially; antennae brown with medial yellowish white; legs appear distinctly banded in yellowish white and black (Fig. 52) ..... ***L. lorenae* sp. n.**

– Carapace apex with two distinct tubercles in dorsal and posterior views (Figs 4, 6, 37, 39, 49, 51, 64, 66, 69, 71); carapace color and pattern variable; antennae variable; legs not distinctly banded in yellowish white and black..... **15**

15 Head, mesosoma, and most of metasoma black or blackish brown..... **16**

– Not as above; mesosoma orange or with patches of orange..... **20**

16 Carapace apex with tubercles blunt so in dorsal view appear as barely projecting or tubercles fall within the apical plane of the carapace and only a protruding flange is visible (Figs 4, 6, 69, 71) **17**

– Carapace apex with tubercles strongly protruding so in dorsal view appear strongly arched between and in lateral view apex terminates in narrow point (Figs 43, 44, 49, 50) **18**

17 In dorsal view, carapace apex with tubercles barely projecting and shallowly arched between (Figs 69, 71); lateral pronotum deeply foveate and rugose at propleural margin; mesopleuron rugose medially with deep foveate groove at precoxal sulcus ..... ***L. pamelabbas* sp. n.**

– In dorsal view, carapace apex sloping so that points appear planar in dorsal view and not protruding or a protruding flange visible (Fig. 6), in posterior view apex strongly arched (Fig. 4); lateral pronotum foveolate and smooth at propleural margin; mesopleuron punctate to foveolate at and posterior to precoxal sulcus, medially with small circular shiny impunctate area..... ***L. alexisae* sp. n.**

18 Mesopleuron medially shiny and impunctate; lateral propleural margin of pronotum shiny and impunctate; legs yellow (Fig. 40)..... ***L. hansoni* sp. n.**

– Not with above combination of characters; mesopleuron medially foveate and/or rugose; lateral propleural margin rugose; legs variable..... **19**

19 Carapace brownish black with basal third yellowish white in distinctive bi-lobed pattern (Fig. 51); small, less than 2.5 mm; in lateral view carapace at the most 3× as long as wide (Fig. 50); legs generally uniform yellow in color, sometimes hind tibia bearing faint basal band; antennae often dilated medially..... ***L. kimbrellae* sp. n.**

– Carapace without distinctive bi-lobed pattern although basal quarter often with cream patches laterally below dorsal carinae (Fig. 39); body robust, more than 3.0 mm; in lateral view carapace more than 3.5× as long as wide (Fig. 38); hind and fore coxae brown, meso coxae white or yellowish white, femur and tibia of all legs dark brown with narrow white basal bands; antennae not dilated medially ..... ***L. gauldilox* sp. n.**

20 Mesosoma orange or burnt orange but uniform in color (Fig. 87); medially corrugated area of mesoscutum arranged in distinct parallel rows; scutellar disc very flat; carapace often with cream patches baso-laterally below dorsal carinae (Fig. 91)..... ***L. scottshawi* sp. n.**

– Mesosoma either brown with orange and black patches or orange with black areas; medially corrugated surface area not arranged in distinct parallel rows; scutellar disc slightly convex; if carapace with yellowish white markings then patch is medial and not lateral below dorsal carinae **21**

21 Body size small, less than 2.5 mm; body mostly dark brown but mottled appearing lighter or darker in some areas (Fig. 92); mesoscutum with square orange patch medially; scutellar disc always darker than surrounding anterior scutellar depression; mesopleuron shiny and weakly punctate medially with deep regularly foveate band at precoxal sulcus..... ***L. shriekae* sp. n.**

– Body size robust, greater than 2.5 mm, mesosoma mostly orange with black patches; mesoscutum with no orange patch medially; scutellar disc same color as surrounding scutellar depression; mesopleuron variable **22**

22 Penultimate flagellomere almost as long as ultimate flagellomere and length greater than width; carapace entirely brownish black (Fig. 112) ... ***L. stasia* sp. n.**

– Penultimate flagellomere approximately half the length of ultimate flagellomere and length equal to width; carapace variable..... **23**

23 Carapace apex with tubercles widely separated (Figs 64, 66); carapace black with medial yellowish orange oval or diamond shaped patch running almost length of carapace; face rugulose-punctate; mesopleuron medially shiny and weakly punctate with shallow foveate band at precoxal sulcus; antennae uniformly brown..... ***L. ninae* sp. n.**

– Carapace apex with tubercles narrowly separated (Figs 21, 23); carapace black with basal yellowish white "cape" (Fig. 23); face coarsely rugulose-punctate; mesopleuron foveate with slightly larger pits forming band at precoxal sulcus; antennae generally yellowish brown basally..... ***L. conleyae* sp. n.**

Leptodrepana alexisae **Dadelahi & Shaw, sp. n.**
http://zoobank.org/D2205D7C-B5A7-4D57-B008-942F0CF19E95
Figs 1–6, 126

Diagnosis. In dorsal view, the carapace apex of *L. alexisae* lacks projecting tubercles instead it has a protruding flange (Fig. 6); in posterior view, two planar points, either strongly or weakly arched between, are visible (Fig. 4). The mesopleuron has a small shiny impunctate area medially with the immediate surrounding area foveolate. The precoxal sulcus appears foveolate. In females, the flagellum is slightly dilated medially. Body mostly brownish black except basal quarter of carapace yellowish white.

Holotype female. BL 2.07 mm; FWL 2.0 mm; CL 0.96 mm; CW 0.32 mm; CL/CW 3.

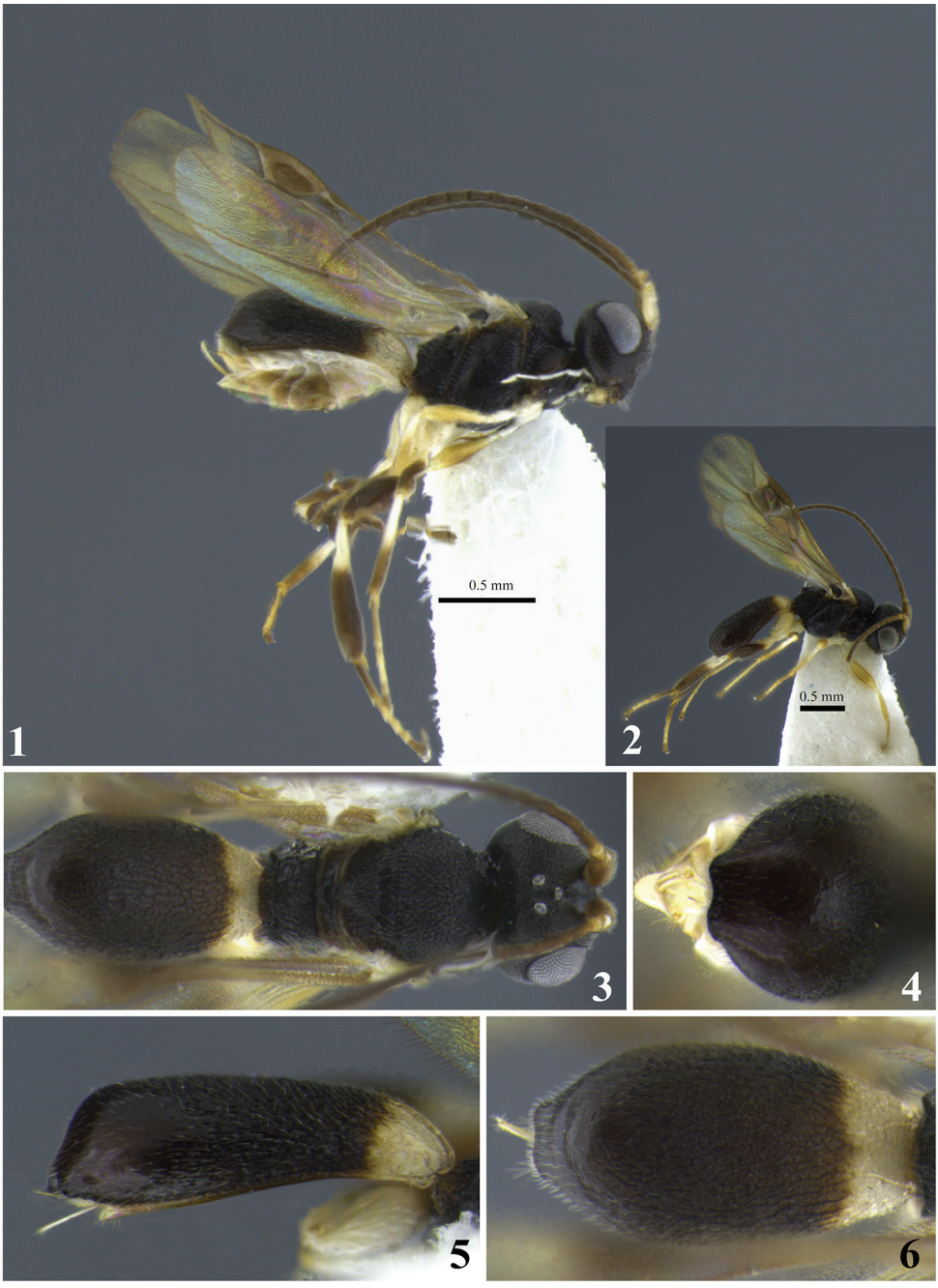
Description. *Color*. Head brownish black, mandibles yellow, blackish brown apically and basally; palpi yellowish white; antennae brown with scape and pedicel yellowish white; mesosoma brownish black; legs with coxa, trochanter and trochantellus yellowish white, femur and tibia of fore leg yellow, basal half of tibia yellowish white; hind and middle legs similar to fore leg but femur and apical half of tibia dark brown; wings lightly pigmented with darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell; yellow/brown venation; carapace mostly black, basal quarter yellowish white.

Head. HW 0.63 mm; HL 0.53 mm; HW/HL 1.19; face, genae, vertex and ocellar triangle rugulose-weakly punctate; frons depressed impunctate with faint median carina; clypeus weakly punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveolate antero-laterally to weakly punctate at propleural margin; propleuron foveate to weakly areolate-rugose; mesoscutum medially weakly areolate-rugose, not greatly differentiated form mesonotal lobes; notauli indistinct; median and lateral mesonotal lobes foveolate-rugose; scutellar sulcus with 6–8 well-defined depressions, all longer than wide; scutellar disc sculptured similar to mesoscutum; mesopleuron anteriorly rugose foveolate, medially with small shiny impunctate area and remainder foveolate to weakly punctate, foveolate at precoxal sulcus and punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to shiny and impunctate at apex; in posterior view apex terminates in two planar points weakly arched between; in dorsal view square rounded or truncated flange just visible below rounded carapace dorsum; in lateral view, apex terminates in sloping point below midline.

Variation of paratype females. Carapace apex strongly arched in posterior view, in dorsal view square rounded or truncated flange strongly protruding below rounded carapace dorsum; carapace apex with broad squared point in lateral view; mesopleuron foveate at precoxal sulcus; coxae with traces of yellowish brown; HW 0.63–0.7 mm; HL 0.53–0.6 mm; HW/HL1.17–1.19; BL 2.07–3.2 mm; FWL 2.0–2.4 mm.; CL 0.96–1.2 mm; CW 0.32–0.4 mm; CL/CW 3.0–3.25.



Figures 1–6. *Leptodrepana alexisae*. **1** Female habitus in lateral view **2** male habitus in lateral view **3** female habitus in dorsal view **4** metasoma in dorso-posterior view terminating in two rounded endings **5** metasoma in lateral view **6** metasoma in dorsal view.

Variation of paratype males. Similar to females except antennae brown with 24 flagellomeres tapering apically; carapace apex not arched in posterior view and no protruding flange visible below rounded dorsum n dorsal view HW 0.7 mm; HL 0.58 mm; HW/HL1.21; BL 1.8 mm; FWL 1.86 mm.; CL 0.84 mm; CW 0.32 mm; CL/CW 2.62.

Material examined. Holotype female: GUANACASTE, Arenales, W side Volcan Cacao, 900 m, 1988–1989 (no collector listed) [UWIM]. Paratype data: 1♀, same data except Sotobosque, 1100 m, ii.1989 (I. Gauld); 2♀, 1♂, Est. Mengo, SW Volcan Cacao, 1988–1989; 1♀, PUNTARENAS, R. B. Monteverde, San Luis 1040 m, L-N-250850-449250, xii.1992 (Z. Fuentes) [INBio, bar code1000-958034].

Remarks. *Leptodrepana alexisae* is similar to and may be confused with *L. pamelabbas*. However, the following characters may be used to separate the two species. In dorsal view, the carapace apex of *L. alexisae* lacks projecting tubercles instead it has a protruding flange (Fig. 6). In posterior view, two planar points, either strongly or weakly arched between, are visible (Fig. 4). The mesopleuron has a small shiny impunctate area medially with the immediate surrounding area foveolate. The precoxal sulcus appears foveolate. In females, the flagellum is slightly dilated medially. However, in dorsal and posterior views, two small weakly protruding tubercles are visible at the carapace apex of *L. pamelabbas* (Figs 69, 71). The mesopleuron is medially rugose with wrinkles appearing somewhat parallel. At the precoxal sulcus there is a wide foveate groove. In females, the flagellum is uniform in width.

Etymology. This species name is a patronym in honor of a sister of SDD, Alexis Satareh Dadelahi.

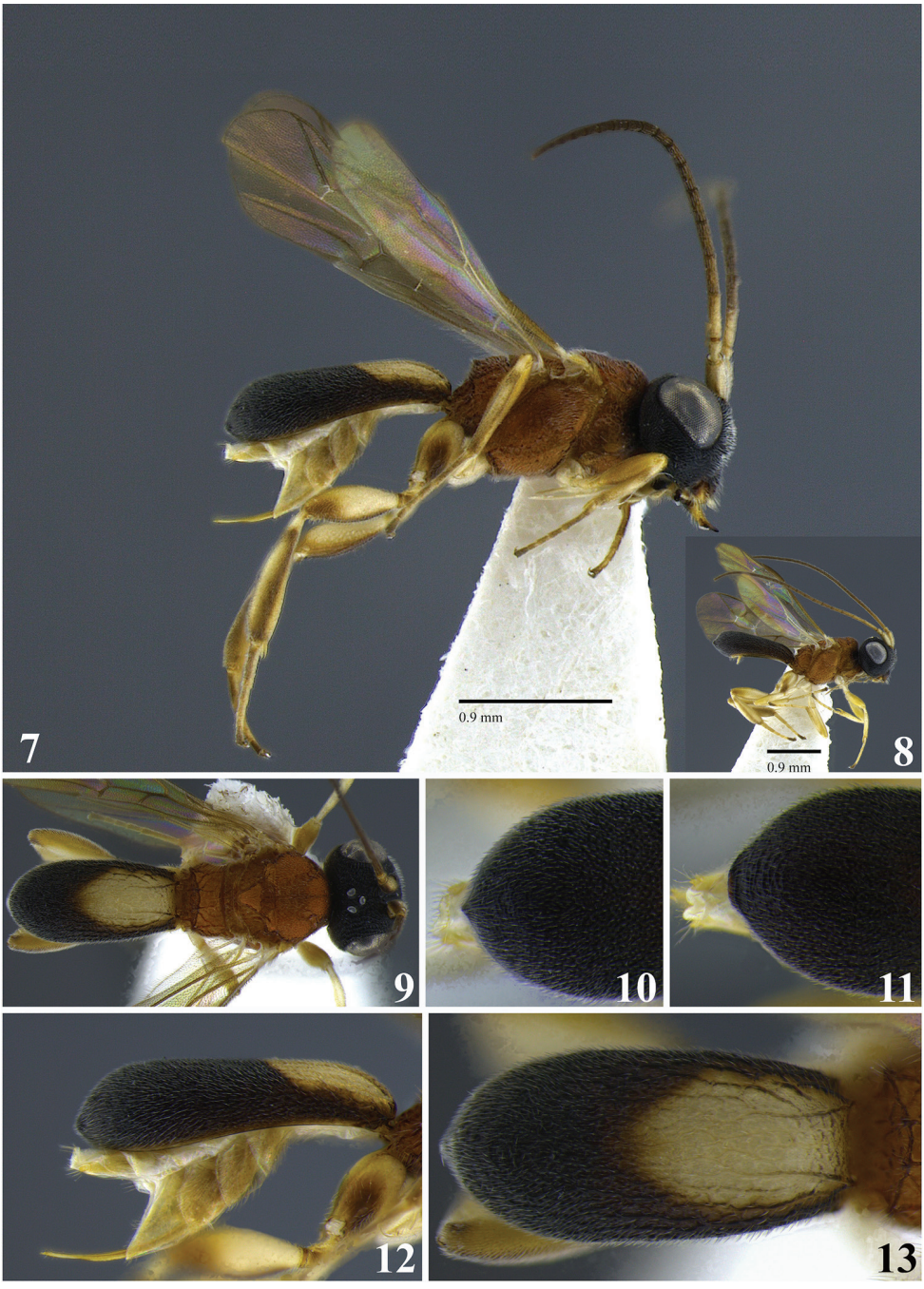
Leptodrepana atalanta Dadelahi & Shaw, sp. n.

http://zoobank.org/B86499A0-E4BC-4B94-9B2E-1480614F86C8
Figs 7–13

Diagnosis. The carapace apex terminates in a single point; carapace black with yellowish white area baso-medially covering dorsal carinae. A wide shallow notauli and a wide band at precoxal sulcus formed by at least two shallow foveate grooves. The mesopleuron and propodeum are entirely orange, and the baso-median patch of yellowish white on the carapace does not extend to the lateral margins of the carapace.

Holotype female. BL 3 mm; FWL 2.26 mm; CL 1.36 mm; CW 0.36 mm; CL/CW 3.7.

Description. *Color*. Head black/brown, mandibles mostly yellowish brown but black/brown basally and apically; palpi yellowish white; antennae brown except scape, pedicel and first flagellomere (basal) yellowish white; mesosoma orange; legs mostly yellow, hind leg with brown areas apically on coxa and femur and white patch laterally on femur, tibia with distinct pattern: linear white ellipse ringed in brown visible dorsally running most of tibial length; wings suffused with light yellow/brown pigmentation except a small linear obfuscate area perpendicular to base of stigma in first discal cell; venation brown but veins 1M, RS+Ma, 2RS and 2M yellow or light brown; carapace black with yellowish white area baso-medially covering dorsal carinae.



Figures 7–13. *Leptodrepana atalanta*. **7** Female habitus in lateral view **8** male habitus in lateral view **9** female habitus in dorsal view **10** metasoma in dorso-posterior view displaying a pointing end **11** metasoma in dorso-posterior view displaying a truncated end **12** metasoma in lateral view **13** metasoma in dorsal view.

Head. HW 0.9 mm; HL 0.78 mm; HW/HL 1.15; Face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, coarsely punctate with fine parallel lineation transverse to median carinae; clypeus weakly punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to weakly areolate-rugose postero-laterally; propleuron weakly areolate-rugose; mesoscutum medially with irregular parallel pitted grooves between notauli; notauli wide and shallow anteriorly; mesonotal lobes granulate-punctate; scutellar sulcus with 5 well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose and remainder deeply foveate especially at and posterior to precoxal sulcus; propodeum coarsely areolate-rugose with distinct transverse carina raised into small roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose basally graduating to coarsely rugulose-punctate at apex; apex terminating in single small point visible in dorsal and lateral views.

Variation of paratype females. Color: carapace with baso-medial yellowish white area not present, greatly reduced to two patches discrete to dorsal carinae or prominent covering basal half of carapace. Head: frons greatly depressed and rugose-punctate. Mesopleuron deeply foveate forming a wide pitted groove at precoxal sulcus; carapace apex rounded. HW 0.78–1 mm; HL 0.65–0.88 mm; HW/HL 1.14–1.2; BL 2.4–3.3 mm; FWL 1.86–3 mm; CL 1.12–1.6 mm; CW 0.32–0.44 mm; CL/CW 3–3.7.

Variation of paratype males. Similar to females except antennae with 25–26 flagellomeres tapering apically; ventral cavity distal carapace apex.

Material examined. Holotype female: PUNTARENAS, Golfo Dulce 3 km SW Rincon, 10 m, iii–v.1989. (P. Hanson) [UWIM]. Paratype females: 2♀♀, GUANACASTE, Est. Pitilla, 9 km S Santa Cecilia 700 m, iv.1989 (I. Gauld); 1♀, same data except ix.1988 (I. Gauld); 1♀, same province except Arenal W side Volcan Cacao, 900 m 1988–1989; 1♀, HEREDIA, Puerto Viejo OTS, La Selva, 100 m, iv.1991; 1♀, same province Chilamate 75 m, v.1989; 1♀, same data as holotype; 1♀, same data as holotype except xii.1989–iii.1990; 3♀, same data as holotype except iii–v.1989; 1♀, same data as holotype except iii.1993; 2♀, same data as holotype except 24 km W Piedras Blancas, 200 m, vi–viii.1989; 2♂, same data except xii.1989–iii.1990; 1♂, same data except 15 km W Piedras Blancas, 100 m, xii.1990; 3♀, same province, Rd. to Rincon, 24 km W Pan. Amer. Hwy, 200 m, iii–v.1989 (P. Hanson & I. Gauld); 2♀, same province, Pen. Osa, 8 km S Rio Rincon, Coopemarti, 30 m, ii.1991; 3♀, same data except 23 km N Pto. Jimenez, La Palma, in large trees, 10 m, viii–ix.1991; 1♀, same province, P. N. Corcovado, Est. Sirena, 50 m, iv–viii.1989; 1♀, same data except 0–100 m, iii.1991 (G. Fonseca) L-S-270500,508300 [INBio]; 2♀, SAN JOSE, Ciudad Colon, 800 m, iv–v.1990 (L. Fournier).

Remarks. *Leptodrepana atalanta* is similar to and may be confused with *L. schuttei*. They are similar in color and the carapace apex of both species terminates in a single point. *Leptodrepana atalanta* may be distinguished from *L. schuttei* by the presence of wide shallow notauli and a wide band at precoxal sulcus formed by at least two shallow

foveate grooves. The mesopleuron and propodeum are entirely orange, and the basomedian patch of yellowish white on the carapace does not extend to the lateral margins of the carapace. The notauli of *L. schuttei* are narrow and there is a scrobiculate groove present at the precoxal sulcus. The posterior mesopleuron and the propodeum are black. The basal third of the carapace is completely yellowish white.

Etymology. This species name stems from the Greek *Atalante,* one of the Argonauts noted for her fleetness of foot.

***Leptodrepana conda* Dadelahi & Shaw, sp. n.**
http://zoobank.org/27B73277-272D-416C-9E3F-48A5CB2FD001
Figs 14–18

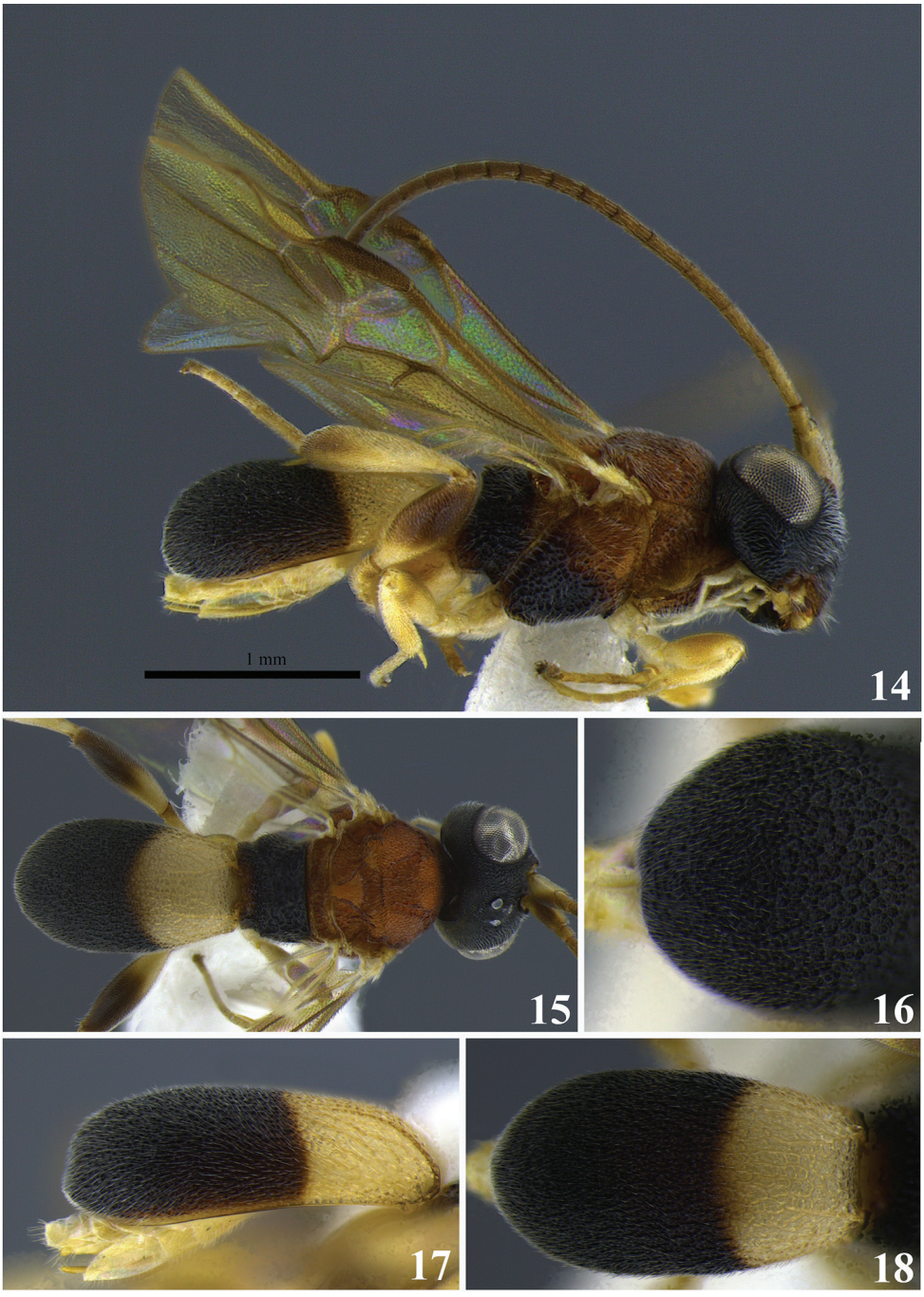
Diagnosis. Rounded carapace apex. Head brownish black; mesosoma mostly orange except posterior half of mesopleuron black and propodeum black; wings suffused with light yellow/brown pigment, darker area below stigma; basal third of carapace yellowish white and apical 2/3 of carapace black/brown. Scrobiculate groove at the precoxal sulcus.

Holotype female. BL 3.13 mm; FWL 2.53 mm; CL 1.44 mm; CW 0.48 mm; CL/CW 3.

Description. *Color*. Head brownish black, mandibles yellow, brownish black apically; apical margin of clypeus yellowish brown; palpi yellowish white; antennae brown with scape and pedicel and flagellomeres 1 and 2 (basal) yellowish white; mesosoma mostly orange except posterior half of mesopleuron black and propodeum black; middle and fore legs yellowish white; hind leg mostly yellowish white except apical portions of coxa, trochantellus, femur, and tibia brown; wings suffused with light yellow/brown pigment, darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell; venation yellowish brown except veins 1M and RS+M yellow; basal third of carapace yellowish white, margin sharply demarcated, and apical 2/3 of carapace black/brown.

Head. HW 1.0 mm; HL 0.725 mm; HW/HL 1.38; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, weakly punctate with fine parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to impunctate at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with irregular parallel pitted grooves between notauli difficult to distinguish and appears areolate-rugose; notauli distinct and visible anteriorly; median and lateral mesonotal lobes rugose-punctate; scutellar sulcus with 5 well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose, medially deeply foveate, scrobiculate groove at precoxal sulcus, foveolate to punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.



Figures 14–18. *Leptodrepana conda*. **14** Female habitus in lateral view **15** female habitus in dorsal view **16** metasoma in dorso-posterior view terminating rounded **17** metasoma in lateral view **18** metasoma in dorsal view.

Metasoma. Carapace completely areolate-rugose; in posterior and dorsal views, apex of carapace rounded.

Variation of paratype females. HW 0.825–1 mm; HL 0.7–0.8 mm; HW/HL 1.18–1.38; BL 2.6–3.2 mm; FWL 2.2–2.53 mm; CL 1.28–1.44 mm; CW 0.4–0.44 mm; CL/CW 2.9–3.0.

Paratype males. No males.

Material examined. Holotype female: GUANACASTE, Cerro el Hacha, NW Volcan Orosi, 300 m, 1988 (no coll. listed) [UWIM]. Paratype data: 1♀, same data as holotype except P. N. Santa Rosa, San Emilio, tropical dry forest, 19.vi–10.vii.1995 (Dadelahi, Price & Zitani); 1♀, same data except site #6, Bosque San Emilio, 50 year old deciduous forest more or less fully shaded as possible, 300 m, 3–24.viii.1985 (I. Gauld & D. Janzen); 1♀, same data except Bosque Humedo mature evergreen dry forest more or less fully shaded as possible, 300 m, 20.xii.1986–10.i.1987.

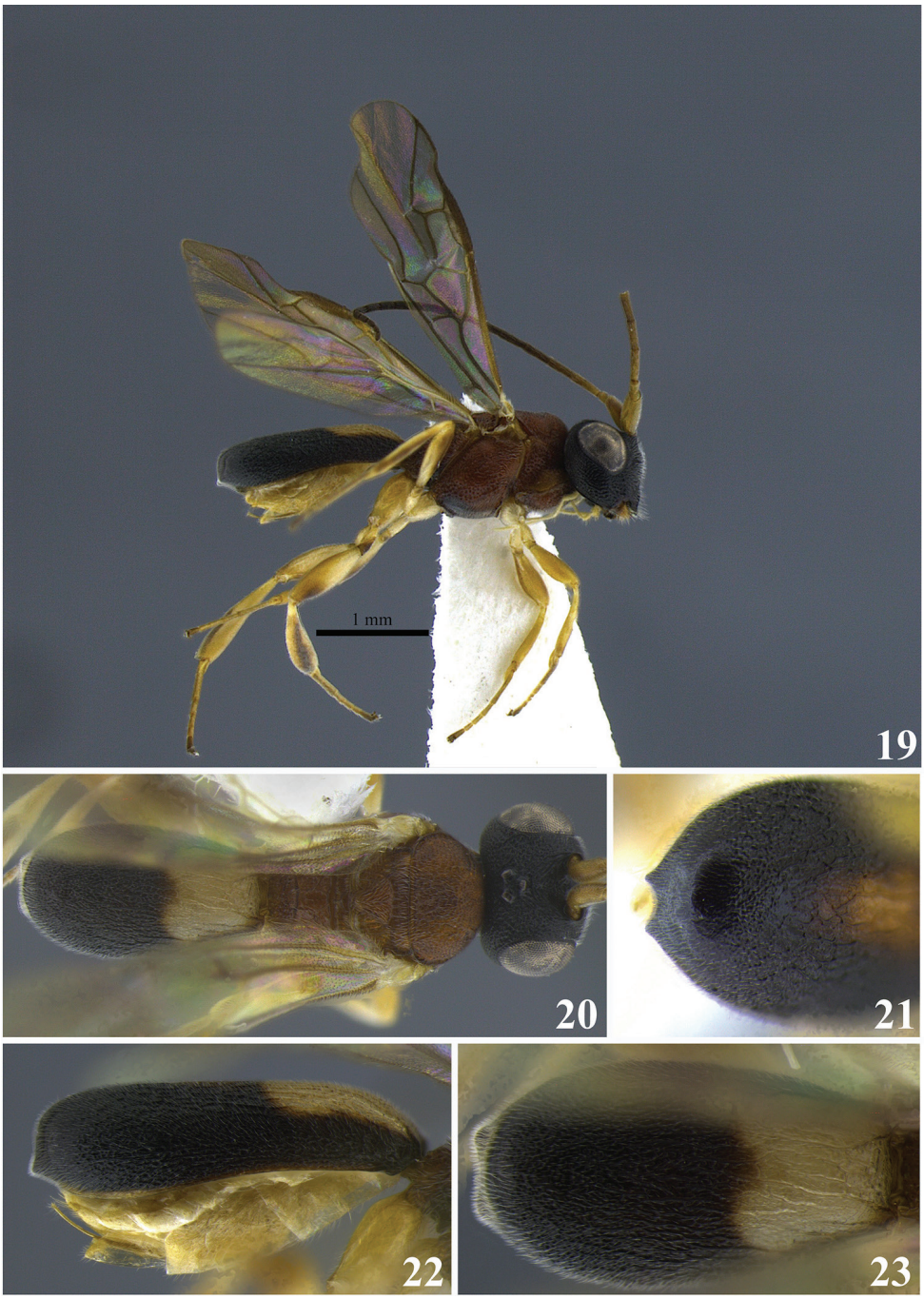
Remarks. *Leptodrepana conda* may be confused with *L. demeter* as both females are similar in color and have a rounded carapace apex. It may be distinguished from *L. demeter* by the presence of a scrobiculate groove as opposed to a wide foveate groove at the precoxal sulcus in *L. conda.* In posterior view, the carapace apex of *L. conda* is weakly areolate-rugose and evenly rounded. Whereas in posterior view, the carapace apex of *L. demeter* is rugulose-lacunose and bears a small transverse carina directly above the posterior margin of the carapace. When viewed laterally, the carapace of *L. conda* is not more than 3× as long as wide (Fig. 17). In lateral view, the carapace of *L. demeter* is more than 4× as long as wide (Fig. 27). Additionally, the propodeum of *L. conda* is blackish brown and the basal third of the carapace is completely yellowish white. The propodeum of *L. demeter* is mostly orange and the baso-median patch of yellowish white, when present, does not extend to the lateral margins of the carapace. Superficially *L. conda* also resembles the *L. atalanta* in color and size. However, the apex of *L. conda* is rounded in dorsal view, while the carapace apex of *L. atalanta* may terminate in a pointed or truncated end (Figs 10, 11).

Etymology. This species name is an arbitrary arrangement of letters to form a euphonious combination.

***Leptodrepana conleyae* Dadelahi & Shaw, sp. n.**
http://zoobank.org/724745CF-549A-4905-9646-37189A1A4CFB
Figs 19–23

Diagnosis. The carapace apex terminates in two small tubercles weakly arched between. Head blackish brown; mesosoma mostly orange, metapleuron with black areas posteriorly; wings suffused with light yellowish brown pigment. The carapace has a baso-medial yellowish white "cape" or patch that extends laterally but not all the way to the lateral margins of the carapace, remainder of carapace blackish brown.

Holotype female. BL 3.7 mm; FWL 3.2 mm; CL 1.68 mm; CW 0.44 mm; CL/CW 3.8.



Figures 19–23. *Leptodrepana conleyae*. **19** Female habitus in lateral view **20** female habitus in dorsal view **21** metasoma in dorso-posterior view terminating in two pointing endings **22** metasoma in lateral view **23** metasoma in dorsal view.

Description. *Color*. Head blackish brown, mandibles yellow, blackish brown apically; palpi yellowish white; antennae with scape, pedicel and basal flagellomere 1 light brown and remainder of flagellum brownish black; mesosoma mostly orange, metapleuron with black areas posteriorly; fore leg yellow; hind and middle legs mostly yellow except trochantellus, apical portion of femur and laterally along length of tibia brown; wings suffused with light yellowish brown pigment; venation yellowish brown; basal third of carapace yellowish white with small median area of yellowish white extending into middle third, remainder of carapace blackish brown.

Head. HW 1.1 mm; HL 0.93 mm; HW/HL 1.19; face and genae, coarsely rugulose-punctate; vertex and ocellar triangle coarsely rugulose-punctate almost weakly areolate-rugose; frons depressed, coarsely rugulose-punctate with fine parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete; antennae with flagellomeres all longer than wide and decreasing in length apically, except penultimate flagellomere almost as long as wide and approximately half the length of ultimate flagellomere.

Mesosoma. Pronotum rugose-foveate antero-laterally to impunctate at propleural margin; propleuron weakly areolate-rugose; mesoscutum areolate-rugose, mesonotal lobes not differentiated from median mesoscutum; notauli indistinct; scutellar sulcus with 7 well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose, medially foveate, foveate groove at precoxal sulcus, foveolate to punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose basally to shiny and punctate at apex; in dorsal view, apex terminates in two small points visible below rounded dorsum carapace; in posterior view, apex terminates in two small points weakly arched between; and in lateral view, carapace apex terminates in narrow point below midline.

Variation of paratype females. HW 0.875–1.025 mm; HL 0.75–0.9 mm; HW/HL 1.12–1.2; BL 2.9–3.6 mm; FWL 2.6–3.2 mm; CL 1.36–1.6 mm; CW 0.4–0.44 mm; CL/CW 3.4–4.0.

Paratype males. No males.

Material examined. Holotype female: PUNTARENAS, San Vito, Est. Las Alturas, 1500 m, i.1992 (P. Hanson) [UWIM]. Paratype data: 1♀, same data as holotype; 1♀, same data except xii.1991; 1♀, same data except xi.1991; 1♀, same province, R. B. Carara, Est. Queb. Bonita, 50 m, L-NL194500-469850, xii.1992 (J. C. Saborio) [INBio, barcode CR1000-900653]; 1♀, same data except i.1994 (R.M. Guzman) [INBio, barcode CR1001-940130]; 1♀, same province, Area de Conservacion Arenal, R. B. Monteverde, Est. La Casona, 1520 m, L-N-253250-449700, xii.1993, (N. G. Obando) [INBio, barcode CR1001-866000]; 1♀, same province, Coto Brus, Est. Las Alturas 1500 m, L-S-322500-591300, xii.1991 (M. A. Zumbado) [INBio, barcode CR1000-487177].

Remarks. *Leptodrepana conleyae* is superficially similar to *L. ninae* but may be distinguished by the following combination of characters. In dorsal and posterior

views the carapace apex of *L. conleyae* terminates in two small tubercles weakly arched between (Figs 21, 23). The propleural margin of the pronotum is shiny and weakly punctate. The mesopleuron is foveate medially and has a foveate groove at the precoxal sulcus. The scutellar sulcus has seven well-defined depressions. The carapace has a baso-medial yellowish white "cape" or patch that extends laterally but not all the way to the lateral margins of the carapace. In *L. ninae*, the carapace apex terminates in two sharp tubercles that are deeply arched between (Fig. 64). The propleural margin of the pronotum is rugose. The mesopleuron is medially shiny and weakly punctate with a shallow foveate band at the precoxal sulcus.

The scutellar sulcus has six well-defined depressions. Dorsally the carapace bears a large oval area of orangish brown.

Etymology. This species is a patronym for Jennifer Katherine Conley, in appreciation for her support, friendship, and ability to argue coherently on any topic for any length of time.

Leptodrepana demeter Dadelahi & Shaw, sp. n.

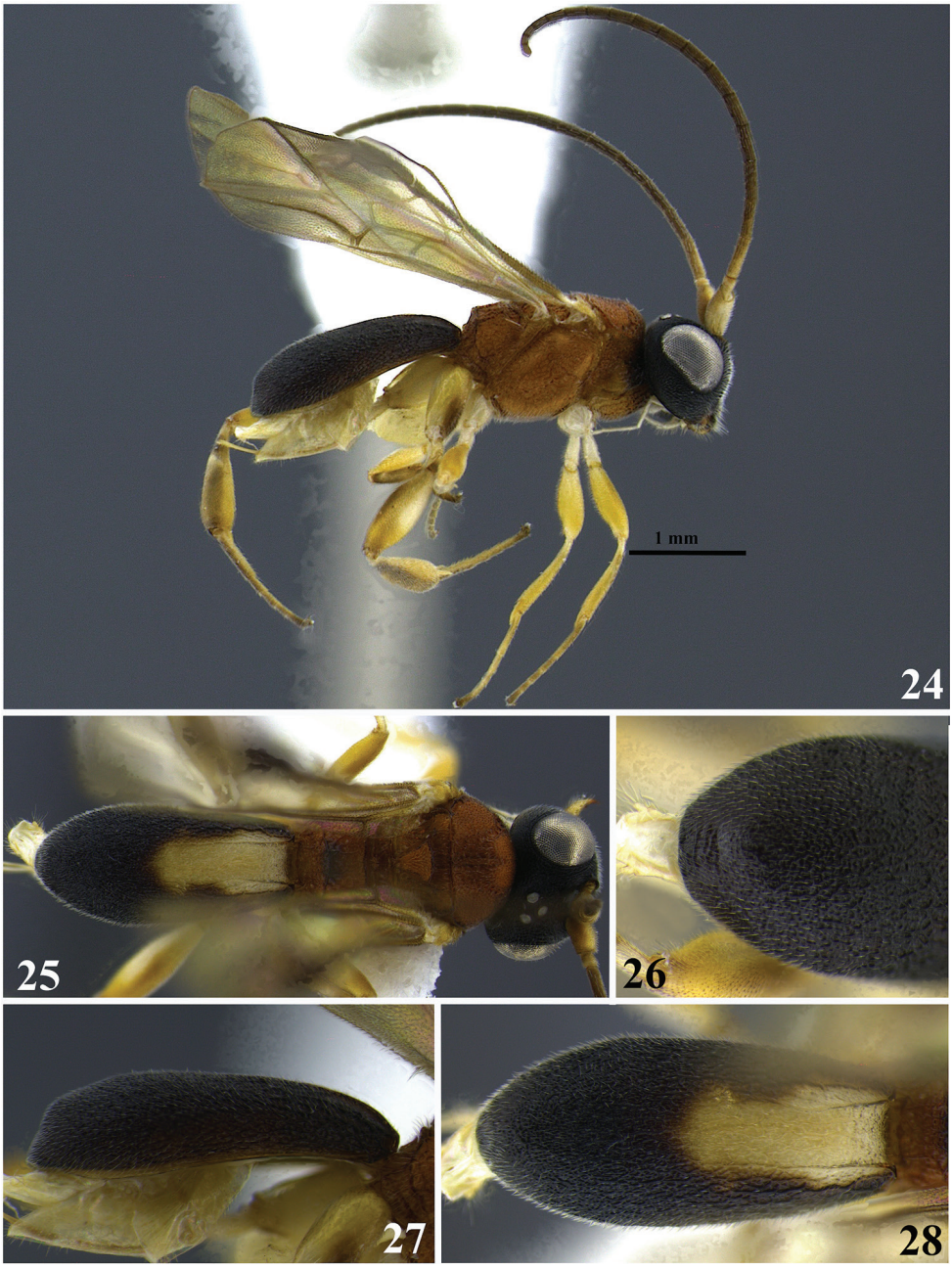
http://zoobank.org/9B11025F-06FB-4E29-9626-90E5E45D537A
Figs 24–28

Diagnosis. Rounded carapace apex. In posterior view, the carapace apex is rugulose-lacunose and bears a small transverse carina directly above the posterior margin of the carapace. In lateral view the carapace is more than 4× as long as wide. Head black-brown; mesosoma mostly orange with some brownish black areas; carapace black with yellowish white elongate oval area baso-medially between dorsal carinae. Presence of the wide foveate groove at the precoxal sulcus.

Holotype female. BL 3.4 mm; FWL 3.06 mm; CL 1.92 mm; CW 0.4 mm; CL/CW 4.8.

Description. *Color*. Head black/brown, mandibles mostly yellowish brown but black/brown basally and apically; palpi yellowish white; antennae brown except scape, pedicel and base of first flagellomere yellowish white; mesosoma mostly orange with some brownish black areas on median pronotum (visible laterally), mesopleuron postero-ventrally and over the median flanges of the propodeal carina; legs mostly yellow, hind leg with brown areas apically on coxa and femur and white patch laterally on femur, tibia with distinct pattern: linear white ellipse ringed in brown visible dorsally running most of tibial length; wings suffused with light yellow/brown pigmentation; venation brown but veins 1M, RS+Ma, 2RS and 2M yellow or light brown; carapace black with yellowish white elongate oval area baso-medially between dorsal carinae.

Head. HW 0.95 mm; HL 0.83 mm; HW/HL 1.15; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, impunctate with fine parallel lineation transverse to median carinae; clypeus rugulose-punctate and apical margin rounded; occipital carina complete.



Figures 24–28. *Leptodrepana demeter*. **24** Female habitus in lateral view **25** female habitus in dorsal view **26** metasoma in dorso-posterior view terminating rounded **27** metasoma in lateral view **28** metasoma in dorsal view.

Mesosoma. Pronotum foveate antero-laterally to weakly areolate-rugose to smooth postero-laterally; propleuron weakly areolate-rugose; mesoscutum medially with 2–3 irregular parallel pitted grooves between notauli; notauli distinct and visible anteriorly; mesonotal lobes granulate-punctate; scutellar sulcus with five well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose and medially foveate; precoxal sulcus with a wide foveate groove; propodeum coarsely areolate-rugose with distinct transverse carina raised into small roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose basally graduating to rugulose-lacunose at apex; in dorsal and lateral views, carapace apex rounded; in posterior view, apex rounded and bearing a small transverse carina directly above the posterior margin of the carapace.

Variation of paratype females. Color: apical margin of clypeus brownish orange; carapace small baso-medial area of brownish orange; HW 0.85–0.88 mm; HL 0.68–0.73 mm; HW/HL 1.2–1.26; BL 2.86 mm; FWL 2.33 mm; CL 1.4 mm; CW 0.32 mm; CL/CW 4.37.

Paratype males. No males.

Material examined. Holotype female: GUANACASTE, Arenales W. side Volcan Cacao, 900 m, 1988–1989 (P. Hanson) [UWIM]. Paratype females: 1♀, same province, Est. Pitilla, 9 km S Santa Cecilia, 700 m, v.1989 (I. Gauld); 1♀, same data except iv.1989.

Remarks. *Leptodrepana demeter* may be confused with *L. conda* as both females are similar in color and have a rounded carapace apex. It may be distinguished from *L. conda* by presence of the wide foveate groove at the precoxal sulcus as opposed to a scrobiculate groove in *L. conda.* In posterior view, the carapace apex of *L. demeter* is rugulose-lacunose and bears a small transverse carina directly above the posterior margin of the carapace. Whereas in posterior view, the carapace apex of *L. conda* is weakly areolate-rugose. When viewed laterally, the carapace of *L. demeter* is more than 4× as long as wide. In *L. conda* the carapace is not more than 3× as long as wide. Additionally the propodeum of *L. demeter* is mostly orange and the baso-median patch of yellowish white, when present, does not extend to the lateral margins of the carapace. The propodeum of *L. conda* is blackish brown and the basal third of the carapace is completely yellowish white.

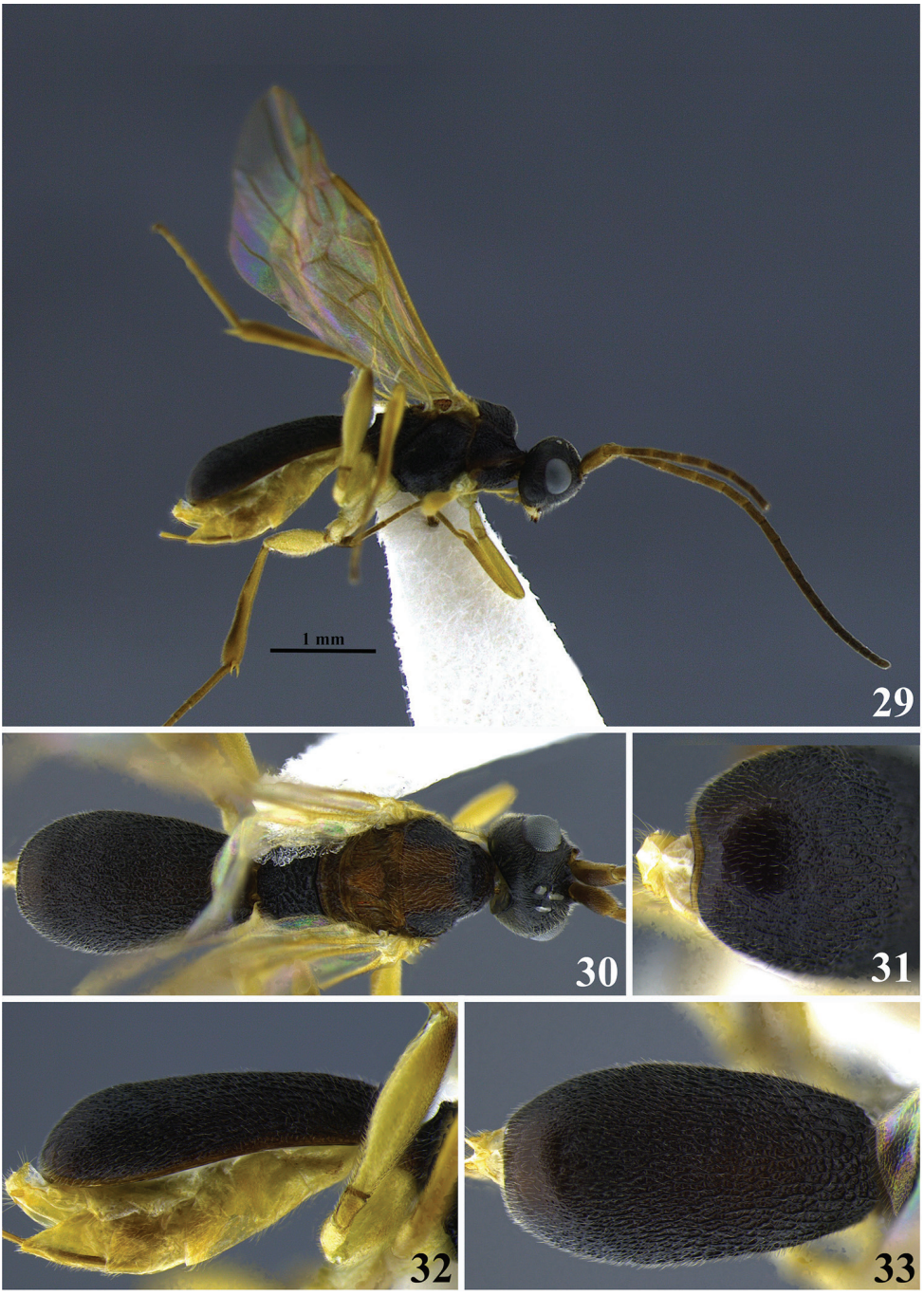
Superficially *L. demeter* also resembles *L. atalanta* in color and size. However, the apex of *L. demeter* is rounded in dorsal view (Figs 26, 28), while the carapace apex of *L. atalanta* may terminate in a single pointed or truncated end (Fig. 10, 11).

Etymology. This species name stems from the Greek *Demeter* representing the goddess of agriculture, sister of Zeus, and mother of Persephone.

Leptodrepana eckerti Dadelahi & Shaw, sp. n.

http://zoobank.org/9EA5B13D-0A23-463F-802F-4CCCF74D4AF4
Figs 29–33

Diagnosis. Robust body, more than 3.0 mm. In dorsal, lateral and posterior views, the carapace apex is rounded; in posterior view, the ventral margin of the carapace is



Figures 29–33. *Leptodrepana eckerti*. **29** Female habitus in lateral view **30** female habitus in dorsal view **31** metasoma in dorso-posterior view displaying a ventral, median depression **32** metasoma in lateral view **33** metasoma in dorsal view.

shallowly arched. The mesopleuron medially is densely foveate and a wide foveate band is present at the precoxal sulcus. The body is mostly blackish brown except for some brownish orange on mesonotum.

Holotype female. BL 3.8 mm; FWL 3.8 mm; CL 1.88 mm; CW 0.52 mm; CL/CW 3.61.

Description. *Color*. Head blackish brown, mandibles yellow, blackish brown apically; palpi yellowish white; antennae brown, distal ends of flagellomeres 1–4 yellowish brown, scape and pedicel yellowish brown; mesosoma mostly brownish black, mesoscutum with medial orangish brown square patch, scutellum and metanotum orange/brown; legs with coxa, trochanter and trochantellus yellowish white, femur and tibia of fore and middle leg yellowish brown, hind leg femur and tibia brown but femur yellowish white ventrally; wings lightly pigmented with yellowish brown venation; carapace blackish brown.

Head. HW 0.95 mm; HL 0.75 mm; HW/HL1.26; face, genae, vertex and ocellar triangle coarsely rugulose-punctate; frons depressed rugulose-punctate with parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to foveolate-rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially areolate-rugose; notauli indistinct; median mesonotal lobe foveolate-granulate and lateral mesonotal lobes foveolate-rugose; scutellar sulcus with five well-defined depressions, all longer than wide; scutellar disc rugose-punctate; mesopleuron anteriorly rugose foveolate, medially densely foveate, wide foveate band at precoxal sulcus, and foveolate-punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into medial and lateral flanges, medial flanges greatly reduced, lateral flanges at least twice the size of median flanges.

Metasoma. Carapace areolate-rugose to punctate at apex; in posterior, lateral and dorsal views, apex rounded.

Variation of paratype females. Mesoscutum medially only orange at transcutal articulation, and scutellar sulcus; metanotum black; scutellar sulcus with 5–6 well-defined depressions; HW 0.88–0.95 mm; HL 0.75 mm; HW/HL 1.17–1.27; BL 3.5–3.8 mm; FWL 3.3–3.8 mm; CL 1.68–1.88 mm; CW 0.48–0.52 mm; CL/CW 3.3–3.61.

Paratype males. No males.

Material examined. Holotype female: SAN JOSE, Cerro de la Muerte, 19 km S 3W Empalme, 2600 m, vi–viii.1993 (P. Hanson) [UWIM]. Paratype data: 3♀, same data except 26 km N San Isidro, 2100 m, ii–v.1991.

Remarks. *Leptodrepana eckerti* may be easily distinguished from other Costa Rican species. The body is robust, more than 3.0 mm. In dorsal, lateral, and posterior views, the carapace apex is rounded (Figs 32, 33). In posterior view, the ventral margin of the carapace is shallowly arched (Fig. 31). The carapace is punctate at the apex. The mesopleuron medially is densely foveate and a wide foveate band is present at the precoxal sulcus. The scutellar sulcus has 6 well-defined depressions. The medial flanges of the

propodeal carina are greatly reduced so that the lateral flanges appear at least twice as large as the medial flanges. In color, the body is mostly blackish brown except for some brownish orange on mesonotum.

Etymology. This species name is a patronym in honor of Jeffery Alan Eckert in thanks for all his mental and financial support.

***Leptodrepana gauldilox* Dadelahi & Shaw, sp. n.**
http://zoobank.org/C3BE4A50-9478-49BF-8C0E-6FD70669B3E2
Figs 34–39

Diagnosis. Body large, more than3.0 mm, and in lateral view the carapace is more than 3.5 times as long as wide. Body mostly brownish black except yellowish white patches baso-laterally below dorsal carinae.

Holotype female. BL 3.47 mm; FWL 3.0 mm; CL 1.6 mm; CW 0.44 mm; CL/CW 3.63.

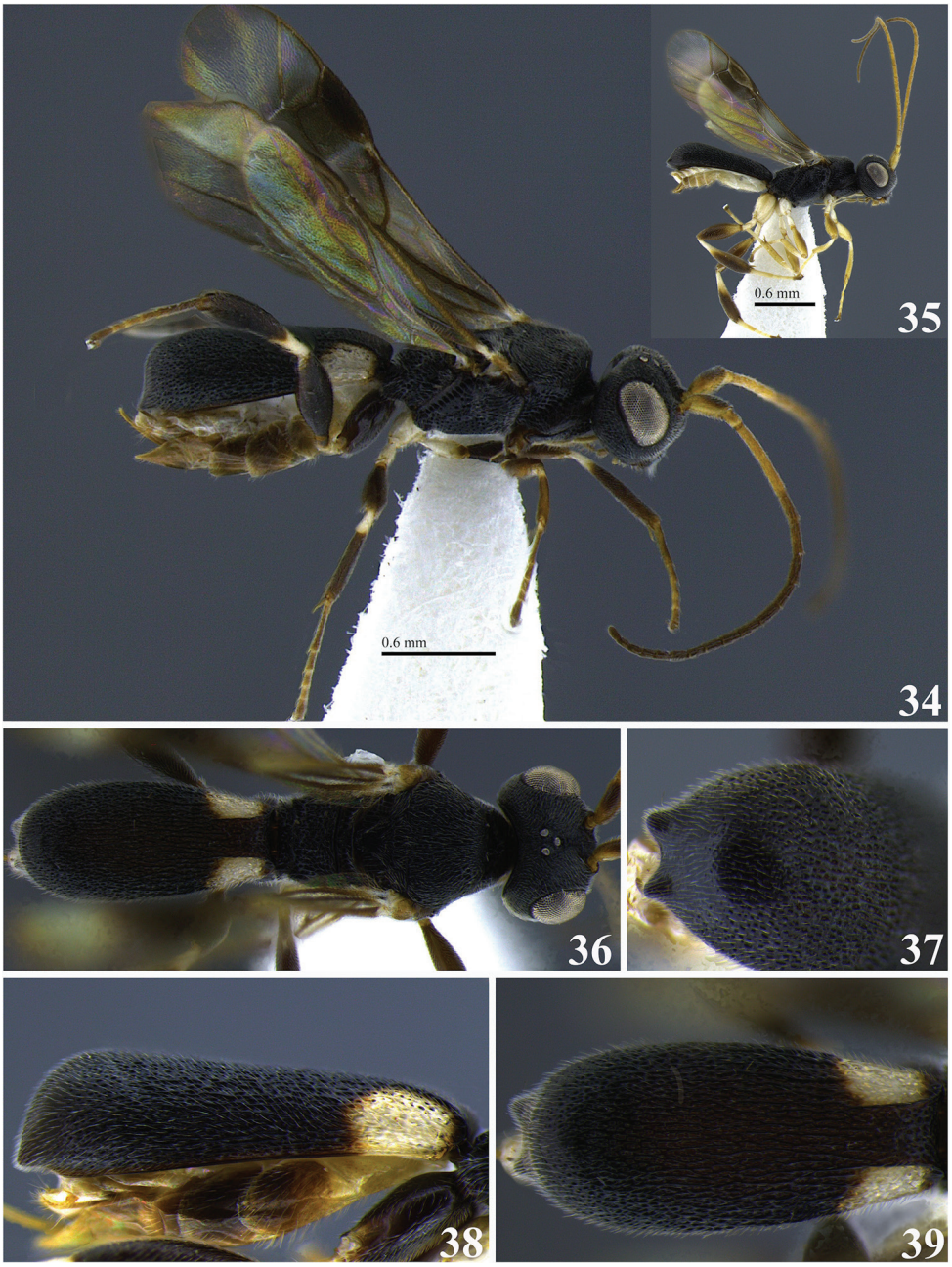
Description. *Color*. Head brownish black, mandibles yellow, blackish brown apically and basally; palpi yellowish white; antennae darkest apically (black) with scape, pedicel, and flagellomeres 1–5 (basal) yellow; mesosoma brownish black; hind leg: coxa dark brown, trochanter and trochantellus yellowish white, femur and tibia dark brown, tibia with narrow yellowish white basal band; fore and middle legs same as hind leg except middle coxa yellowish white; wings mostly suffused with brown pigment especially apical half of 1st Submarginal, 2nd Submarginal, and basal most portion of marginal cell, obfuscate linear area running from base of stigma to slightly beyond vein RS+Mb; brown venation; carapace blackish brown with yellowish white patches baso-laterally below dorsal carinae.

Head. HW 0.95 mm; HL 0.7 mm; HW/HL 1.36; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed rugulose-punctate, median carina present; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveolate antero-laterally to rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with distinct regular parallel pitted grooves between notauli; notauli narrow and visible anteriorly; median mesonotal lobe coarsely punctate and lateral mesonotal lobes rugulose-punctate; scutellar sulcus with 7 well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose, medially and at precoxal sulcus evenly foveate, foveate to weakly punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to shiny punctate at apex; in dorsal and posterior views, apex terminating in two points widely separated; in lateral view, carapace terminates in narrow point below midline.

Variation of paratype females. Antennae with scape partly brown and only flagellomeres 1 and 2 yellow remainder of flagellum brown; HW 0.8–0.95 mm; HL 0.55–



Figures 34–39. *Leptodrepana gauldilox*. **34** Female habitus in lateral view **35** male habitus in lateral view **36** female habitus in dorsal view **37** metasoma in dorso-posterior view with a couple of pointing projections **38** metasoma in lateral view **39** metasoma in dorsal view.

0.68 mm; HW/HL 1.29–1.32; BL 3.4–3.47 mm; FWL 2.6–3.0 mm; CL 1.4-1.6 mm; CW 0.32–0.44 mm; CL/CW 3.63–4.38.

Variation of paratype males. Similar to females except antennae with 25 flagellomeres, all longer than wide and tapering apically; scape, pedicel and flagellum yellowish white; mesopleuron sometimes medially shiny and impunctate, carapace sometimes completely black; all legs with coxa, trochanter, and trochantellus yellowish white; HW 0.73–0.8 mm; HL 0.5–0.65 mm; HW/HL 1.23–1.45; BL 2.33 mm; FWL 2.2–2.53 mm; CL 1.32–1.4 mm; CW 0.32 mm; CL/CW 4.13–4.75.

Material examined. Holotype female: SAN JOSE, Zurqui de Moravia, 1600 m, ix–x.1990 (P. Hanson) [UWIM]. Paratype data: 1♀, 1♂, ALAJUELA, Area Conservation de Arenal, Est. San Ramon, in vegetation on sendero W. F. 5.vi–15.vii.1998 (Zitani, Dadelahi, Krenzelok & Fenoff); 1♀, GUANACASTE, Est. Pitilla, 9 km S. Santa Cecilia, 700 m, iv.1989 (I. Gauld); 1♂, HEREDIA, 3 km S. Puerto Viejo OTS La Selva, 100 m, xii.1992; 1♀, same as holotype except vi.1990; 1♀, same as holotype except vi.1992.

Remarks. Superficially *L. gauldilox* is most similar to *L. kimbrellae* but upon closer examination they are easily distinguished from one another. *Leptodrepana gauldilox* is large, more than 3.0 mm, and in lateral view the carapace is more than 3.5 times as long as wide. Conversely, *L. kimbrellae* is small, less than 2.5 mm, and in lateral view the carapace is no more than 3 times as long as wide.

Etymology. This species name is an arbitrary arrangement of letters to form a euphonious combination.

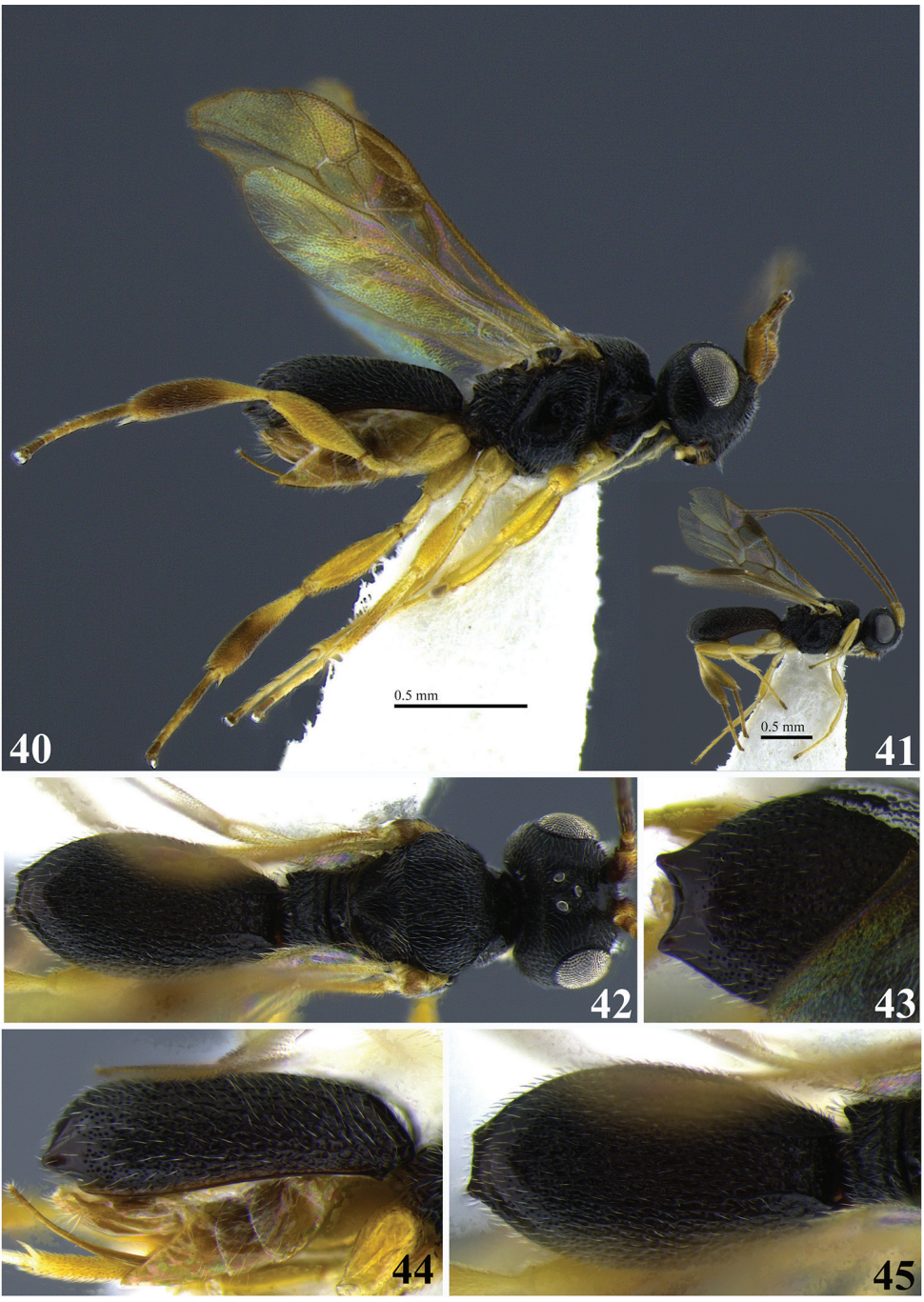
***Leptodrepana hansoni* Dadelahi & Shaw, sp. n.**
http://zoobank.org/CABF0128-B4B0-4FF9-9644-A20C4157B4BC
Figs 40–45

Diagnosis. The carapace apex terminates in 2 points. Body brownish black and wings lightly pigmented. Shiny impunctate area medially on the mesopleuron, and presence of four well-defined depressions in the scutellar sulcus.

Holotype female. BL 1.87 mm; FWL 1.47 mm; CL 0.84 mm; CW 0.32 mm; CL/CW 2.63.

Description. *Color*. Head brownish black, mandibles yellow, brownish black apically and basally; palpi yellowish white; antennae brown scape, pedicel, and first flagellomere (basal) yellowish brown; mesosoma brownish black; legs yellowish brown except tibia of hind leg brown; wings lightly pigmented with yellowish brown venation; carapace brownish black.

Head. HW 0.575 mm; HL 0.375 mm; HW/HL1.53; face finely punctuate; genae, vertex and ocellar triangle rugulose-punctate; frons depressed, weakly punctate and median carina present; clypeus punctate and apical margin rounded; occipital carina complete; antennae with flagellum dilated medially so that flagellomeres 8–14 (basal) appear almost as long as wide, remaining flagellomeres decreasing in length apically.



Figures 40–45. *Leptodrepana hansoni*. **40** Female habitus in lateral view **41** male habitus in lateral view **42** female habitus in dorsal view **43** metasoma in dorso-posterior view with a couple of pointing projections **44** metasoma in lateral view **45** metasoma in dorsal view.

Mesosoma. Pronotum foveolate antero-laterally to shiny and impunctate at propleural margin; propleuron areolate-rugose; mesoscutum medially with irregular pitted grooves between notauli so that area appears areolate-rugose; notauli narrow and visible anteriorly; median and lateral mesonotal lobes rugose-coarsely punctate; scutellar sulcus with four well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose foveolate, medially shiny and impunctate, narrow scrobiculate groove at precoxal sulcus, weakly punctate to impunctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to shiny punctate at apex; in posterior and dorsal views, apex with 2 tubercles; in lateral view, apex terminating in narrow point below midline.

Paratype females. No paratype females.

Variation of paratype males. Similar to female except antennae with 22 flagellomeres all longer than wide and tapering apically; propleural margin of pronotum rugose; mesoscutum coarsely punctate with medial area not sculpturally differentiated from mesonotal lobes; notauli indistinct; carapace apex rounded; HW 0.63 mm; HL 0.46 mm; HW/HL 1.36; BL 2.13 mm; FWL 1.87 mm; CL 0.96 mm; CW 0.32 mm; CL/CW 3.

Material examined. Holotype female: PUNTARENAS, R. F. Golfo Dulce, 3 km SW Rincon, 10 m, ii.1993 (P. Hanson) [UWIM]. Paratype data: 1♂, SAN JOSE, Ciudad Colon 800 m, iv-v.1990 (L. Fournier).

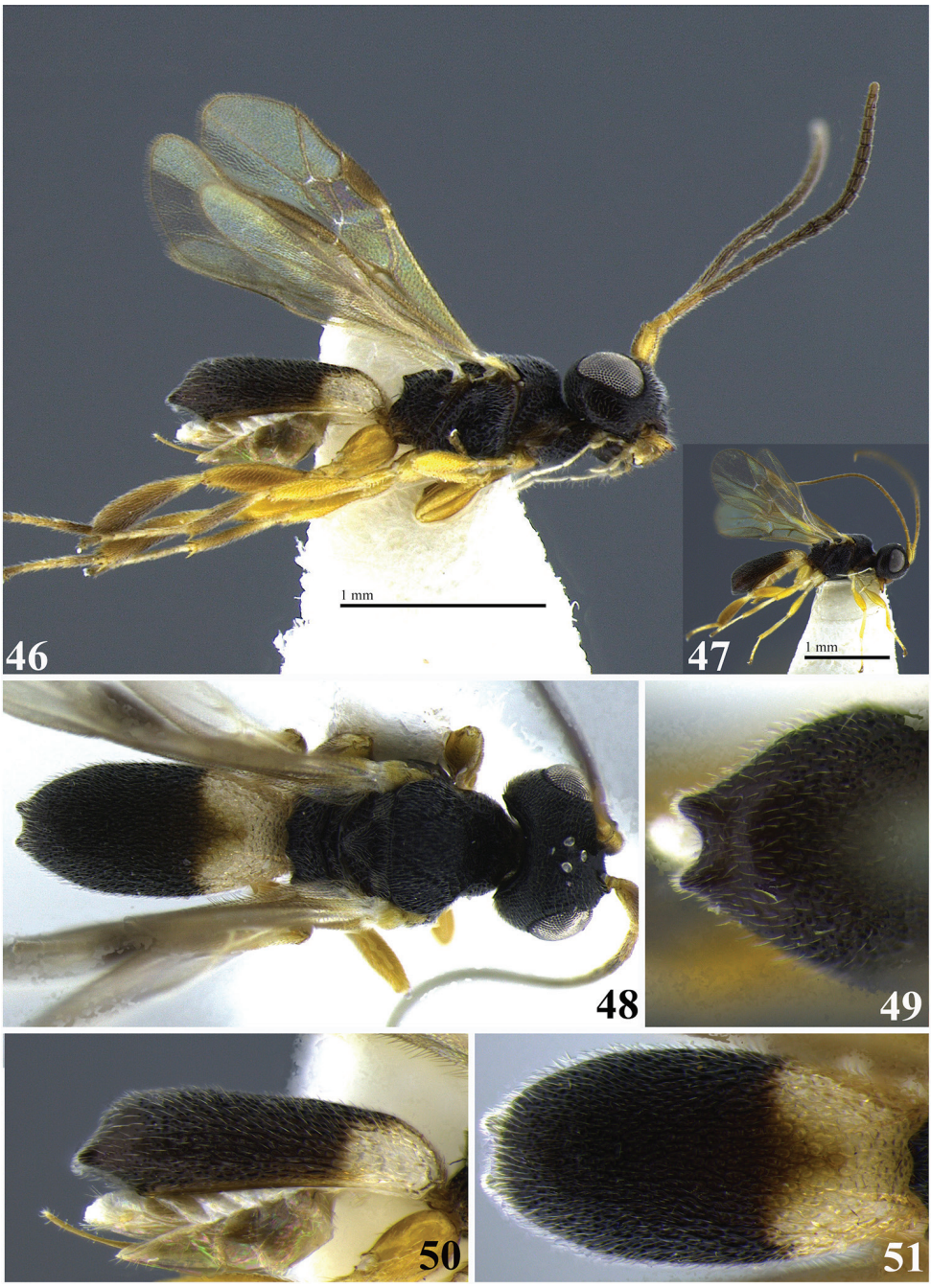
Remarks. *Leptodrepana hansoni* is superficially similar to *L. kimbrellae*. They are both similar in size, color, and the carapace apex terminates in two points. It may be distinguished from *L. kimbrellae* by the shiny impunctate area medially on the mesopleuron and the presence of four well-defined depressions in the scutellar sulcus. Additionally, the carapace of *L. hansoni* is entirely brownish black. The mesopleuron of *L. kimbrellae* is deeply foveate medially. The scutellar sulcus has six well-defined depressions. The posterior margin of the basal yellowish white patch is usually deeply notched.

Etymology. This species name is a patronym for Professor Paul Hanson in appreciation for his extensive efforts in collecting braconids of all shapes and sizes.

Leptodrepana kimbrellae Dadelahi, sp. n.

http://zoobank.org/A98E7A29-CAFA-45F2-A26B-89EAF02ACD9D
Figs 46–51

Diagnosis. In posterior view apex terminating in two points deeply arched between; in dorsal view, apex terminates in two points visible below rounded carapace dorsum. The mesopleuron is deeply foveate medially. The scutellar sulcus has 6 well-defined depressions. The posterior margin of the basal yellowish white patch on the carapace is



Figures 46–51. *Leptodrepana kimbrellae*. **46** Female habitus in lateral view **47** male habitus in lateral view **48** female habitus in dorsal view **49** metasoma in dorso-posterior view with a couple of pointing projections **50** metasoma in lateral view **51** metasoma in dorsal view.

usually deeply notched. Body mostly blackish brown but carapace with basal third yellowish white, posterior margin of this area is medially deeply notched giving the basal area a bi-lobed appearance.

Holotype female. BL 2.46 mm; FWL 2.06 mm; CL 1.16 mm; CW 0.4 mm; CL/CW 2.9.

Description. *Color*. Head blackish brown, mandibles mostly yellowish brown but blackish brown basally and apically; palpi yellowish white; antennae brown darkest apically with scape, pedicel and first flagellomere (basal) yellow; mesosoma black; legs yellowish orange with a narrow basal band of white on tibiae of hind and middle legs; wings suffused with light brown pigmentation and appear slightly dusky with brown venation, parastigma and vein 1M lighter in color; carapace blackish brown with basal third yellowish white, posterior margin of this area is medially deeply notched giving the basal area a bi-lobed appearance.

Head. HW 0.75 mm; HL 0.63 mm; HW/HL 1.2; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, coarsely punctate with fine parallel lineation to median carinae; clypeus punctate and apical margin rounded; occipital carina complete; antennae with a slightly swollen appearance medially.

Mesosoma. Pronotum foveate antero-laterally to weakly areolate-rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with irregular parallel pitted grooves between notauli difficult to distinguish and appears areolate-rugose; notauli narrow and visible anteriorly; medial mesonotal lobe granulate-punctate, lateral mesonotal lobes rugose-coarsely punctate; scutellar sulcus with 6 well-defined depressions, all longer than wide; scutellar disc coarsely punctate; mesopleuron anteriorly rugose, medially deeply foveate especially at and posterior to precoxal sulcus; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose basally, graduating to shiny and weakly punctate at apex; in posterior view apex terminating in two points deeply arched between; in dorsal view, apex terminates in two points visible below rounded carapace dorsum; in lateral view, apex terminates in sloping point below midline; ventral cavity almost reaching apex.

Variation of paratype females. Color: clypeus orange; scape pedicel flagellum uniformly brown; legs yellowish white to orange/brown and basal tibial bands appear faint on lighter colored legs; carapace with basal yellowish white area weakly to deeply bi-lobed; parastigma and vein 1M same color as remaining venation; HW 0.63–0.78 mm; HL 0.53–0.63 mm; HW/HL 1.2–1.25; BL 1.7–2.4 mm; FWL 2.1–2.9 mm; CL 0.9–1.2 mm; CW 0.32–0.44 mm; CL/CW 2.4–2.8.

Variation of paratype males. Similar to females except clypeus yellow/orange; antennae with 24 flagellomeres, tapering apically; flagellum yellowish white; mesopleuron coarsely punctate medially; in posterior view, carapace apex terminating in two points shallowly arched between; ventral cavity distal carapace apex. HW 0.58–0.63

mm; HL 0.48–0.5 mm; HW/HL 1.2–1.3; BL 1.9–2.1 mm; FWL 1.7–1.9 mm; CL 1.0 mm; CW 0.32 mm; CL/CW 3.13.

Material examined. Holotype female: PUNTARENAS, R. F. Golfo Dulce, 3 km SW Rincon, 10 m, vi–viii.1989 (P. Hanson) [UWIM]. Paratype females: 3♀, 1♂, same data as holotype; 1♀, GUANACASTE, P. N. Guanacaste Arenales, SW side Volcan Cacao, 900 m, ii–v.1989 (I. Gauld); 1♀, same data as holotype except ii–iii.1989 (P. Hanson & I. Gauld); 6♀, 1♂, same data as holotype except iii–v.1989; 1♀, same data as holotype except xii.1989–iii.1990; 1♀, same data as holotype except vi.1991; 1♀, same data as holotype except x.1991; 5♀, same data as holotype except ii.1993; 1♀, 1♂, same data as holotype except iii.1993; 3♀,1♂, same data as holotype except in primary forest, iv.1993; 1♂, PUNTARENAS, P. N. Corcovado, Est. Sirena, 0–100 m, i.1992 (G. Fonseca) L-S-270500,508300 [INBio]; 1♀, PUNTARENAS, San Vito Est Biol. Las Alturas, 1700 m, ii–iv.1993; 2♀, SAN JOSE, 26 km N San Isidro 2100 m, malaise in secondary growth, ii–iv.1993; 3♀, SAN JOSE, Cerro de la Muerte, 2 km W. Empalme 2300 m, vi.1995.

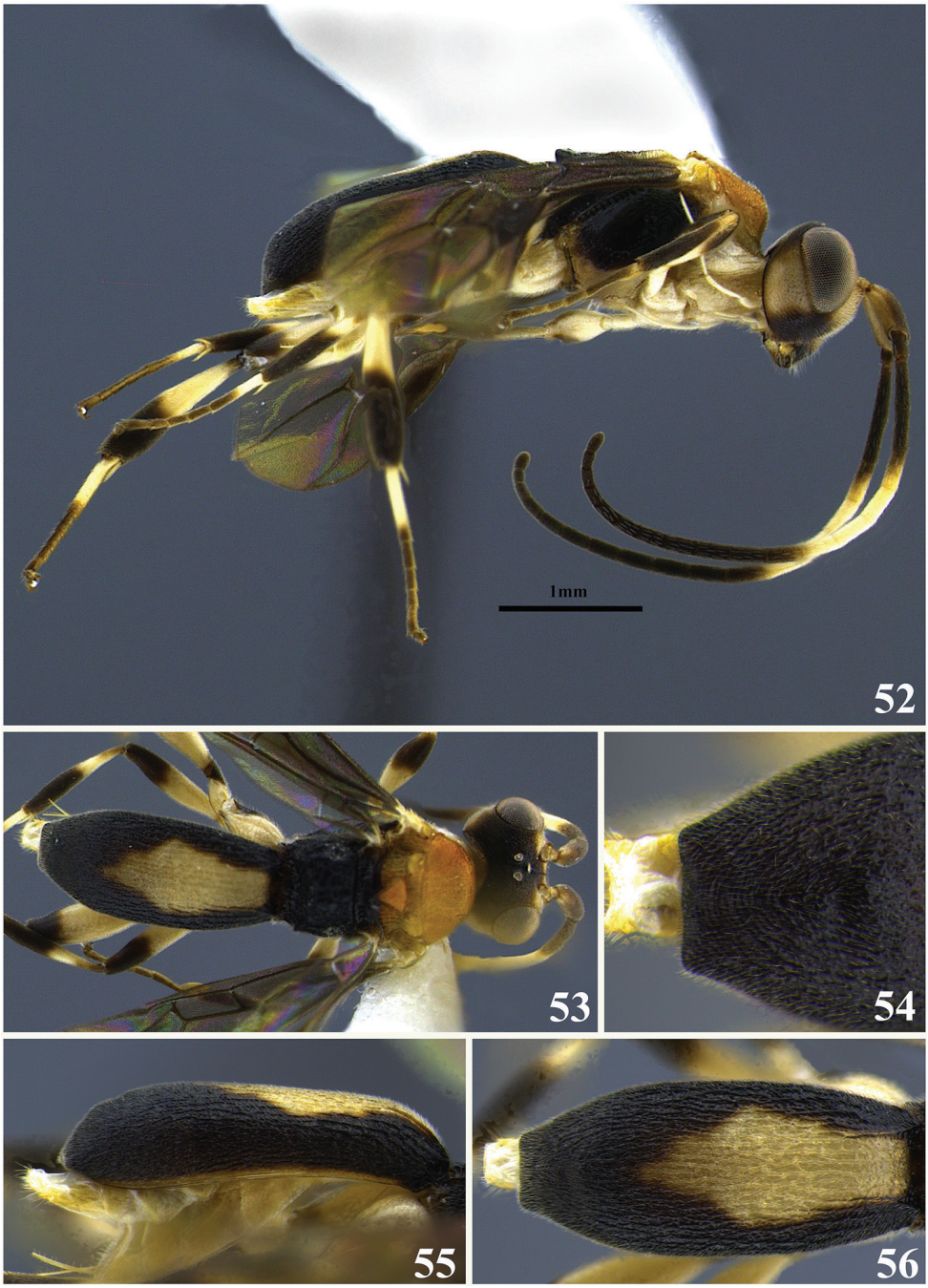
Remarks. Superficially *Leptodrepana kimbrellae* is most similar to *L. gauldilox.* Both species are similar in color and in posterior and lateral views, have two tubercles on the carapace apex. However, upon examination they are easily distinguished from one another. *Leptodrepana kimbrellae* is small, less than 2.5 mm and in lateral view, the carapace is at the most 3 times as long as wide. *Leptodrepana gauldilox* is large, more than 3.0 mm and in lateral view, the carapace is more than 3.5 times as long as wide. *Leptodrepana kimbrellae* is also similar to *L. hansoni* in size, color, and presence of two tubercles on the carapace apex, visible in posterior and dorsal views. *Leptodrepana kimbrellae* may be easily distinguished from this species. The mesopleuron is deeply foveate medially. The scutellar sulcus has six well-defined depressions. The posterior margin of the basal yellowish white patch on the carapace is usually deeply notched. *Leptodrepana hansoni* has a shiny impunctate area medially on the mesopleuron and the scutellar sulcus has four well-defined depressions. Additionally, the carapace of *L. hansoni* is entirely brownish black.

Etymology. This species name is a patronym named in honor of a sister of SDD, Sarah Kimbrell Migrants.

Leptodrepana lorenae Dadelahi & Shaw, sp. n.

http://zoobank.org/9BD8D7BF-964B-474E-8175-1DA02142E947
Figs 52–56

Diagnosis. Large body size, more than 3.0 mm. In dorsal view, the carapace apex in females appears distinctly truncated; in posterior view, the points are visible; in lateral view the carapace is approximately 4.5× as long as wide. Head yellowish white except vertex, temple, medial area of frons and apical margin of clypeus blackish brown; lateral pronotum and propleuron yellowish white; mesonotum orange;



Figures 52–56. *Leptodrepana lorenae*. **52** Female habitus in lateral view **53** female habitus in dorsal view **54** metasoma in dorso-posterior view terminating truncated **55** metasoma in lateral view **56** metasoma in dorsal view.

mesopleuron blackish brown except postero-ventrally yellowish white; metanotum, metapleuron and propodeum blackish brown; wings suffused with dark brown pigment; carapace mostly black with large yellowish white diamond shaped patch covering most of dorsal surface.

Holotype female. BL 3.6 mm; FWL 3.0 mm; CL 1.84 mm; CW 0.4 mm; CL/CW 4.6.

Description. *Color*. Head yellowish white except vertex, temple, medial area of frons and apical margin of clypeus blackish brown; clypeus orange medially; mandibles yellow, blackish brown apically; palpi yellowish white; antennae with scape, pedicel and flagellomeres 1–3 brownish black, flagellomeres 3–6 yellowish white and flagellomeres 7–17 brownish black; lateral pronotum and propleuron yellowish white; mesonotum orange; mesopleuron blackish brown except postero-ventrally yellowish white; metanotum, metapleuron and propodeum blackish brown; legs appear distinctly banded in yellowish white and brownish black: fore leg yellowish white with femur basally brownish black and tibia mostly brownish black except for narrow basal band of yellowish white; middle leg similar to fore leg except tibial band bordered by brownish black basally; hind leg similar to fore and middle legs except coxa brownish black dorso-laterally, femur with wide medial band of yellowish white otherwise brownish black and tibia same pattern as femur; wings suffused with dark brown pigment; venation dark brown; carapace mostly black with large yellowish white diamond shaped patch covering most of dorsal surface.

Head. HW 1.05 mm; HL 0.9 mm; HW/HL 1.16; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed with fine parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum mostly impunctate except foveolate at mesoscutal and mesopleural margins; propleuron foveate; mesoscutum medially with numerous pitted parallel grooves; median and lateral rugose-punctate; notauli shallow and visible anteriorly; scutellar sulcus with four well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose, medially shiny and impunctate, foveate at precoxal sulcus, weakly punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into medial and lateral flanges, lateral flanges at least twice the size of median flanges.

Metasoma. Carapace areolate-rugose basally to rugulose-punctate at apex; in dorsal view, carapace apex appears distinctly squared or truncated; in posterior view, apex terminates in two blunt points widely separated and weakly arched between, in lateral view, carapace apex terminates in blunt point below midline.

Paratype males. No males.

Material examined. Holotype female: ALAJUELA, Est. San Ramon, 900 m, vii-xi.1995 (P. Hanson) [UWIM].

Remarks. *Leptodrepana lorenae* may be easily distinguished from other Costa Rican species because of its many unique characters. The species is large, more than 3.0 mm. In dorsal view, the carapace apex in females appears distinctly truncated (Fig. 56). The square shape is due to the presence of two blunt points widely sepa-

rated from one another. In posterior view, the points are visible. Additionally, in lateral view the carapace is approximately 4.5 times as long as wide (Fig. 55). On the mesosoma, the scutellar sulcus bears three well-defined depressions and the mesopleuron is medially shiny and impunctate. Coloration of the species is also quite distinct. The head yellowish white except at the vertex, temple, medial area of frons and apical margin of clypeus which are blackish brown. The antennae are brownish black but bear a yellowish white annulus at basal flagellomeres 3–6. The mesosoma is multicolored with the lateral pronotum and propleuron yellowish white. The mesonotum is orange and the remaining portions of the mesosoma are brownish black except for postero-ventrally on the mesopleuron that is yellowish white. The legs have a distinctly banded appearance, alternating sections appearing yellowish white and brownish black. The carapace mostly black with large yellowish white diamond-shaped patch.

Etymology. This species name is a patronym in honor of the niece of SDD, Loren Paige Migrants, an incredible animated force of nature.

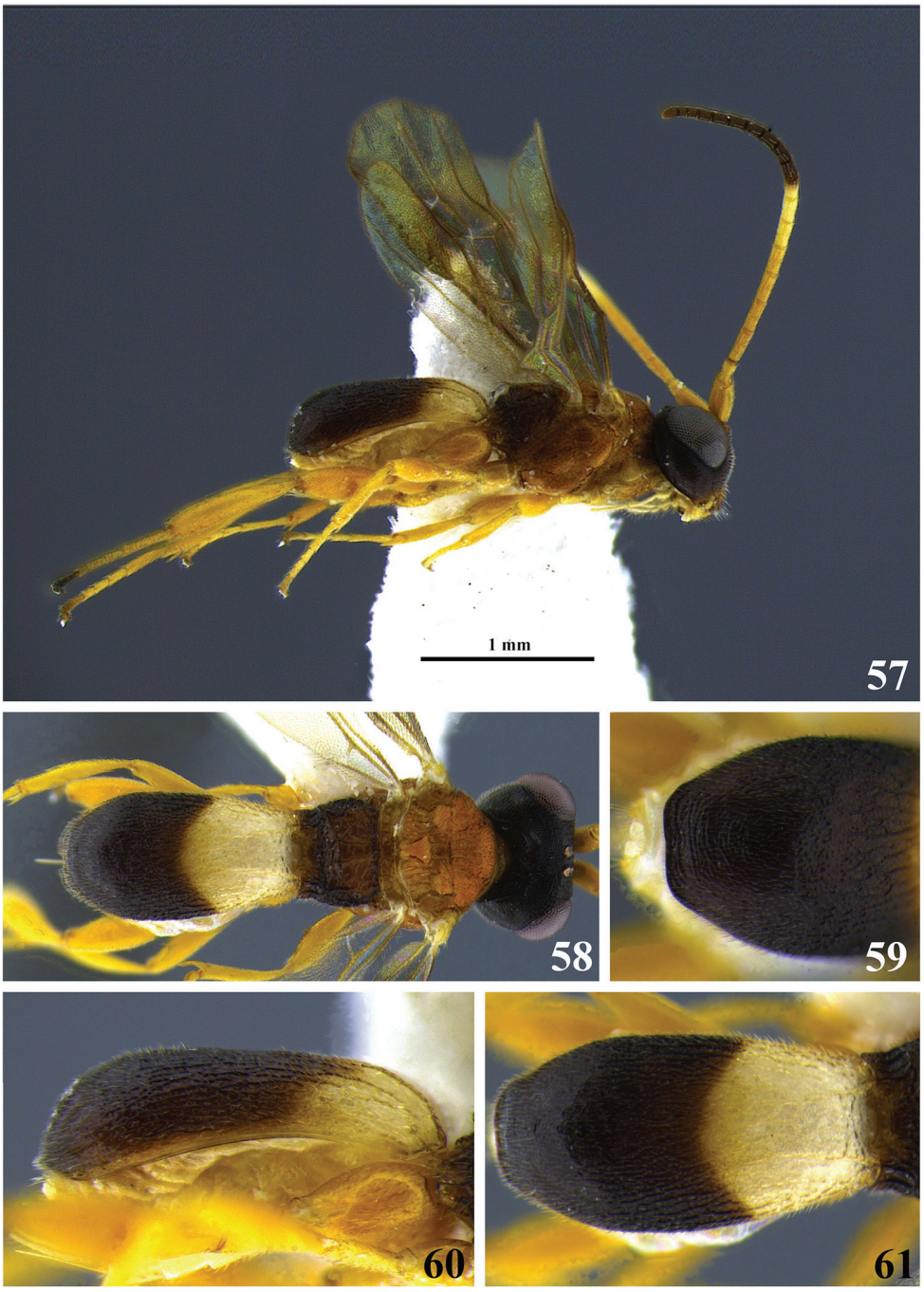
***Leptodrepana munjuanae* Dadelahi & Shaw, sp. n.**
http://zoobank.org/C3645F8E-91B8-45A4-8B8C-A22F6BC10E3B
Figs 57–61

Diagnosis. In dorsal view, the carapace apex is square-rounded; in posterior view, the carapace apex is rounded with a weakly arched transverse ridge or carina; in lateral view, the apex is mostly rounded but the carina is visible. Tri-colored antennae: the scape, pedicel, and flagellomeres 1–4 are yellow; the flagellomeres 4–6 are yellowish white; flagellomeres 6–17 are black. The mesoscutum medially has two wide irregular parallel-pitted grooves between the notauli. The mesopleuron is medially foveate with a wide scrobiculate groove at the precoxal sulcus. The scutellar sulcus has 3 well-defined depressions.

Holotype female. BL 2.6 mm; FWL 2.13 mm; CL 1.16 mm; CW 0.44 mm; CL/CW 2.64.

Description. *Color*. Head mostly brownish black, face medially yellow; clypeus yellow; mandibles yellow, blackish brown apically; apical margin of clypeus yellowish brown; palpi yellowish white; tri-colored antennae: scape, pedicel, and flagellomeres 1–4 yellow; flagellomeres 4–6 yellowish white; flagellomeres 6–17 black; mesosoma mostly yellowish orange except metapleuron and propodeum black; middle and fore leg coxae yellowish white and remainder yellow; hind leg mostly yellow except apical portions of femur, and tibia yellowish brown; wings suffused with brown pigment; basal half of carapace yellowish white, apical half of carapace blackish brown.

Head. HW 0.83 mm; HL 0.6 mm; HW/HL 1.38; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, weakly punctate with fine parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete.



Figures 57–61. *Leptodrepana munjuanae*. **57** Female habitus in lateral view **58** female habitus in dorsal view **59** metasoma in dorso-posterior view terminating truncated **60** metasoma in lateral view **61** metasoma in dorsal view.

Mesosoma. Pronotum rugose antero-laterally to impunctate at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with two wide irregular parallel pitted grooves between notauli; notauli visible anteriorly; median and lateral mesonotal lobes rugulose-punctate; scutellar sulcus with three well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose, medially foveate, wide scrobiculate groove at precoxal sulcus, foveolate to punctate posteroventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace completely areolate-rugose to rugulose-punctate at apex; in dorsal view, carapace apex square-rounded; in posterior view, apex of carapace rounded with weakly arched transverse ridge or carina; in lateral view, apex mostly rounded but carina visible.

Variation of paratype females. Face mostly blackish brown with yellow area reduced to clypeus and directly above fronto-clypeal suture; mesosoma mostly orangish brown; femur and tibia of hind leg not darker apically; HW 0.68–0.8 mm; HL 0.575–0.6 mm; HW/HL 1.17-1.3; BL 2.2–3.06 mm; FWL 1.8–2.53 mm; CL 1.08–1.4 mm; CW 0.28–0.4 mm; CL/CW 3.37–3.85.

Paratype males. No males.

Material examined. Holotype female: LIMON, P. N. Tortuguera, Est. 4-esquinas, 0 m, vi–viii.1989 (Solano) [UWIM]. Paratype data: 1♀, CARTAGO, Ref. Nac. Fauna Silv., Tapanti, 1150, L-N-194000-559800, i.1992 (G. Mora & F. Quesada) [INBio, barcode CR1000-553528]; 1♀, same data except 1250 m, iii.1992, L-N-194000-560000, (G. Mora) [INBio, barcode CR1000-612020]; 1♀, PUNTARENAS, P. N. Corcovado, Est. Sirena, 50 m, iv–viii.1989 (no coll. listed); 2♀, same province R. F. Golfo Dulce, 3 km SW Rincon, primary forest, 10 m, ii.1993; 1♀, same province, Peninsula de Osa, Rancho Quemado, 200 m, L-S-292500-511000, v.1991 (F. Quesada) [INBio, barcode CR1001-294765]; 1♀, same data except v.1991, (J.C. Saborio) [INBio, barcode CR1000-594547]; 1♀, same province, Coto Brus, Est. Las Alturas, 1500 m, L-S-322500-591300, 23.iii–2.v.1992, (F. Araya) [INBio, barcode CR1000-790814].

Remarks. *Leptodrepana munjuanae* has unique characters that make it easy to distinguish it from other Costa Rican species. In dorsal view, the carapace apex is square-rounded (Fig. 61). In posterior view, the carapace apex is rounded with a weakly arched transverse ridge or carina. In lateral view, the apex is mostly rounded but the carina is visible. The carapace is areolate-rugose to rugulose-punctate at the apex. The mesoscutum medially has two wide irregular parallel-pitted grooves between the notauli. The mesopleuron is medially foveate with a wide scrobiculate groove at the precoxal sulcus. The scutellar sulcus has three well-defined depressions. *Leptodrepana munjuanae* is the only Costa Rican species described that has tri-colored antennae: the scape, pedicel, and flagellomeres 1–4 are yellow; the flagellomeres 4–6 are yellowish white; flagellomeres 6–17 are black.

Etymology. This species is a patronym for Munjuan Kaur, in appreciation for her friendship.

Leptodrepana ninae **Dadelahi & Shaw, sp. n.**
http://zoobank.org/40E056E0-BED8-4E24-9847-F6519B411264
Figs 62–66

Diagnosis. In dorsal and posterior views, the carapace apex terminates in two sharp tubercles that are deeply arched between. Head, metanotum and propodeum brownish black; lateral pronotum and mesopleuron mostly orange. The mesopleuron is medially shiny and weakly punctate with a shallow foveate band at the precoxal sulcus. The scutellar sulcus has six well-defined depressions. Dorsally the carapace bears a large oval area of orangish brown.

Holotype female. BL 2.93 mm; FWL 2.8 mm; CL 1.44 mm; CW 0.4 mm; CL/CW 3.6.

Description. *Color*. Head brownish black, mandibles yellow, blackish brown apically; palpi yellowish white; antennae brown; lateral pronotum mostly orange; mesonotum orange; metanotum brownish black; mesopleuron mostly orange but dark brownish orange posteriorly; propodeum black; fore and middle leg mostly yellowish brown; hind leg with coxa, trochanter and basal portion of femur yellowish white, trochantellus and dorso-apical portions of femur brown, tibia yellowish white ventrally and brown dorsally; wings lightly pigmented with brown venation except parastigma and vein 1M yellow; carapace mostly blackish brown except large oval area of orangish brown.

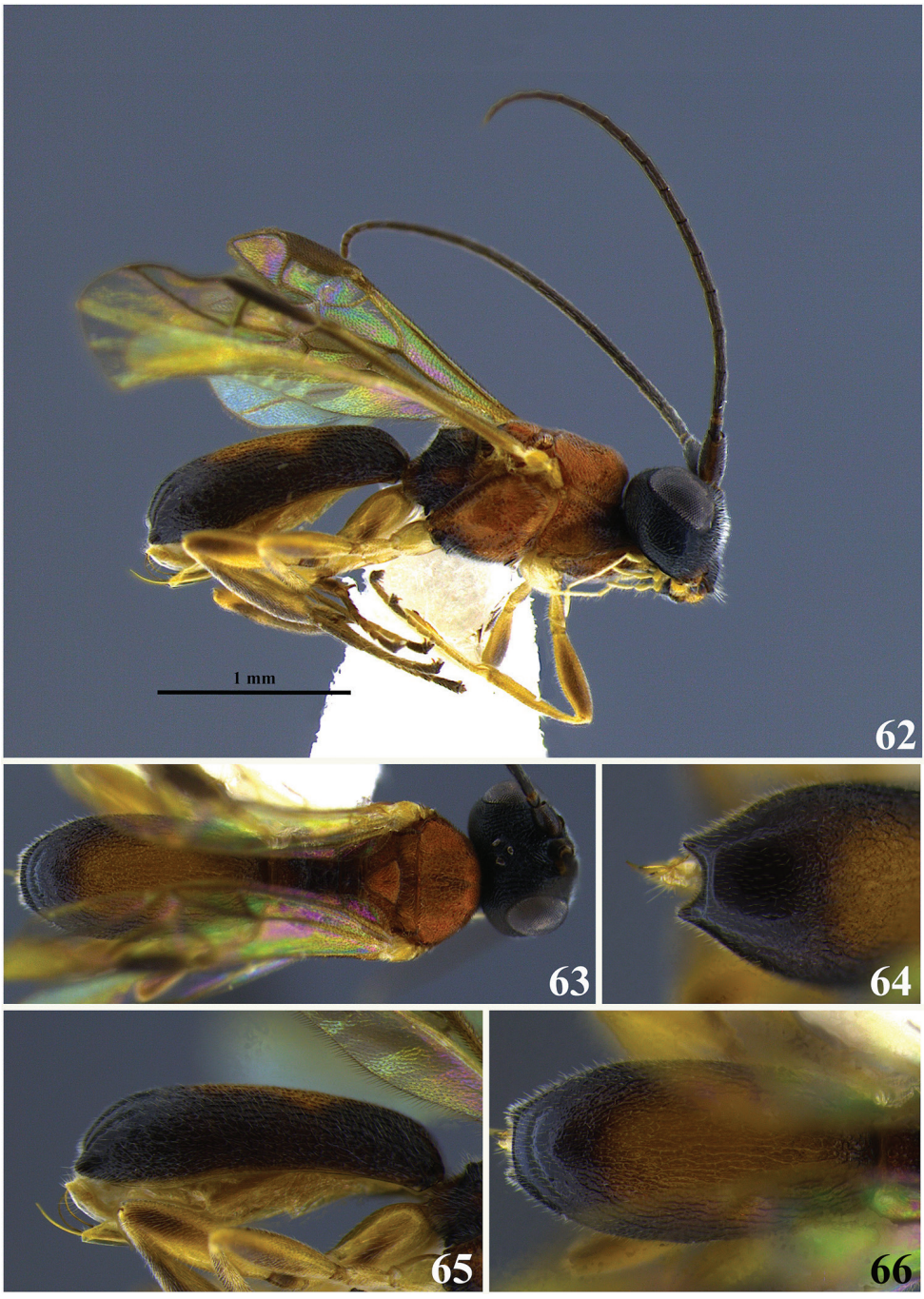
Head. HW 0.825 mm; HL 0.65 mm; HW/HL 1.26; face finely punctuate; genae, vertex and ocellar triangle rugulose-punctate; frons depressed rugulose-punctate with weak median carina; clypeus punctate and apical margin rounded; occipital carina complete; antennae with flagellomeres all longer than wide and decreasing in length apically except penultimate flagellomere almost as long as wide and approximately half the length of ultimate flagellomere.

Mesosoma. Pronotum foveolate antero-laterally to rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially areolate-rugose; notauli narrow, visible anteriorly; median and lateral mesonotal lobes punctate; scutellar sulcus with six well-defined depressions, all longer than wide; scutellar disc rugose-weakly punctate; mesopleuron anteriorly rugose, medially shiny and weakly punctate with shallow foveate band at precoxal sulcus, postero-ventrally weakly punctate; propodeum coarsely areolate-rugose with distinct transverse carina raised into small roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose basally to shiny and weakly punctate at apex; in dorsal and posterior views, apex terminating in two sharp tubercles deeply arched between; in lateral view, apex terminating in narrow sloping point below midpoint.

Variation of paratype females. Median carina distinct; HW 0.83–0.88 mm; HL 0.65–0.75 mm; HW/HL1.1.7–1.27; BL 2.93–3.06 mm; FWL 2.66–2.8 mm; CL 1.44–1.48 mm; CW 0.4–0.44 mm; CL/CW 3.36–3.6.

Paratype males. No males.



Figures 62–66. *Leptodrepana ninae*. **62** Female habitus in lateral view **63** female habitus in dorsal view **64** metasoma in dorso-posterior view with a couple of pointing projections **65** metasoma in lateral view **66** metasoma in dorsal view.

Material examined. Holotype female: SAN JOSE, Zurqui de Moravia, 1600 m, iii.1991 (P. Hanson) [UWIM]. Paratype data: 1♀, CARTAGO, Dulce Nombre, Vivero Linda Vista, 1400 m, vi–viii.1993; 1♀, PUNTARENAS, Monteverde, San Luis, L-N-250850-449250, 1992 (Z. Fuentes) [INBio, barcode CR1000-805992].

Remarks. *Leptodrepana ninae* is superficially similar to *L. conleyae* but may be distinguished by the following combination of characters. In dorsal and posterior views, the carapace apex terminates in two sharp tubercles that are deeply arched between (Figs 64, 66). The propleural margin of the pronotum is rugose. The mesopleuron is medially shiny and weakly punctate with a shallow foveate band at the precoxal sulcus. The scutellar sulcus has six well-defined depressions. Dorsally the carapace bears a large oval area of orangish brown. In dorsal and posterior views the carapace apex of *L. conleyae* terminates in two small tubercles weakly arched between (Figs 21, 23). The propleural margin of the pronotum is shiny and weakly punctate. The mesopleuron of *L. conleyae* is foveate medially and has a foveate groove at the precoxal sulcus. The scutellar sulcus has five well-defined depressions. The carapace has a baso-medial yellowish white "cape" or patch that extends laterally but not all the way to the lateral margins of the carapace.

Etymology. This species is a patronym in honor of Nina Michelle Zitani for her invaluable aid and advice in all matters entomological.

Leptodrepana pamelabbas Dadelahi & Shaw, sp. n.

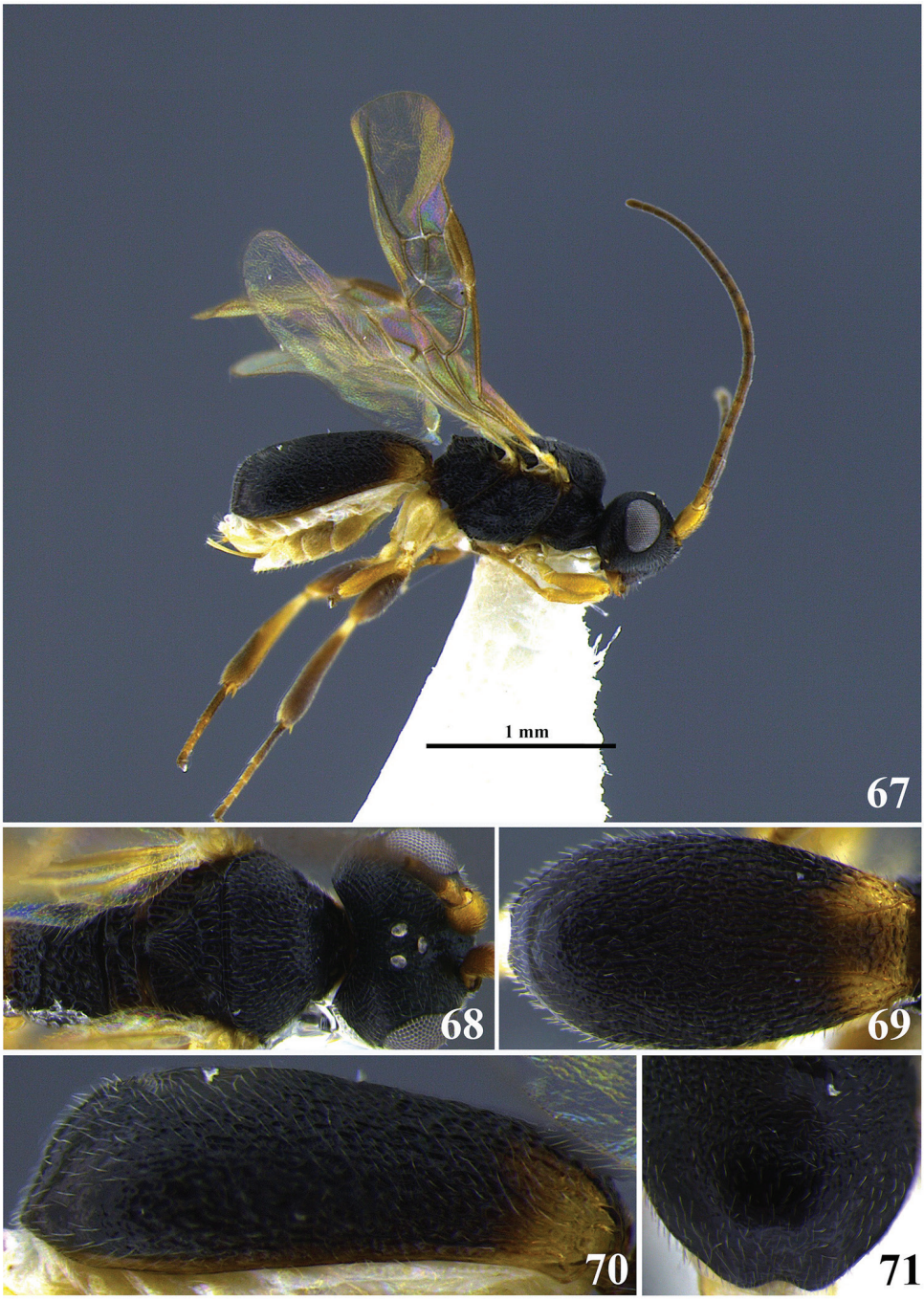
http://zoobank.org/59FB6236-0D84-4FE8-ABAA-67C9A109351D
Figs 67–71

Diagnosis. In dorsal and posterior views, two small weakly protruding tubercles are visible at the carapace apex. The mesopleuron is medially rugose with wrinkles appearing somewhat parallel. Body mostly brownish black except yellowish brown patches basolaterally below dorsal carinae; wings lightly pigmented with darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell.

Holotype female. BL 2.4 mm; FWL 2.3 mm; CL 1.12 mm; CW 0.36 mm; CL/CW 3.11.

Description. *Color*. Head brownish black, clypeus brown, mandibles yellow, blackish brown apically; palpi yellowish white; antennae brown with scape and pedicel yellowish brown; mesosoma brownish black; fore and middle legs with coxa, trochanter and trochantellus yellowish white, femur and tibia yellowish brown; hind leg similar to fore and middle legs but trochantellus, femur and tibia dark brown; tibia with narrow basal band of yellowish white; wings lightly pigmented with darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell; yellowish brown venation; carapace mostly black, with yellowish brown patches basolaterally below dorsal carinae.

Head. HW 0.63 mm; HL 0.48 mm; HW/HL 1.32; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed impunctate-weakly punctate with median



Figures 67–71. *Leptodrepana pamelabbas*. **67** Female habitus in lateral view **68** female head and mesoscutum in dorsal view **69** metasoma in dorsal view **70** metasoma in lateral view **71** metasoma in dorsoposterior view with a couple of rounded projections.

carina faint and weakly foveolate; clypeus weakly punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum deeply foveolate antero-laterally to rugose-foveolate at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with irregular pitted grooves between notauli so that area appears areolate-rugose; notauli indistinct; median and lateral mesonotal lobes rugose-punctate; scutellar sulcus with six well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose and medially regularly rugose (roughly parallel wrinkles); wide foveate band at precoxal sulcus; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to shiny and weakly punctate at apex; in dorsal and posterior views, carapace apex with blunt barely projecting tubercles; in lateral view, apex terminates in broad point.

Variation of paratype females. Color: basal quarter of carapace yellowish brown or carapace entirely black/brown; HW 0.63–0.68 mm; HL 0.48–0.53 mm; HW/HL 1.28–1.37; BL 2.4–2.53 mm; FWL 2.3–2.47 mm.; CL 1.12–1.24 mm; CW 0.36–0.44 mm; CL/CW 2.8–3.2.

Paratype males. No males.

Material examined. Holotype female: SAN JOSE, Cerro de la Muerte, 26 km N San Isidro, 2100 m, ii–v.1991 (P. Hanson) [UWIM]. Paratype data: 1♀, GUANACASTE, P. N. Santa Rosa, Bosque Humedo mature evergreen dry forest in clearing fully insolated part of the day, 300 m, 28.xii.1985–18.i.1986 (I. Gauld & D. Janzen).

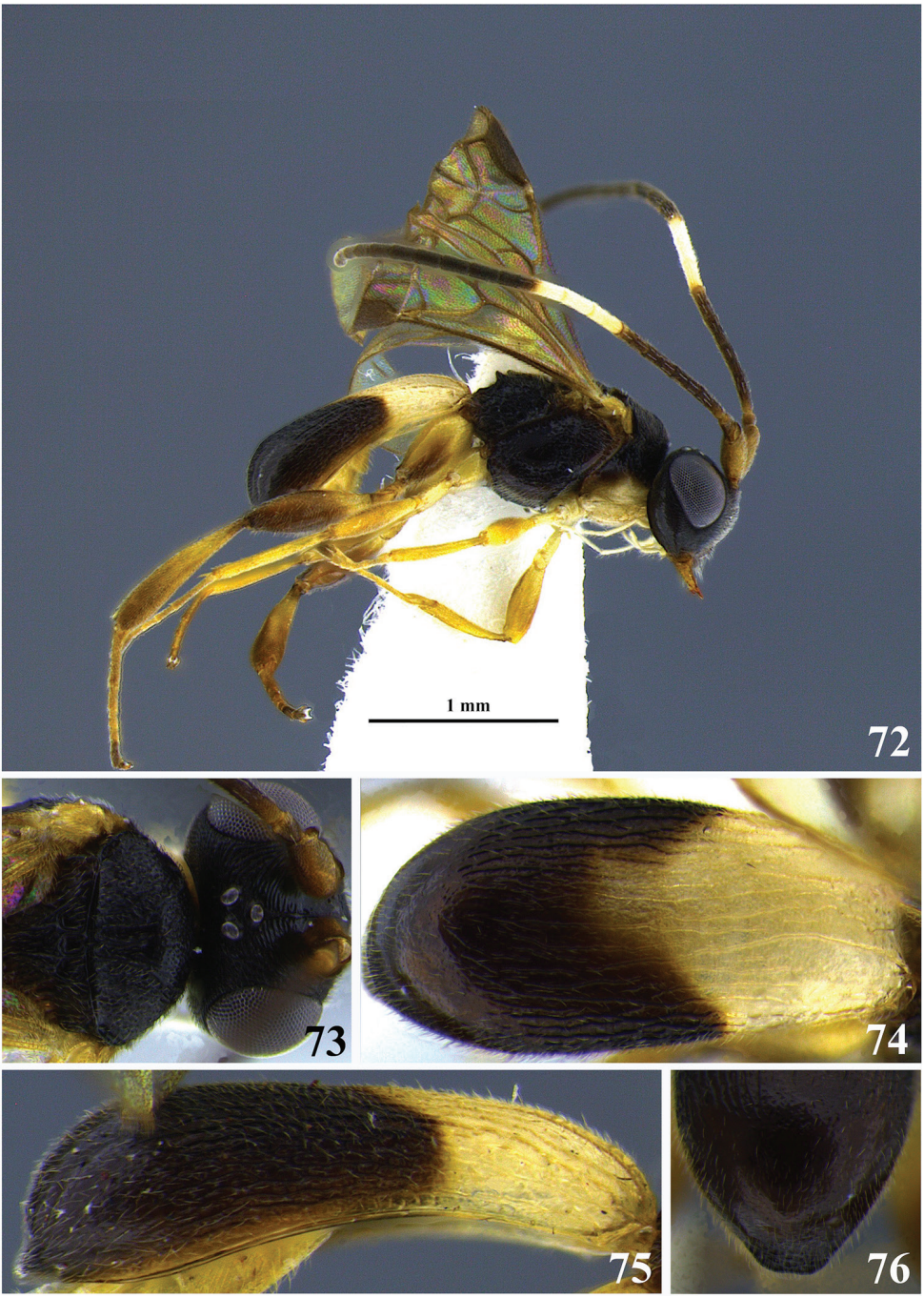
Remarks. *Leptodrepana pamelabbas* and *L. alexisae* are similar in size, shape, and color. However, the following characters may be used to separate the two species. In dorsal and posterior views, two small weakly protruding tubercles are visible at the carapace apex of *L. pamelabbas* (Figs 69, 71). The mesopleuron is medially rugose with wrinkles appearing somewhat parallel. At the precoxal sulcus there is a wide foveate groove. In females, the flagellum is uniform in width. In dorsal view, the carapace apex of *L. alexisae* lacks projecting tubercles instead it has a protruding flange (Fig. 6). In posterior view, two planar points, either strongly or weakly arched between, are visible (Fig. 4). The mesopleuron has a small shiny impunctate area medially with the immediate surrounding area foveolate. The precoxal sulcus appears foveolate. In females, the flagellum is slightly dilated medially.

Etymology. This species name is an arbitrary arrangement of letters to form a euphonious combination.

Leptodrepana ronnae Dadelahi & Shaw, sp. n.

http://zoobank.org/F327E81D-9B3C-42C9-B599-60D52CCEEC46
Figs 72–76

Diagnosis. In dorsal view, apex appears rounded or with barely protruding truncated flange below rounded dorsum of carapace; in lateral view, carapace apex terminates in



Figures 72–76. *Leptodrepana ronnae.* **72** Female habitus in lateral view **73** female head and mesoscutum in dorsal view **74** metasoma in dorsal view **75** metasoma in lateral view **76** metasoma in dorso-posterior view terminating truncated.

narrow sloping point below midline. Presence of a transverse carina at the carapace apex in posterior view. Scutellar sulcus with three well-defined depressions, all longer than wide. Body mostly brownish black except flagellum brown that bears a yellowish white annulus at flagellomeres 4–6, and carapace with basal half yellowish white.

Holotype female. BL 2.87 mm; FWL 2.6 mm; CL 1.32 mm; CW 0.4 mm; CL/CW 3.3.

Description. *Color*. Head brownish black, mandibles yellow, blackish brown apically; palpi yellowish white; antennae brown, except for flagellomeres 4–6 yellowish white, scape and pedicel yellowish brown; mesosoma mostly black, pronotum yellowish white postero-laterally, propleuron yellowish white; fore and middle legs with coxa and trochanter yellowish white, trochantellus, femur and tibia yellowish brown; hind leg similar except brown and coxa with apical brown patch; wings lightly pigmented with darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell; carapace blackish brown with basal half yellowish white.

Head. HW 0.85 mm; HL 0.7 mm; HW/HL 1.21; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed punctate with distinct parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete; antennae with flagellum slightly dilated medially.

Mesosoma. Pronotum mostly shiny and impunctate but rugose-punctate near tegula; propleuron weakly areolate-rugose; mesoscutum medially with shallow irregular pitted grooves between notauli, mesonotal lobes rugose-punctate; notauli visible anteriorly; scutellar sulcus with three well-defined depressions, all longer than wide; scutellar disc rugose-punctate; mesopleuron anteriorly rugose, medially shiny and weakly punctate, some shallow irregularly shaped pits at precoxal sulcus, and weakly punctate to impunctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into medial and lateral flanges, lateral flanges greatly protruding approximately 3× the size of median flanges.

Metasoma. Carapace areolate-rugose to punctate at apex; in dorsal view, apex appears rounded or with barely protruding truncated flange below rounded dorsum of carapace; in lateral view, carapace apex terminates in narrow sloping point below midline; in posterior view, apex terminates in shallowly arched ridge or carina.

Variation of paratype females. No paratype females.

Paratype males. No males.

Material examined. Holotype female: PUNTARENAS, San Vito, Jardin Bot. Las Cruces, 1200 m, vi–vii.1988 (P. Hanson) [UWIM].

Remarks. *Leptodrepana ronnae* is similar to *L. strategeri* in shape and color. It may be easily distinguished from *L. strategeri* by the presence of a transverse carina at the carapace apex in posterior view. Also when viewed posteriorly, the carapace apex appears distinctly wrinkled or rugulose. The scutellar sulcus has only three well-defined depressions and the mesopleuron has shallow irregularly shaped pits at the precoxal sulcus. In females, the flagellum is brown but bears a yellowish white annulus at flagellomeres 4–6. *Leptodrepana strategeri* lacks a transverse carina at the carapace apex in posterior view. The carapace is shiny and weakly punctate at the apex. The scutellar

sulcus has 4–5 well-defined depressions and the mesopleuron has a scrobiculate groove at the precoxal sulcus. In females the flagellum is light brown.

Etymology. This species name is a patronym for Ronnae Lynn Nemitz, a close friend of SDD, always ready to point out that we do not know everything.

***Leptodrepana rosanadana* Dadelahi & Shaw, sp. n.**
http://zoobank.org/16AF8298-02ED-4B07-8BE7-3163EC69EC15
Figs 77–81, 127

Diagnosis. In lateral and dorsal views, the carapace apex is rounded; in posterior view, the carapace apex is rounded with the posterior margin weakly arched. The scutellar disc is distinctly bulging and punctate. Body mostly black except basal third of carapace with median yellowish white oval shape; the wings are suffused with dark brown pigment except for an obfuscate circular area in the basal cell, directly below the stigma in the first submarginal cell, and a linear area parallel to the vein 1A in subbasal cell.

Holotype female. BL 3.27 mm; FWL 2.3 mm; CL 1.44 mm; CW 0.44 mm; CL/CW 3.27.

Description. *Color*. Head black, mandibles yellow, blackish brown apically; palpi dark brown; antennae dark brown except flagellomeres 2–4 yellowish white; mesosoma black; middle and fore leg coxae and dorsum of trochanter yellowish white; femur and tibia dark brown both with narrow basal bands of yellowish white; hind leg same as fore and middle legs except coxa basal and apical portions of coxa and trochanter yellowish white; wings suffused with dark brown pigment except for obfuscate circular area in basal cell, directly below stigma in first submarginal cell, and linear area parallel to vein 1A in subbasal cell; venation brown; basal third of carapace with median yellowish white oval shape, remainder of carapace black.

Head. HW 1.03 mm; HL 0.85 mm; HW/HL 1.21; face, genae, vertex and ocellar triangle coarsely rugulose-punctate; frons depressed and pubescent, pubescence obscuring sculpture and posterior portion of median carina; clypeus coarsely punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum laterally deeply foveate; propleuron weakly areolate-rugose; mesoscutum coarsely punctate; notauli narrow and visible anteriorly; scutellar sulcus with six well-defined depressions, all longer than wide; scutellar disc distinctly bulging and punctate; anterior scutellar depression foveate; mesopleuron anteriorly rugose, medially shiny and impunctate, foveate at precoxal sulcus, foveolate to weakly punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into medial and lateral flanges, median flanges reduced and lateral flanges at least twice size of median flanges.

Metasoma. Carapace basally areolate-rugose to rugulose at apex; in dorsal and lateral views, apex of carapace rounded; in posterior view, carapace apex rounded with posterior margin weakly arched.

Variation of paratype females. HW 1.13 mm; HL 0.875 mm; HW/HL 1.29; BL 3.5 mm; FWL 2.6 mm; CL 1.6 mm; CW 0.56 mm; CL/CW 2.86.

Figures 77–81. *Leptodrepana rosanadana.* **77** Female habitus in lateral view **78** female habitus in dorsal view **79** metasoma in dorso-posterior view with a small, median, ventral depression **80** metasoma in lateral view **81** metasoma in dorsal view.

Variation of paratype males. Similar to females except posterior margin of carapace apex rounded not weakly arched; antennae broken; HW 1.11 mm; HL 0.86 mm; HW/HL 1.29; BL 3.54 mm; FWL 2.8 mm; CL 1.49 mm; CW 0.44 mm; CL/CW 3.38.

Material examined. Holotype female: PUNTARENAS, R. F. Golfo Dulce, 3 km SW Rincon, primary forest, 10 m, iii.1993 (P. Hanson) [UWIM]. Paratype data: 1♀,

same data as holotype; 1♂, same province except P. N. Corcovado, Est. Sirena, 0–100 m, L-S-270500-508300, vi.1991 (G. Fonseca) [INBio, barcode CR1000-669411].

Remarks. *Leptodrepana rosanadana* has unique characters that easily distinguish it from other Costa Rican species. In lateral and dorsal views, the carapace apex is rounded (Figs 80, 81). In posterior view, the carapace apex is rounded with the posterior margin weakly arched (Fig. 79). The carapace apex is rugulose. The scutellar disc is distinctly bulging and punctate. The anterior scutellar depression is foveate. The mesopleuron is medially shiny and impunctate and foveate at the precoxal sulcus. The medial flanges of the propodeal carina are reduced so that the lateral flanges appear at least twice the size of the median flanges. The wings are suffused with dark brown pigment except for an obfuscate circular area in the basal cell, directly below the stigma in the first submarginal cell, and a linear area parallel to the vein 1A in subbasal cell (Fig. 127).

Leptodrepana rosanadana showed *Ascogaster*-like variation in the scutellar disc. In *Leptodrepana* the disc tends to be characteristically flattened and polished while, in *Ascogaster*, it tends to be bulging or convex and sculptured. *Leptodrepana rosanadana* had a noticeably bulging coarsely sculptured scutellar disc. However, we firmly believe this species to be within the genus *Leptodrepana*. The antennae consist of 17 flagellomeres of uniform width, the ventral cavity is roughly the same length as the carapace, and the ocellar triangle is equilateral in shape.

Etymology. This species name is an arbitrary arrangement of letters to form a euphonious combination.

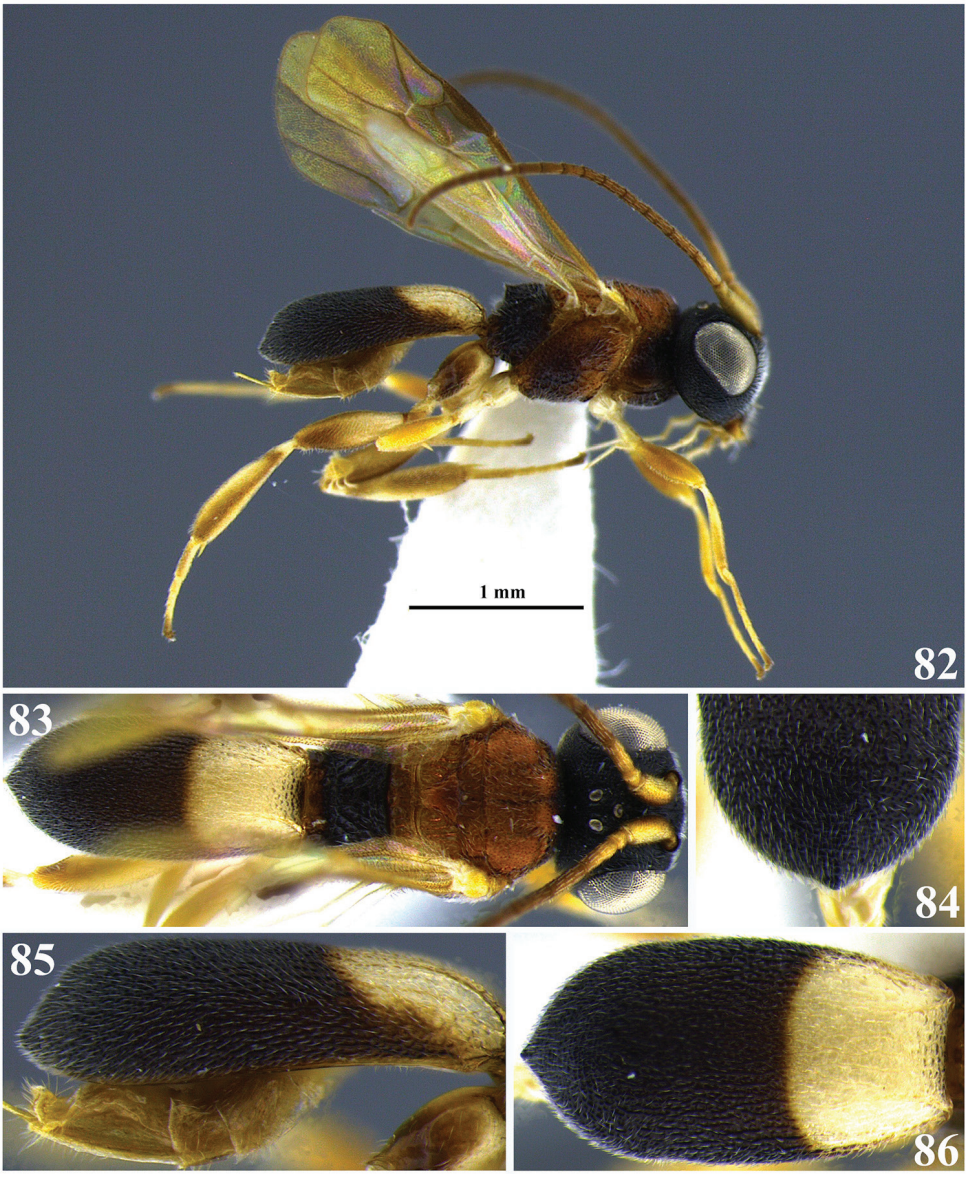
Leptodrepana schuttei Dadelahi & Shaw, sp. n.

http://zoobank.org/2D77F1B5-14CF-4F51-B448-F06FDC4DE5EB
Figs 82–86

Diagnosis. Carapace apex terminates in single small point; in lateral view apex terminates in broad point at midline. Head brownish black, mesosoma mostly orange, wings suffused with light yellowish brown pigment, darker area below stigma, basal third of carapace yellowish white and apical 2/3 of carapace blackish brown.

Holotype female. BL 3.07 mm; FWL 2.4 mm; CL 1.32 mm; CW 0.36 mm; CL/CW 3.6.

Description. *Color*. Head brownish black, mandibles yellow, blackish brown apically; apical margin of clypeus orange; palpi yellowish white; antennae brown with scape and pedicel and first flagellomere (basal) yellowish white; mesosoma mostly orange except posterior half of mesopleuron black, metapleuron, and propodeum black; middle and fore legs yellowish white; hind leg mostly yellowish white except apical portion of coxa brown; wings suffused with light yellowish brown pigment, darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell; venation yellowish brown; basal third of carapace yellowish white and apical 2/3 of carapace blackish brown.



Figures 82–86. *Leptodrepana schuttei.* **82** Female habitus in lateral view **83** female habitus in dorsal view **84** metasoma in dorso-posterior view with a pointing projection **85** metasoma in lateral view **86** metasoma in dorsal view.

Head. HW 0.9 mm; HL 0.75 mm; HW/HL 1.2; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, weakly punctate with fine parallel lineation lateral to weak median carina; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to foveolate-rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with irregular parallel pitted grooves between notauli difficult to distinguish and appears areolate-rugose; notauli distinct and visible anteriorly; median and lateral mesonotal lobes rugose-punctate; scutellar sulcus with 5 well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose, medially deeply foveate, wide scrobiculate groove at precoxal sulcus, foveate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace completely areolate-rugose; in dorsal and posterior views, carapace apex terminates in single small point; in lateral view apex terminates in broad point at midline.

Variation of paratype females. HW 0.85–0.95 mm; HL 0.725–0.8 mm; HW/HL 1.17–1.2; BL 2.6–3.2 mm; FWL 2.7–2.47 mm; CL 1.24–1.4 mm; CW 0.36–0.4 mm; CL/CW 3.1–3.8.

Paratype males. No males.

Material examined. Holotype female: GUANACASTE, P. N. Santa Rosa, site #12, Bosque Humedo mature evergreen dry forest more or less fully shaded as possible, 300 m, 27.ix–18.x.1986 (I. Gauld & D. Janzen) [UWIM]. Paratype data: 1♀, same data as holotype; 3♀, same data except site #5, Bosque San Emilio, 50 year old deciduous forest in clearing fully insolated part of the day, 6–27.ix.1986; 1♀, same data except more or less fully shaded as possible, 18.x–8.xi.1986.

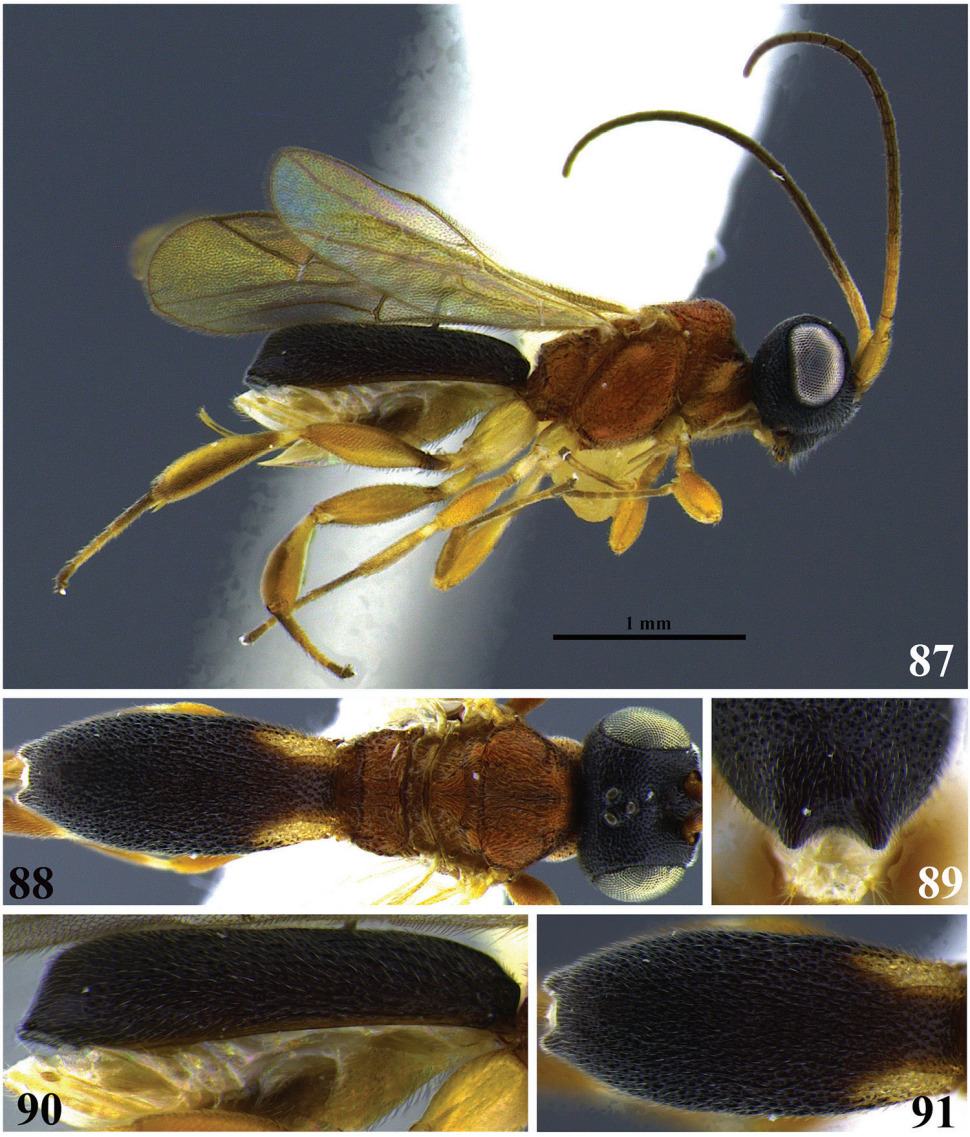
Remarks. *Leptodrepana schuttei* may be confused with *L. atalanta.* They are similar in color and the carapace apex of both species terminates in a single point. *Leptodrepana schuttei* may be distinguished from this species by the following combination of characters. The notauli of *L. schuttei* is narrow and a scrobiculate groove is present at the precoxal sulcus. The posterior mesopleuron and the propodeum are black. The basal third of the carapace is completely yellowish white. The notauli of *L. atalanta* are wide and shallow. There is a wide band at the precoxal sulcus formed by at least two shallow foveate grooves. The mesopleuron and propodeum are entirely orange. The carapace has a baso-median patch of yellowish white that does not extend to the lateral margins of the carapace.

Etymology. This species is a patronym for Vincent Paul Schutte. After all the science fiction watched together, it seemed fitting that something as "alien" as a koinobiont parasitoid should bear his name.

Leptodrepana scottshawi Dadelahi, sp. n.

http://zoobank.org/251BEE78-791A-41F9-A051-F1E7AC11B9D9
Figs 87–91

Diagnosis. The carapace apex appears coarsely rugulose-punctate and terminates in two protruding points or tubercles that are visible in both dorsal and posterior views. Medially, the mesoscutum is divided into 5–6 neat parallel-pitted grooves and scutellar



Figures 87–91. *Leptodrepana scottshawi.* **87** Female habitus in lateral view **88** female habitus in dorsal view **89** metasoma in dorso-posterior view with a couple of pointing projections **90** metasoma in lateral view **91** metasoma in dorsal view.

disc is very flat. Mesosoma orange; head and metasoma mostly blackish brown except with yellowish white patches baso-laterally below dorsal carinae.

Holotype female. BL 2.9 mm; FWL 2.26 mm; CL 1.44 mm; CW 0.36 mm; CL/CW 4.

Description. *Color*. Head blackish brown, mandibles mostly yellowish brown but blackish brown basally and apically; palpi yellowish white; antennae dark brown with

scape, pedicel and first two basal flagellomeres yellowish white; mesosoma orange; legs orange except middle coxae and trochanter yellowish white, hind trochanter yellowish white and tibia of all legs with basal yellowish white band; venation brown with parastigma and vein 1M lighter in color, yellow-brown; carapace brownish black with yellowish white patches baso-laterally below dorsal carinae.

Head. HW 0.88 mm; HL 0.68 mm; HW/HL 1.3; face, vertex genae and ocellar triangle rugulose-punctate; frons depressed, rugulose-punctate with fine parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to weakly rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with 5–6 distinct regular parallel lacunose grooves between notauli; notauli narrow and visible anteriorly; median and lateral mesonotal lobes rugulose-punctate; scutellar sulcus with 6–7 well-defined depressions, all longer than wide; scutellar disc punctate and very flat; mesopleuron anteriorly rugose, medially rugose-foveate and, at precoxal sulcus, two foveate grooves form an wide band; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to coarsely rugulose-punctate at apex; in posterior view, apex terminating in two points shallowly arched between; in dorsal view, apex terminates in two points visible below rounded carapace dorsum; in lateral view, apex terminates in sloping point below midline; ventral cavity almost reaching apex.

Variation of paratype females. Color: middle and hind tibia brown with basal yellowish white band; carapace entirely black or with baso-lateral white patches continuing dorsally sometimes meeting dorsally; frons weakly punctate with lineation lateral to median carina weak or well-defined; pronotum smooth at propleural margin; HW 0.73–0.88 mm; HL 0.58–0.68 mm; HW/HL 1.23–1.3; BL 2.5–3.0 mm; FWL 1.8–2.4 mm; CL 1.6–1.44 mm; CW 0.36–0.4 mm; CL/CW3.2–3.89.

Variation of paratype males. Similar to females except all legs with coxa, trochanter, and trochantellus yellowish white; mesopleuron medially weakly punctate and foveate at precoxal sulcus but not forming a wide grooved band; HW 0.73–0.8 mm; HL 0.58–0.63 mm; HW/HL 1.26–1.28; BL 2–2.27 mm; FWL 1.87–2.13 mm; CL 1.16–1.4 mm; CW 0.36 mm; CL/CW 3.2–3.89.

Material examined. Holotype female: PUNTARENAS, Golfo Dulce 24 km W Piedras Blancas, 200 m, vi–viii.1989 (P. Hanson) [UWIM]. Paratype females: 1♀, HEREDIA, 3 km S Puerto Viejo, OTS, La Selva, 100 m, xi.1992; 1♀, GUANACASTE, Est. Mengo, SW Volcan Cacao, 1100 m, 1988–1989 (No collector listed); 2♀, same data except Est. Pitilla, 9 km S Santa Cecilia, 700 m, v.1989 (I. Gauld); 1♀, 1♂, LIMON, R. B. Hitoy Cerere, Est. Hitoy Cerere, 100 m, 19–29.iv.1992 (E. Lopez) L-N 184200,643300 [INBio]; 1♀, Sector Cerro Cocori, Fca. De E. Rojas, 150 m, L-N-286000,567500, 5.vi–5.vii.1992 (No Collector listed) [INBio]; 1♀, 3♂, Las Cruces biological station, Pacific slope, 1100 m, light trap, 6–9.vii.1999 (N. Zitani); 3♀, same as holotype; remaining paratypes are from PUNTARENAS; 1♀, R. F. Golfo Dulce, 3 km SW Rincon 10 m, ii–iii.1989 (Hanson & Gauld); 2♀, same

data except x–xii.1990; 2♀, same data except vi.1991; 1♀, same data except ii.1993; 5♀, road to Rincon, 10 km W of Pan-American Hwy, 100 m, iii–v.1989 (Hanson & Gauld); 1♀, Corcovado, Est Sirena, 50 m, x–xii.1990; 1♀, same data except 0–100 m, L-S-270500,508800, xii.1991 (G. Fonseca) [INBio]; 1♀, 3♂, P. N. Manuel Antonio, Quepos, 80 m, L-S-370900,448800 #1181 iv.1992 (C.Cano) [INBio]; 2♀, R. B. Carara, Est. Queb. Bonito, 50 m, L-N-194500, 469850, ii.1993 (R. Guzman) [INBio].

Remarks. *Leptodrepana scottshawi* is easily distinguished from other Costa Rican *Leptodrepana*. Medially, the mesoscutum is divided into 5–6 neat parallel pitted grooves and scutellar disc is very flat. The carapace apex appears coarsely rugulose-punctate and terminates in two protruding points or tubercles that are visible in both dorsal and posterior views.

Etymology. This species name by SDD is a patronym for her advisor Scott Shaw, in appreciation for all the encouragement, advice, and occasional lash of the whip he has been obliged to give over the years.

Leptodrepana shriekae Dadelahi & Shaw, sp. n.

http://zoobank.org/52E77A3A-2FC8-455E-91A6-3DC66E2EDC15
Figs 92–96

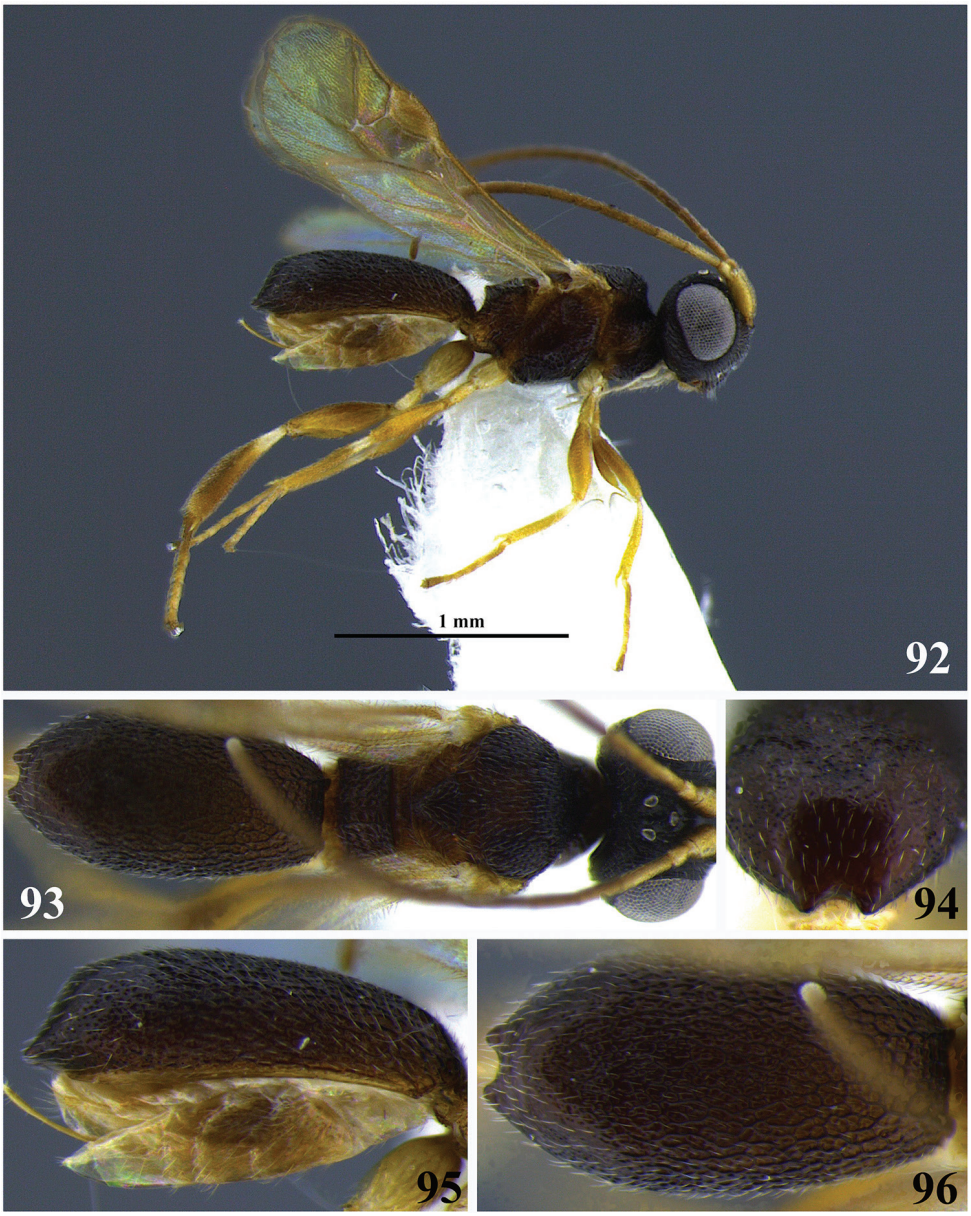
Diagnosis. Body small, less than 2.5 mm; the carapace apex has two protruding points or tubercles that are visible in both dorsal and posterior view; the apex is shiny and weakly punctate; the mesopleuron is medially shiny-impunctate and it is deeply foveate at the precoxal sulcus. Body mottled brownish orange in color with a very characteristic median orange square patch on mesoscutum.

Holotype female. BL 2.13 mm; FWL 1.67 mm; CL 0.96 mm; CW 0.32 mm; CL/CW 3.

Description. *Color*. Head blackish brown, mandibles mostly yellowish brown but blackish brown basally and apically; palpi yellowish white; antennae dark brown with scape, pedicel and first flagellomere (basal) yellowish white; mesosoma mostly brownish black except mesoscutum with median yellowish brown square patch and anterior scutellar depression surrounding scutellar disc yellowish brown; legs yellow with faint basal white band on tibia; wings lightly pigmented with darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell; yellowish brown venation; carapace brownish black.

Head. HW 0.5 mm; HL 0.53 mm; HW/HL 0.94; face, vertex and ocellar triangle rugulose-punctate, genae weakly so; frons depressed, weakly punctate, and median carina lacking; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to weakly rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with irregular parallel pitted grooves between notauli difficult to distinguish and appears areolate-rugose; notauli narrow and visible anteriorly; median and lateral lobes rugulose-punctate; scutellar sulcus with six well-defined depressions, all longer than wide; scutellar disc punc-



Figures 92–96. *Leptodrepana shriekae.* **92** Female habitus in lateral view **93** female habitus in dorsal view **94** metasoma in dorso-posterior view with a couple of pointing projections **95** metasoma in lateral view **96** metasoma in dorsal view.

tate; mesopleuron anteriorly rugose, medially impunctate and shiny deeply foveate at precoxal sulcus and impunctate to weakly punctate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose basally graduating to shiny and weakly punctate at apex; but weak; in posterior view, apex terminating in two points shallowly arched between; in dorsal view, apex terminates in two points visible below rounded carapace dorsum; in lateral view, apex terminates in sloping point below midline; ventral cavity almost reaching apex.

Variation of paratype females. Color: clypeus orange; color pattern more pronounced with yellowish cream tibial band and orange square patch on mesoscutum in stark contrast with surrounding areas; median carina weak medially; points at apex of carapace deeply arched between; HW 0.58–0.7 mm; HL 0.48–0.56 mm; HW/HL 1.2–1.3; BL 1.9–2.3 mm; FWL 1.5–1.9 mm; CL 0.9–1.1 mm; CW 0.32 mm; CL/CW 2.8–3.4.

Paratype males. Similar to females except clypeus yellow/orange; antennae broken in male examined; flagellum yellowish white; face sometimes with orange markings below antennae; mesoscutum without median orange square patch coarsely punctate medially; anterior scutellar depression surrounding scutellar disc same color as disc; ventral cavity distal carapace apex by at least twice the distance in females; HW 0.58 mm; HL 0.5 mm; HW/HL 1.2; BL 2.1 mm; FWL broken; CL 0.92 mm; CW 0.36 mm; CL/CW 2.56.

Material examined. Holotype female: SAN JOSE, San Antonio de Escazu, 1300 m, i–ii.1989 (W. Eberhard) [UWIM]. Paratype females: 3♀, GUANACASTE, P. N. Santa Rosa, Bosque Humedo mature evergreen dry forest in clearing fully isolated part of the day, 300 m, 28.xii.1985–18.i.1986 (I. Gauld & D. Janzen); 8♀, 1♂, same data except 29.xi–20.xii.1986.

Remarks. *Leptodrepana shriekae* may be distinguished from other Costa Rican species by the following combination of characters: the body is small, less than 2.5 mm; the carapace apex has two protruding points or tubercles that are visible in both dorsal and posterior view; the apex is shiny and weakly punctate; the mesopleuron is medially shiny-impunctate and it is deeply foveate at the precoxal sulcus. *Leptodrepana shriekae* is an interesting mottled brownish orange in color with a very characteristic median orange square patch on mesoscutum.

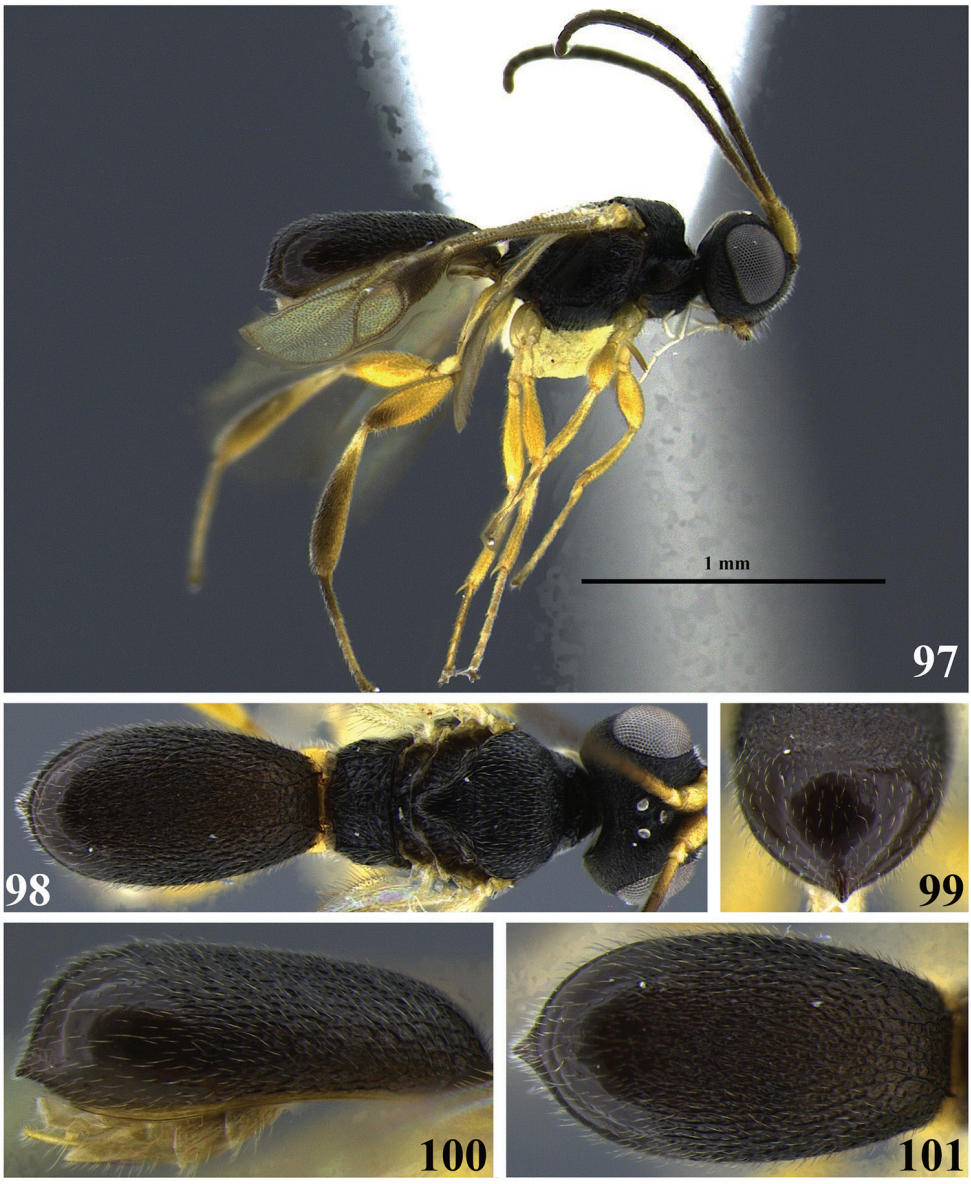
Etymology. This species name is a patronym for Erika L. Smith, affectionately known as Shriek since the age of fourteen, in appreciation for all the commiseration she has provided to SDD over the years.

Leptodrepana sohailae Dadelahi & Shaw, sp. n.

http://zoobank.org/17F2BFC9-DE52-4B94-9CE1-874D3348358B
Figs 97–101

Diagnosis. Body small, less than 2.5 mm in length. The carapace apex terminates in a single point, which is visible in both dorsal and posterior views. The carapace apex is shiny-impunctate. The mesopleuron is medially shiny and weakly punctate and the precoxal sulcus is defined by a scrobiculate groove. The body is dark brown in color.

Holotype female. BL 1.7 mm; FWL 1.4 mm; CL 0.8 mm; CW 0.2 mm; CL/CW 4.



Figures 97–101. *Leptodrepana sohailae.* **97** Female habitus in lateral view **98** female habitus in dorsal view **99** metasoma in dorso-posterior view with a pointing projection **100** metasoma in lateral view **101** metasoma in dorsal view.

Description. *Color*. Head brown, mandibles mostly yellowish brown but blackish brown basally and apically; palpi yellowish white; antennae dark brown, darkest apically with scape, pedicel and first two basal flagellomeres yellowish brown; mesosoma brown; legs yellow with dark area dorso-apically on femur and tibia with faint yellowish white band basally; venation yellowish brown; carapace brown.

Head. HW 0.58 mm; HL 0.43 mm; HW/HL 1.35; face, vertex and ocellar triangle rugulose-punctate, genae weakly so; frons depressed, weakly punctate and median carina weak; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum weakly foveolate-punctate antero-laterally to smooth at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with irregular parallel pitted grooves between notauli difficult to distinguish and appears areolate-rugose; notauli narrow and visible anteriorly; median and lateral mesonotal lobes rugose-foveolate; scutellar sulcus with 5–6 well-defined depressions, all longer than wide; scutellar disc weakly punctate; mesopleuron anteriorly rugose, medially suture shiny and weakly punctate, scrobiculate groove at precoxal sulcus; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to shiny and impunctate at apex; in dorsal view, apex terminates in single point; in lateral view, apex terminates in sloping point approximately at midline; ventral cavity almost reaching apex.

Variation of paratype females. Color: color patterns ,tibial basal band and basal portions of antennae, well differentiated; tibia of hind leg dark brown dorsally ; HW 0.58–0.65 mm; HL 0.43–0.48 mm; HW/HL 1.35–1.4; BL 1.7–2.2 mm; FWL 1.4–2.1 mm; CL 0.8–1.0 mm; CW 0.2–0.36 mm; CL/CW2.8–4.

Paratype males. No males.

Material examined. Holotype female: ALAJUELA, San Pedro de la Tigra Cacao, 200 m, iii–iv.1990 (R. Cespedes) [UWIM]. Paratype female: 1♀, GUANACASTE, Est. Pitilla 9 km S Santa Cecilia, 700 m, v.1989 (I. Gauld).

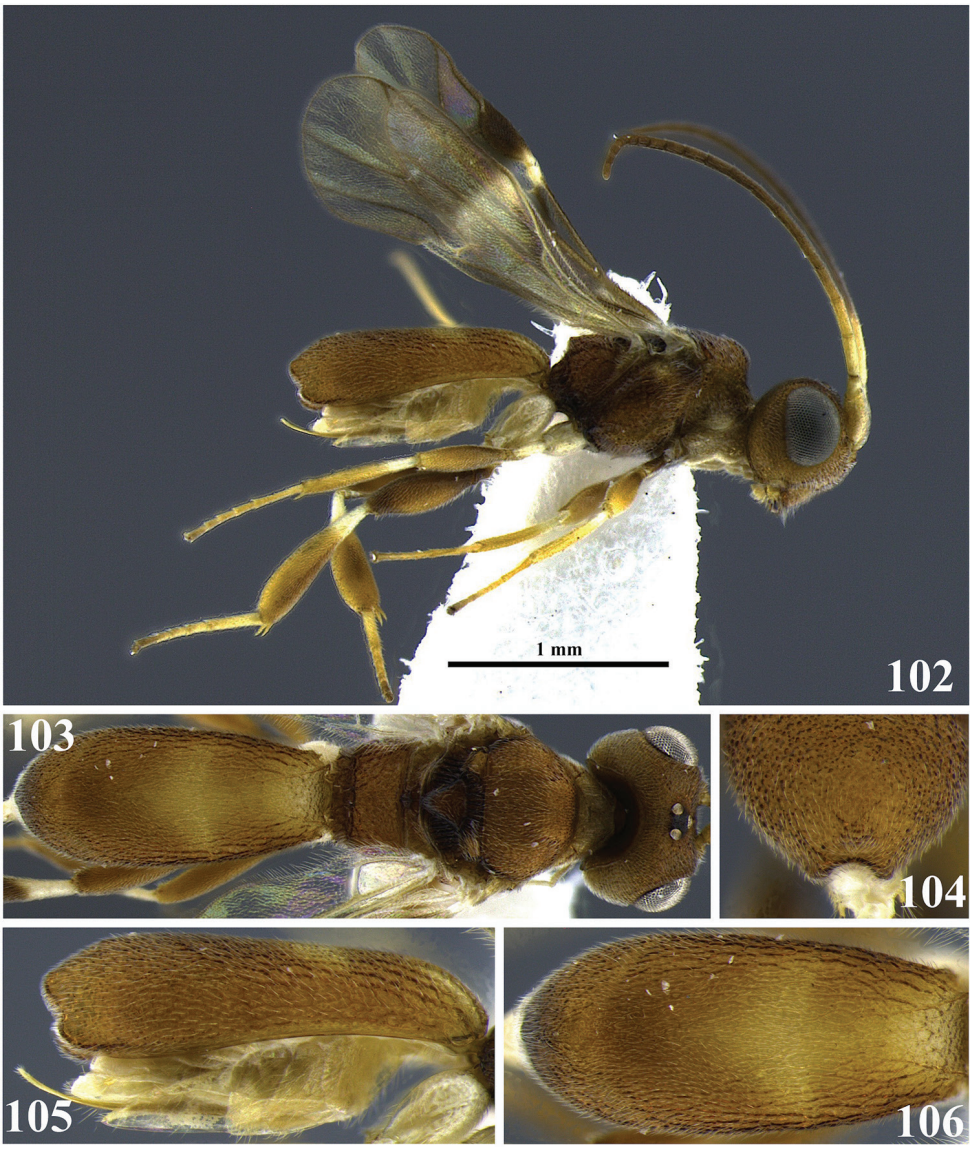
Remarks. *Leptodrepana sohailae* may be distinguished from other Costa Rican species by the following combination of characters. The body is small, being less than 2.5 mm in length. The carapace apex terminates in a single point, which is visible in both dorsal and posterior views. The carapace apex is shiny-impunctate. The mesopleuron is medially shiny and weakly punctate and the precoxal sulcus is defined by a scrobiculate groove. The body is dark brown in color.

Etymology. This species name is a patronym named in honor of a sister of SDD, Sohaila Catherine Dadelahi.

Leptodrepana sorayae Dadelahi & Shaw, sp. n.

http://zoobank.org/7B0661BF-5C7D-4C17-94F2-28750691EA53
Figs 102–106, 128

Diagnosis. In lateral view, the carapace bears a rounded flange posterior to the dorsoapical point. In posterior view the carapace apex terminates in a single broad point below which is a strongly arched medially notched flange. Body mostly yellowish orange; wings suffused with smoky brown pigmentation except for a white band running from the and including the parastigma.



Figures 102–106. *Leptodrepana sorayae.* **102** Female habitus in lateral view **103** female habitus in dorsal view **104** metasoma in dorso-posterior view with a couple of terminal projections **105** metasoma in lateral view **106** metasoma in dorsal view.

Holotype female. BL 2.6 mm; FWL 2.13 mm; CL 1.2 mm; CW 0.4 mm; CL/CW 3.3.

Description. *Color*. Head yellow, mandibles yellow, blackish brown apically; palpi yellowish white; antennae brown with scape, pedicel and first two flagellomeres (basal) yellow; mesosoma yellowish orange except scutellar sulcus dark brown, propleural

margin of pronotum and propleuron yellowish white; fore leg coxa brown, trochanter brown and apically white, trochantellus yellow, femur, tibia and tarsus orangish yellow; middle leg coxa white, trochanter mostly white, trochantellus mostly brown, femur, tibia and tarsus orangish yellow; hind leg coxa white, trochanter mostly white, trochantellus mostly brown, femur orangish yellow but dark brown dorsally, tibia white basally and orangish brown apically, tarsus orangish brown; wings suffused with smoky brown pigmentation except for white band running from parastigma (white) over veins RS+Ma, RS+Mb, 1m-cu, 2Cua and basal most portions of veins 2RS, 2M, and 3CU; remaining venation dark brown; carapace mostly orange, basally with median yellowish white patch between dorsal carinae, posterior margin of basal third of carapace with very faint ridge followed by transverse crescent shaped yellowish white patch.

Head. HW 0.9 mm; HL 0.75 mm; HW/HL 1.2; face and genae rugulose punctate; vertex and ocellar triangle coarsely rugulose-punctate; frons depressed, coarsely punctate with fine parallel lineation transverse to median carinae; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to rugose-foveate at propleural margin; propleuron weakly foveolate-rugose; mesoscutum medially with 3–4 irregular parallel pitted grooves between notauli so that area appears neatly divided parallel lines; notauli narrow and visible anteriorly; medial mesonotal lobe granulate, lateral mesonotal lobes weakly areolate-rugose; scutellar sulcus with 6–7 well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose, medially foveate, scrobiculate groove at precoxal sulcus followed by a foveate groove together appearing as a wide grooved depression; propodeum coarsely areolate-rugose with distinct transverse carina raised into small, roughly equal, medial and lateral flanges.

Metasoma. Carapace areolate-rugose to weakly areolate-rugose at apex; in posterior view apex terminating in a single broad point with arched flanges beneath; in dorsal view, apex terminates in single point; in lateral view, posterior to apical point is rounded flange; ventral cavity distal apex.

Variation of paratype females. Color: head yellow to orange; pronotum orange to yellowish white at propleural margin; propleuron orange to yellowish white; mesosoma orange/brown; anterior and posterior portion of mesopleuron brown/black; carapace orange/brown; pattern on carapace faint; propleural margin of pronotum rugose; propleuron weakly areolate-rugose; HW 0.8–0.9 mm; HL 0.7–0.73 mm; HW/HL 1.1–1.2; BL 2.6–3.1 mm; FWL 2.1–2.3 mm; CL 1.2–1.5 mm; CW 0.36–0.44 mm; CL/CW 3.2–3.7.

Variation of paratype males. Similar to females except sometimes frons and vertex darker in color than remainder of head; antennae with 26 flagellomeres tapering apically; pronotum foveate to smooth at propleural margin; mesoscutum sometimes mottled orange/brown/black with or without lighter orange patches at anterior notauli; median area of mesoscutum without well-defined parallel grooves appearing more areolate-rugose; HW 0.7–0.8 mm; HL 0.6–0.68 mm; HW/HL 1.16–1.2; BL 2.5–2.86 mm; FWL 2.0–2.13 mm; CL 1.2–1.36 mm; CW 0.4 mm; CL/CW 3.3–3.4.

Material examined. Holotype female: PUNTARENAS, R.F. Golfo Dulce, 3 km SW Rincon, 10 m, xii.1989–iii.1990 (P. Hanson) [UWIM]. Paratype females: 1♀, GUANACASTE, Est. Los Almendros, 300 m, Amarilla, 6–29.i.1995 (E.E. Lopez) LN 334850, 369500 #4785 [INBio]; remainder of paratype females are from PUNTARENAS province; 1♀, P. N. Corcovado, Est. Sirena, 50 m, iv–viii.1989; 2♀, same data as holotype; 1♀, same data as holotype except vi–viii.1989; 1♂, same data as holotype except S Rincon, iii–v.1989; 1♀, same data as holotype except iii–v.1989; 1♀, same data as holotype except x–xii.1990; 2♀, same data as holotype except vi.1991; 2♀, same data as holotype except i.1992; 1♀, same data as holotype except iii.1993; 4♀, same data as holotype except iv.1993; 8♀, same data as holotype except primary forest, xii.1992; 11♀, same data except ii.1993; 1♀, Puerto Jimenez, 10 m, full sun grassy weedy site, x.1991; 1♀, 1♂, same data except grassy weedy site, i–ii.1992; 1♀, 23 km N Puerto Jimenez, La Palma ,10 m, in large trees, viii–ix.1991; 2♀, 5 km N Puerto Jimenez 10 m, iii–iv.1991; 2♂, Pen. Osa, Puerto Jimenez, 10 m, ii–iii.1993; 2♀, Pen. Osa, Cerro Rincon, 200 m, S del Hito, 745 m, i.1991 (Hanson & Quiros); 1♀, same data except ii.1991 (Hanson & Godoy); 2♀, San Vito Est. Biol. Las Alturas, 1500 m, xii.1991.

Remarks. *Leptodrepana sorayae* may be easily distinguished from other Costa Rican species because of its many unique characters. The configuration of the carapace apex is diagnostic for this species. In lateral view, the carapace bears a rounded flange posterior to the dorso-apical point (Fig. 105). In posterior view the carapace apex terminates in a single broad point below which is a strongly arched medially notched flange. The carapace is areolate-rugose from base to apex. The wings also have a characteristic pattern. They are suffused with smoky brown pigmentation except for a white band running from the and including the parastigma over veins RS+Ma, RS+Mb, 1m-cu, 2Cua and basal most portions of veins 2RS, 2M and 3CU (Fig. 128).

Etymology. This species name is a patronym named in honor of a sister of SDD, Soraya Elizabeth Dadelahi.

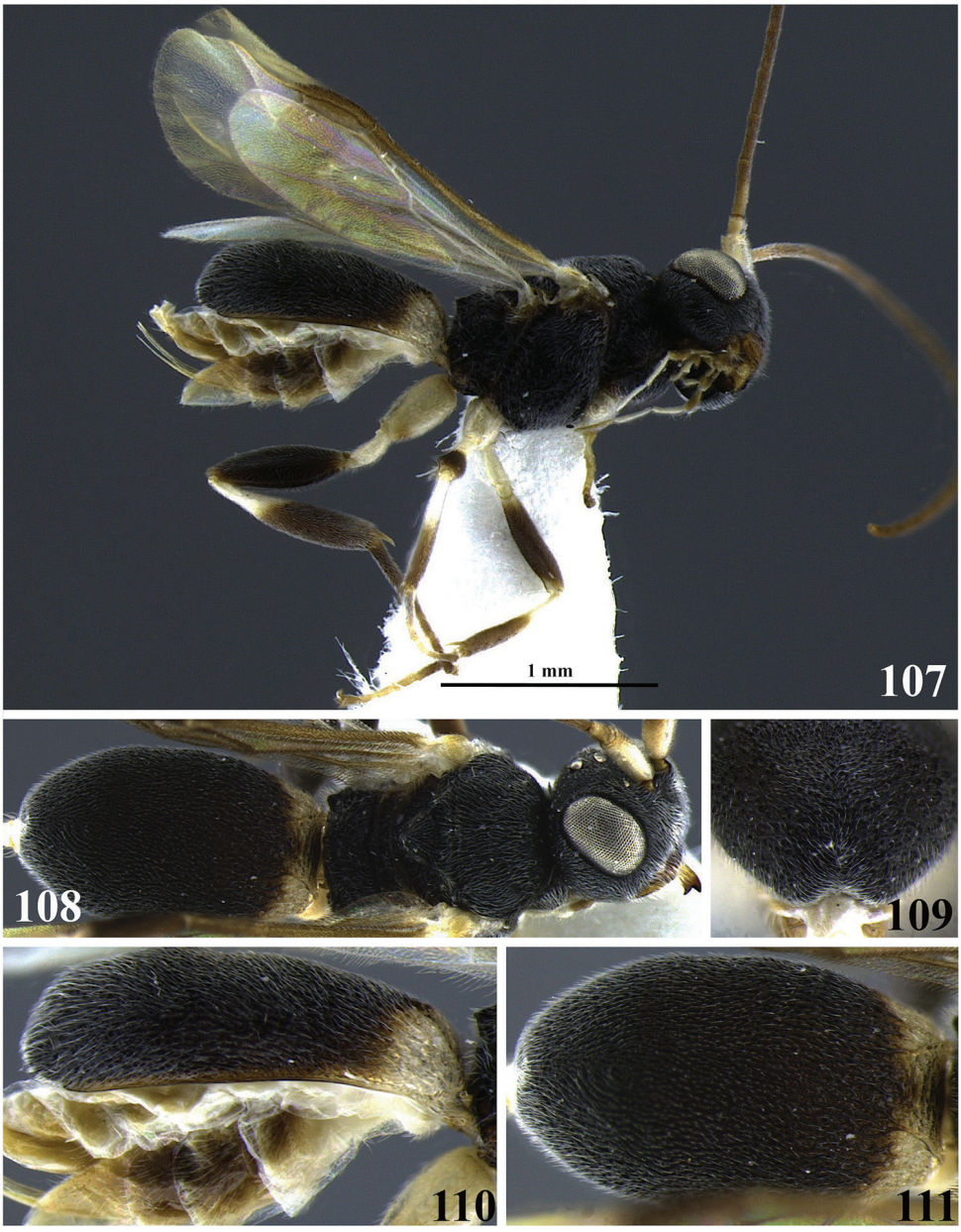
Leptodrepana soussanae Dadelahi & Shaw, sp. n.

http://zoobank.org/C6354D5D-5139-4A20-8A59-DE1416EACBE5
Figs 107–111

Diagnosis. Body robust, over 3mm in length. In posterior view apex of carapace arched; in dorsal and lateral views, apex rounded. Flagellum with uniform thickness and densely setose. Wings obfuscate except for circular area below the stigma suffused with brown pigmentation. Body mostly black, except basal fourth of carapace yellowish white.

Holotype female. BL 2.93 mm; FWL 2.4 mm; CL 1.28 mm; CW 0.4 mm; CL/CW 3.2.

Description. *Color*. Head black, clypeus orangish brown with yellow at apical margin; mandibles mostly yellowish brown but blackish brown basally and apically; palpi yellowish white; antennae light brown with scape, pedicel and first 2 flagellomeres (basal) yellowish white; mesosoma black; fore leg with coxa, trochanter, and



Figures 107–111. *Leptodrepana soussanae.* **107** Female habitus in lateral view **108** female habitus in dorsal view **109** metasoma in dorso-posterior view with a couple of terminal projections **110** metasoma in lateral view **111** metasoma in dorsal view.

trochantellus white-yellow, femur brown, tibia and tarsus white-yellow, tarsal claw brown; middle and hind leg same as foreleg except tibia brown with basal band of yellowish white and tarsus brown; wings obfuscate except for circular area below stigma suffused with brown pigmentation and densely setose covering apical half of 1st sub-

marginal cell and most of 2nd submarginal cell; carapace mostly black, basal fourth of carapace yellowish white.

Head. HW 0.9 mm; HL 0.68 mm; HW/HL 1.33; head densely pubescent; face, genae, vertex and ocellar triangle rugulose punctate; frons depressed and median carina largely obscured by rugulose sculpture; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate; propleuron weakly areolate-rugose; mesoscutum densely pubescent and medially with irregular pitted grooves appearing areolate-rugose; notauli narrow and visible anteriorly; mesoscutal lobes rugulose-punctate; scutellar sulcus with five well-defined depressions, all longer than wide; scutellar disc pubescent and apparently granulate-punctate; mesopleuron anteriorly rugose, medially foveate, with wide deeply foveate groove at precoxal sulcus and foveolate-punctate below; mesopleural scrobiculate groove proximal metapleuron wide; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to weakly areolate-rugose at apex; in posterior view apex arched; in dorsal and lateral views, apex rounded.

Variation. Paratype females. HW 0.9 mm; HL 0.68–0.7 mm; HW/HL 1.28–1.33; BL 2.93–3.06 mm; FWL 2.4 mm; CL 1.28–1.4 mm; CW 0.4–0.44 mm; CL/CW 3.18–3.2.

Paratype males. No males.

Material examined. Holotype female: GUANACASTE, Santa Rosa National Park, Bosque San Emilio 30-year-old, in clearing fully insolated part of the day, 300 m, 1.vi–22.vi.1985 (I. Gauld & D. Janzen) [UWIM]. Paratype female: 1♀, same data except old forest more or less fully shaded as possible, 14.vi–5.vii.1986.

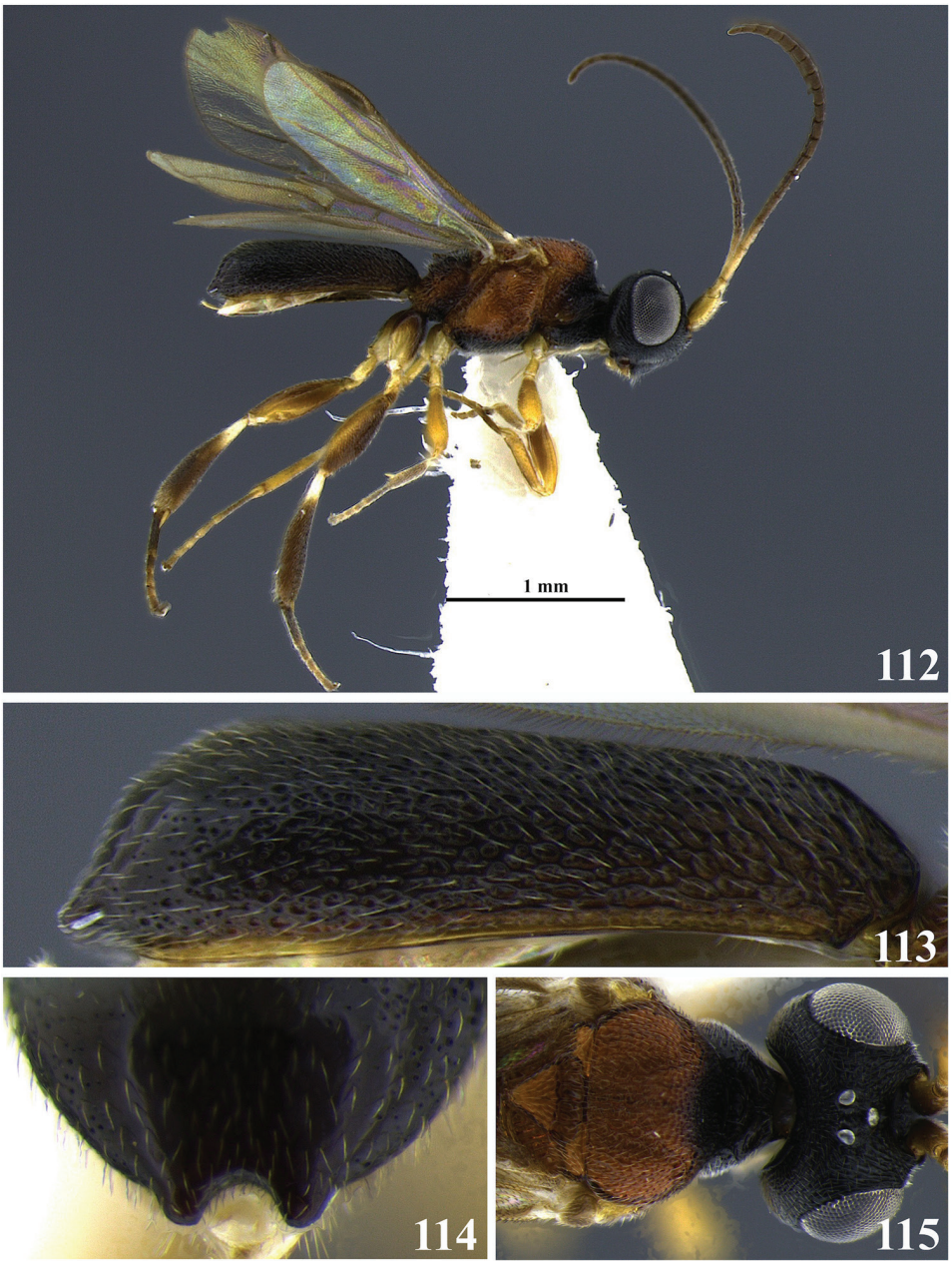
Remarks. *Leptodrepana soussanae* is superficially similar to *L. thema* but may be distinguished from this species by its robust body, over 3mm in length, uniform thickness of the flagellum and the densely setose circular area below the stigma suffused with brown pigmentation and covering apical half of 1st submarginal cell and most of 2nd submarginal cell. *Leptodrepana thema* is small, less than 2.5 mm. The flagellum appears slightly dilated medially. The wings are lightly suffused with yellowish brown pigment and do not have a densely setose darkly pigmented patch below the stigma.

Etymology. This species name is a patronym in honor of a sister of SDD, Soussan Parker Dadelahi.

Leptodrepana stasia Dadelahi & Shaw, sp. n.

http://zoobank.org/599BA93F-0F9C-4AD1-857D-73A1BD08382D
Figs 112–115

Diagnosis. Presence of 2 tubercles on the apex of the carapace. The penultimate flagellomere is almost the same length as the ultimate flagellomere. The carapace is completely brownish black; head and carapace brownish black; mesosoma mostly orange, anteriorly and ventrally blackish; wings lightly pigmented with yellowish brown venation.



Figures 112–115. *Leptodrepana stasia.* **112** Female habitus in lateral view **113** metasoma in lateral view **114** metasoma in dorso-posterior view with a couple of pointing-terminal projections **115** head and mesoscutum in dorsal view.

Holotype female. BL 2.53 mm; FWL 2.13 mm; CL 1.16 mm; CW 0.36 mm; CL/CW 3.2.

Description. *Color*. Head brownish black, mandibles yellow, blackish brown apically; palpi yellowish white; antennae brown with scape, pedicel and first flagellomere

yellowish white; mesosoma mostly orange, median mesonotal lobe black, postero-ventral portion of mesopleuron black, posterior metapleuron black; propodeum orangish black; middle and fore leg coxae yellowish white, remainder of legs brown; hind leg coxa brown basally and yellowish brown apically, trochanter yellowish brown, femur and tibia brown and tibia with basal white band; wings lightly pigmented with yellowish brown venation; carapace blackish brown.

Head. HW 0.73 mm; HL 0.6 mm; HW/HL 1.22; face, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, rugulose-punctate and median carina present; clypeus punctate and apical margin rounded; occipital carina complete.

Mesosoma. Pronotum foveate antero-laterally to rugose-punctate at propleural margin; propleuron weakly areolate-rugose; mesoscutum medially with irregular parallel pitted grooves between notauli difficult to distinguish and appears areolate-rugose; notauli visible anteriorly; median and lateral mesonotal lobes rugose-punctate; scutellar sulcus with 6 well-defined depressions, all longer than wide; scutellar disc punctate; mesopleuron anteriorly rugose foveolate, medially weakly punctate, narrow foveate band at precoxal sulcus, foveolate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to punctate at apex; in posterior and dorsal views, apex terminating in two thick tubercles close together; in lateral view, carapace terminates in narrow sloping point below midline.

Variation of paratype females. Metapleuron orange and black; lateral pronotum orange and black; HW 0.73–0.75 mm; HL 0.63 mm; HW/HL 1.16–1.2; BL 2.5–2.8 mm; FWL 2.13–2.3 mm; CL 1.16 mm; CW 0.32–0.36 mm; CL/CW 3.2–3.63.

Paratype males. No males.

Material examined. Holotype female: GUANACASTE, Arenales W side Volcan Cacao, 900 m, 1988–1989 (P. Hanson) [UWIM]. Paratype data: 1♀, same data as holotype.

Remarks. *Leptodrepana stasia* is superficially similar to both *L. ninae* and *L. conleyae* in color and the presence of 2 tubercles on the apex of the carapace. However it may be easily distinguished from both of these species. In *L. stasia* the penultimate flagellomere is almost the same length as the ultimate flagellomere. The carapace is completely brownish black. In both *L. ninae* and *L. conleyae* the penultimate flagellomere is almost the same length as width and approximately half the length of the ultimate flagellomere. Additionally, the carapace of both species is yellowish white basally.

Etymology. This species name is an arbitrary arrangement of letters to form a euphonious combination.

Leptodrepana strategeri Dadelahi & Shaw, sp. n.

http://zoobank.org/111C5EB3-3ED3-4AA0-A48E-B07ED859A770
Figs 116–120

Diagnosis. In dorsal and posterior views, apex rounded; in lateral view, apex terminates in broad rounded point. The scutellar sulcus has 4–5 well-defined depressions and the meso-

Figures 116–120. *Leptodrepana strategeri.* **116** Female habitus in lateral view **117** female habitus in dorsal view **118** metasoma in dorso-posterior view terminating truncated **119** metasoma in lateral view **120** metasoma in dorsal view.

pleuron has a scrobiculate groove at the precoxal sulcus. In females, the flagellum is light brown. Body mostly blackish brown except carapace with basal third yellowish white.

Holotype female. BL 2.13 mm; FWL 1.73 mm; CL 0.92 mm; CW 0.28 mm; CL/CW 3.28.

Description. *Color*. Head black, clypeus brown, and mandibles yellow, brown apically; palpi yellowish white; antennae light brown with scape and pedicel yellowish white; mesosoma black; legs mostly yellowish brown except coxa, trochanter, trochantellus and basal portions of femur and tibia yellowish white; wings lightly pigmented with darker area below stigma covering apical half of 1st submarginal cell and anterior portion of 2nd submarginal cell; yellowish brown venation; carapace blackish brown with basal third yellowish white.

Head. HW 0.63 mm; HL 0.45 mm; HW/HL 1.39; face finely punctate, genae, vertex and ocellar triangle rugulose-punctate; frons depressed, impunctate and median carina lacking; clypeus finely punctate and apical margin rounded; occipital carina complete; antennae with flagellum slightly dilated medially.

Mesosoma. Pronotum densely foveolate antero-laterally to punctate at propleural margin; propleuron foveolate to weakly areolate-rugose; mesoscutum medially with irregular pitted grooves between notauli so that area appears areolate-rugose; notauli narrow and visible anteriorly; median and lateral mesonotal lobes densely foveolate; scutellar sulcus with 4–5 well-defined depressions, length almost equal to width; scutellar disc foveolate; mesopleuron anteriorly rugose-foveolate, medially shiny and weakly punctate, scrobiculate groove at precoxal sulcus and weakly punctate posteroventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace areolate-rugose to shiny and weakly punctate at apex; in dorsal and posterior views, apex rounded; in lateral view, apex terminates in broad rounded point.

Variation of paratype females. Color: frons with faint median carina more visible anteriorly than posteriorly; first basal flagellomere yellowish brown; HW 0.63–0.65 mm; HL 0.5–0.53 mm; HW/HL 1.19–1.3; BL 2.13–2.2 mm; FWL 1.73–1.87 mm; CL 0.92–0.96 mm; CW 0.28–0.32 mm; CL/CW 2.88–3.43.

Paratype males. No males.

Material examined. Holotype female: SAN JOSE, Ciudad Colon, 80 m, xii.1989–iii.1990 (L. Fournier) [UWIM]. Paratype data: 1♀, GUANACASTE, Arenales, W. side of Volcan cacao, 900 m, xi–xii.1990; 1♀, same as holotype; 2♀, same data except iii–iv. 1990; 2♀, same data except iv–v.1990.

Remarks. Superficially *L. strategeri* is similar to *L. ronnae* but may be distinguished from this species by the lack of a transverse carina at the carapace apex in posterior view. The carapace is shiny and weakly punctate at the apex. The scutellar sulcus has 4–5 well-defined depressions and the mesopleuron has a scrobiculate groove at the precoxal sulcus. In females, the flagellum is light brown. *Leptodrepana ronnae* has a transverse carina at the carapace apex in posterior view and the apex appears rugulose. The scutellar sulcus has only three well-defined depressions and the mesopleuron has shallow irregularly shaped pits at the precoxal sulcus. In females the flagellum is brown but bears a yellowish white annulus at flagellomeres 4–6.

Etymology. This species name is an arbitrary arrangement of letters to form a euphonious combination.

Leptodrepana thema **Dadelahi & Shaw, sp. n.**
http://zoobank.org/FDB0797C-B7A9-424D-B5F6-FE81FC47030E
Figs 121–125

Diagnosis. Small body size, less than 2.5 mm. In posterior, dorsal, and lateral views, carapace apex rounded. The flagellum appears slightly dilated medially. The wings are lightly suffused with yellowish brown pigment and do not have a densely setose darkly pigmented patch below the stigma.

Holotype female. BL 2.06 mm; FWL 1.87 mm; CL 0.92 mm; CW 0.36 mm; CL/CW 2.56.

Description. *Color*. Head blackish brown, mandibles yellow, blackish brown apically; apical margin of clypeus yellowishish brown; palpi yellowish white; antennae with scape and pedicel a yellowish brown and flagellum brown; mesosoma blackish brown; middle and fore legs yellow; hind leg mostly yellow except apical portions of femur and tibia yellowish brown; wings suffused with light yellowish brown pigment; venation yellowish brown; basal third of carapace yellowish white and apical 2/3 of carapace blackish brown.

Head. HW 0.68 mm; HL 0.53 mm; HW/HL 1.58; face, genae, vertex and ocellar triangle coarsely rugulose-punctate; frons depressed, coarsely rugulose-punctate with fine parallel lineation lateral to median carina; clypeus punctate and apical margin rounded; occipital carina complete; antennae with a slightly dilated appearance medially.

Mesosoma. Pronotum deeply foveate antero-laterally to weakly areolate-rugose at propleural margin; propleuron weakly areolate-rugose; mesoscutum areolate-rugose, mesonotal lobes not differentiated from median mesoscutum; notauli indistinct and visible anteriorly; scutellar sulcus with five well-defined depressions, all longer than wide; scutellar disc rugose-punctate; mesopleuron anteriorly rugose, medially coarsely foveate, foveate groove at precoxal sulcus, foveate postero-ventrally; propodeum coarsely areolate-rugose with distinct transverse carina raised into small and roughly equal medial and lateral flanges.

Metasoma. Carapace completely areolate-rugose; in posterior, dorsal, and lateral views, carapace apex rounded.

Variation of paratype females. HW 0.7–0.75 mm; HL 0.575 mm; HW/HL 1.21–1.30; BL 2.26–2.4 mm; FWL 1.86–2.06 mm; CL 0.96–1.04 mm; CW 0.4–0.44 mm; CL/CW 2.36–2.4.

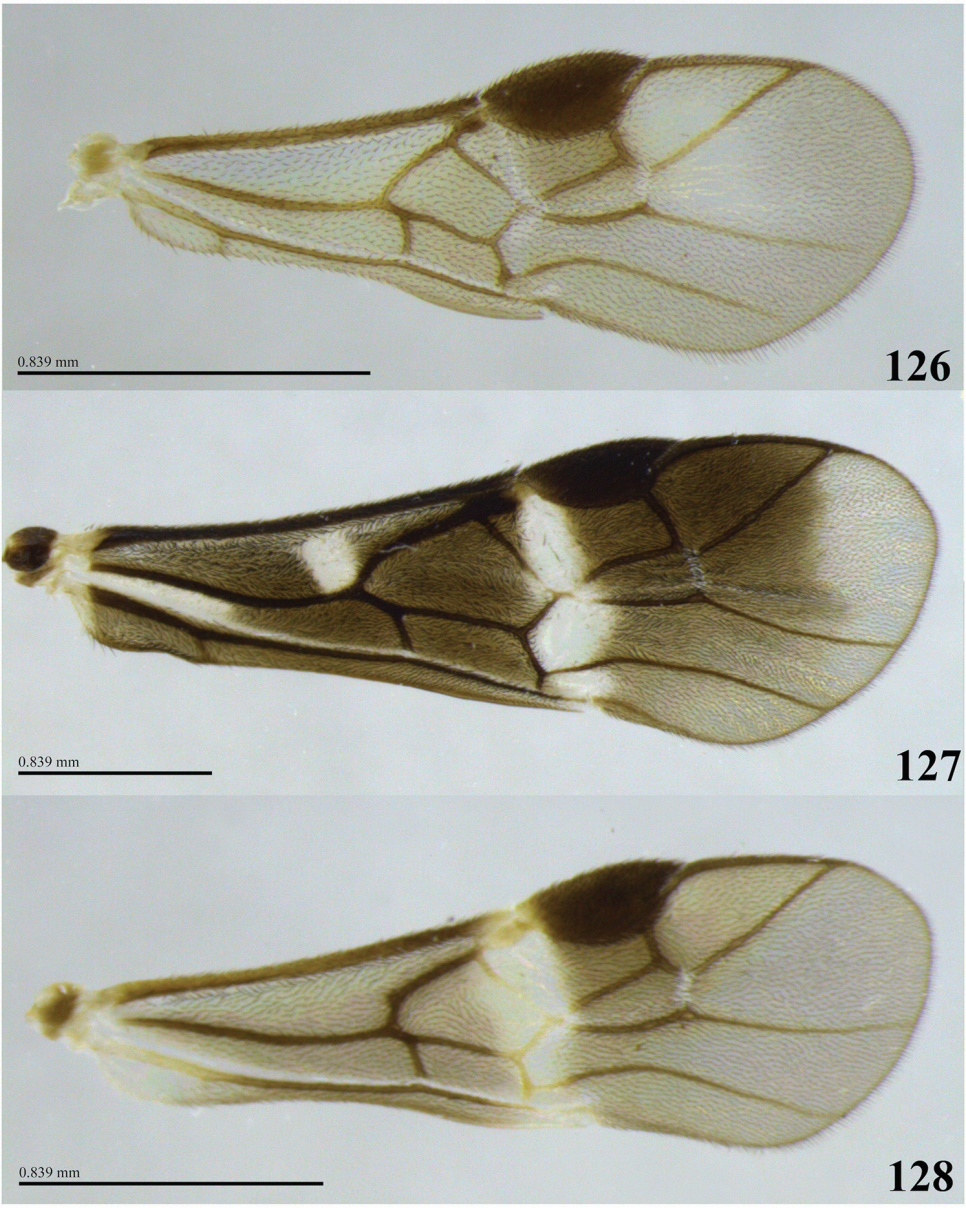
Paratype males. No males.

Material examined. Holotype female: GUANACASTE, P. N. Santa Rosa, Bosque San Emilio, 50 year old deciduous forest in clearing fully isolated part of day, 300 m, 24.v–14.vi.1986 (I. Gauld & D. Janzen) [UWIM]. Paratype data: 1♀, same data as holotype; 1♀, same data except 31.i–21.ii.1987; 1♀, same data except site #2, open regenerating woodland, 10 years old, more or less fully shaded as possible, 6–27.ix.1986.

Remarks. *Leptodrepana thema* is superficially similar to *L. soussanae* but may be distinguished from this species by its small body size, less than 2.5 mm. The flagellum

Figures 121–125. *Leptodrepana thema.* **121** Female habitus in lateral view **122** female habitus in dorsal view **123** metasoma in dorso-posterior view terminating rounded **124** metasoma in lateral view **125** metasoma in dorsal view.

appears slightly dilated medially. The wings are lightly suffused with yellowish brown pigment and do not have a densely setose darkly pigmented patch below the stigma. *Leptodrepana soussanae* has a robust body, more than 3 mm in length. The thickness of



Figures 126–128. Wing color patterns in *Leptodrepana*. **126** *Leptodrepana alexisae.* **127** *Leptodrepana rosanadana.* **128** *Leptodrepana sorayae.*

the flagellum is uniform. The wing bears a densely setose circular area below the stigma that is suffused with brown pigmentation and covers the apical half of 1st submarginal cell and most of 2nd submarginal cell.

Etymology. This species name is an arbitrary arrangement of letters to form a euphonious combination.

Discussion

The flagellum of all female *Leptodrepana* described here is reduced to 17 flagellomeres. This reduction is also found in two N. American species described by Shaw (1983): *L. opuntiae* and *L. oriens.* Since this character is found in all female Costa Rican *Leptodrepana* it may be a synapomorphic character closely relating these species to *L. opuntiae* and *L. oriens*.

The species described in this work differ slightly from Shaw's (1983) generic diagnosis. All females of Costa Rican *Leptodrepana* have 17 flagellomeres. The depressions of the scutellar sulcus vary from 3–8, and the propodeal tubercles are often distinct. In the original diagnosis, Shaw (1983) stated that the flagellum is sometimes reduced to 17 flagellomeres and that the scutellar sulcus usually consists of 7–10 depressions. Additionally, the diagnosis holds that the propodeal tubercles of *Leptodrepana* are usually short or indistinct.

None of the newly described Costa Rican species share the intermediate character states sometimes found in the Palearctic species. Intermediate forms are problematic but the solution is not synonymy. As noted in the introduction, inclusion of *Leptodrepana* in *Ascogaster* renders the genus paraphyletic. This is no less problematic than the question of what to do with intermediate forms between the two genera. Phylogenetic data support genus status in *Leptodrepana*, in addition to strong morphological and biological evidence (Chen 1999, Shaw 1983, 1997).

Acknowledgments

Many thanks are due to the curators and institutions that loaned the specimens used in this study: Carolina Godoy and the Instituto Nacional de Biodiversidad; Suzanne Lewis and the Natural History Museum; W. J. Pulawski and the California Academy of Sciences. Special thanks is given to Professor Paul Hanson, of the Universidad de Costa Rica, for running extensive numbers of Malaise traps, and countless hours of sorting braconids from bulk samples. Funding and academic support for Samin Dadelahi was provided by the McNair Scholars Program, the National Science Foundation (Research Experience for Undergraduates program), and the University of Wyoming Graduate School. Imaging equipment and additional funding was provided by National Science Foundation grants DEB-10-20751 and DEB 14-42110 (Dimensions of Biodiversity Program). Any opinions, findings, and conclusions expressed are those of the authors and do not necessarily reflect the views of the National Science Foundation. Travel was supported, in part, by grants from U.W. International Program and the U.W. Global Perspectives Program.

References

van Achterberg C (1990) Revision of the western Palearctic Phanerotomini (Hymenoptera, Braconidae). Zoologische Verhandelingen Leiden 255: 3–106. http://repository.naturalis.nl/document/148860

Chen Y (1999) Polydnaviruses of the chelonine egg-larval parasitoids. PhD Thesis, Washington State University, Pullman.

Dudarenko GP (1974) Formation of the abdominal carapace in braconids (Hymenoptera, Braconidae) and some aspects of the classification of the family. Entomological Review 53: 80–90.

Harris RA (1979) A glossary of surface sculpturing. Occasional Papers in Entomology 28: 1–31. https://www.cdfa.ca.gov/plant/ppd/PDF/Occasional_Papers%20_28.pdf

Huddleston T (1984) The Palearctic species of *Ascogaster* (Hymenoptera, Braconidae). Bulletin of the British Museum (Natural History) (Entomology) 49: 341–392. https://biodiversitylibrary.org/page/2288257

Kittel RN, Austin AD (2014) Synopsis of Australian chelonine wasps (Hymenoptera, Braconidae, Cheloninae) with description of two new genera. Austral Entomology 53: 183–202. http://dx.doi.org/10.1111/aen.12070

Kittel RN, Austin AD, Klopfstein S (2016) Molecular and morphological phylogenetics of chelonine parasitoids waps (Hymenoptera, Braconidae), with a critical assessment of divergence time estimations. Molecular Phylogenetics and Evolution 101: 224–241. https://www.ncbi.nlm.nih.gov/pubmed/27179700

Sharkey MJ, Wharton RA (1997) Morphology and terminology. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of the New World Genera of the Family Braconidae (Hymenoptera). Special Publication of the International Society of Hymenopterists, Washington DC, 20–37.

Shaw MR, Huddleston T (1991) Classification and biology of braconid wasps (Hymenoptera, Braconidae). Handbooks for Identification of British Insects. Royal Entomological Society of London, London, 126 pp.

Shaw SR (1983) A taxonomic study of Nearctic *Ascogaster* and a description of a new genus *Leptodrepana* (Hymenoptera, Braconidae). Entomography 2: 1–54.

Shaw SR (1995) The Braconidae. In: Hanson P, Gauld I (Eds) The Hymenoptera of Costa Rica. Oxford University Press, Oxford, 431–464.

Shaw SR (1997) Subfamily Cheloninae. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of the New World Genera of the Family Braconidae (Hymenoptera). Special Publication of the International Society of Hymenopterists, Washington DC, 192–201.

Shaw SR, Dadelahi S (2002) *Ascogaster bugabensis* Cameron belongs in the Helconinae sensu lato (Hymenoptera, Braconidae). Journal of Hymenoptera Research 11: 368–369.

Shaw SR (2006) Familia Braconidae. In: Hanson P, Gauld I (Eds) Hymenoptera de la Región Neotropical. Memoirs of the American Entomological Institute, Philadelphia, 487–525.

Tang Y, Marsh PM (1994) A taxonomic study of the genus *Ascogaster* in China (Hymenoptera, Braconidae, Cheloninae). Journal of Hymenoptera Research 3: 279–302. https://biodiversitylibrary.org/page/2867899

Wharton RA, Marsh PM, Sharkey MJ (Eds) (2017) Identification Manual of the New World Genera of the Family Braconidae (Hymenoptera), vol. 1 (2nd edn). International Society of Hymenopterists Special Publication, Washington DC, 486 pp.

Yu DS (2014) Taxapad. Home of Ichneumonoidea. http://www.taxapad.com

Zettel H (1990) Eine Revision der Gattungen der Cheloninae (Hymenoptera, Braconidae) mit Beschreibungen neuer Gattungen und Arten. Annales Naturhistoriches Museum Wien 91: 147–196. http://www.jstor.org/stable/41766816

ZooKeys 750: 131–140 (2018)
doi: 10.3897/zookeys.750.23486
http://zookeys.pensoft.net

RESEARCH ARTICLE

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

A new species of *Neopanorpa* with an extremely long notal organ from Sichuan, China (Mecoptera, Panorpidae)

Meng Wang[1], Bao-Zhen Hua[2]

1 *Key Laboratory of Plant Protection Resources and Pest Management, Ministry of Education, Entomological Museum, Northwest A&F University, Yangling, Shaanxi 712100, China*

Corresponding author: *Bao-Zhen Hua* (huabzh@nwafu.edu.cn)

Academic editor: *B. Price* | Received 8 January 2018 | Accepted 26 March 2018 | Published 18 April 2018

http://zoobank.org/8921358B-5CDA-4A41-BD2B-22AAF54A75A7

Citation: Wang M, Hua B-Z (2018) A new species of *Neopanorpa* with an extremely long notal organ from Sichuan, China (Mecoptera, Panorpidae). ZooKeys 750: 131–140. https://doi.org/10.3897/zookeys.750.23486

Abstract

Neopanorpa setigera **sp. n.** is described and illustrated from Sichuan, China. It is characterized by an extremely long notal process, a well-developed postnotal organ, and a pair of setiferous gonostyli. This is the second species of *Neopanorpa* van der Weele with an extremely long notal organ in Sichuan. A key to Sichuan species of *Neopanorpa* is provided.

Keywords

Gonostylus, Insecta, mating behavior, postnotal organ

Introduction

Panorpidae are the most speciose family of Mecoptera with approximately 420 species assigned in seven genera (Hu et al. 2015; Gao et al. 2016). They are commonly called scorpionflies due to their swollen male genital bulb bearing striking resemblance to the sting of scorpions. Scorpionflies are generally distributed over the Holarctic and the Oriental regions. They often inhabit deep and mesic forests and are commonly encountered among dense herbaceous vegetation in lowlands or open areas near water (Carpenter 1931a; Byers and Thornhill 1983). They are saprophagous insects, mainly

feeding on dead arthropods (Byers and Thornhill 1983). They also feed on fruits, and likely flower pollens sometimes (Byers and Thornhill 1983).

Panorpidae exhibit diversity in mating behavior and strategies. The males generally provide a prey or salivary secretions as nuptial gifts, or practice coercive mating to the female during copulation (Thornhill 1980; Zhong and Hua 2013; Zhong et al. 2015a, b). Recent studies show that the mating strategies are closely related with some non-genital structures, for example the notal organ and anal horns (Zhong and Hua 2013; Zhong et al. 2015a). The notal organ is the posterior median process of abdominal tergum III (notal process) paired with the minor projection on tergum IV (postnotal organ) as an appendage to clamp the wings of the female during copulation and plays a significant role in prolonging the copulatory duration (Mickoleit 1971; Thornhill 1980; Thornhill and Sauer 1991; Zhong and Hua 2013). In *Furcatopanorpa longihypovalva* (Hua & Cai) the absence of notal organ leads it to prolong the copulatory duration by providing serial salivary secretions instead of seizing the female wings (Zhong et al. 2015b). In contrast, *Neopanorpa longiprocessa* Hua & Chou bears a greatly elongate notal organ, and lacks nuptial feeding during courtship and copulation (Zhong and Hua 2013).

Neopanorpa van der Weele is the second largest genus of Panorpidae endemic to the Oriental Region. China owns the greatest species richness with 95 of the total 160 species to date (Wang and Hua 2017). The genus is characterized by vein 1A ending before the origin of Rs. Most species are morphologically distinguished from other genera by the slender wings, an elongate notal organ, and undeveloped salivary glands (Ma et al. 2011). *Neopanorpa* eggs exhibit separate and independent neighbouring ridges on the exochorion, whereas those ridges are fused together among other genera in Panorpidae (Ma et al. 2009). In addition, the larvae adopt a euedaphic life with the presence of shallow furrows on the head and prolegs of the first four abdominal segments greatly reduced (Jiang and Hua 2015).

Sichuan is located in the southwestern part of China, and is mostly covered by masses of high mountains. Its western part belongs to the Hengduan Mountains, one of the well-known biodiversity hotspots in the world (Myers et al. 2000). Eleven species of *Neopanorpa* have been recorded from Sichuan so far (Carpenter 1938, 1945; Cheng 1949, 1957; Wang and Hua 2017). However, the taxonomy of *Neopanorpa* is poorly known yet in this region to date. Recently, an eye-catching species of *Neopanorpa* from Sichuan with a greatly elongate notal organ and a pair of setiferous gonostyli was recognized as new to science. The discovery of this new species raises the number of *Neopanorpa* in Sichuan to twelve species in total. A key to Sichuan species of *Neopanorpa* is provided.

Materials and methods

Adult specimens were captured in the mountainous area of Sichuan province, China in July 2016 and preserved in 75% ethanol. The holotype and paratypes are deposited in the Entomological Museum, Northwest A&F University, Yangling, China (**NWAFU**).

Males and females were dissected and photographs were taken with an advanced Stereo Microscope system Discovery V20 (Zeiss, Germany). Serial photographs were stacked with software Helicon Focus Pro 6.2.2 and further processed with Adobe Photoshop CS6. The measurements of wings were conducted with an electronic digital caliper.

Results

Key to Sichuan species of *Neopanorpa* (males)

Males of the following species are unknown: *N. banksi* Carpenter, *N. latipennis* Cheng, *N. parva* Carpenter, and *N. varia* Cheng.

1 Notal organ extended beyond abdominal tergum VI **2**
– Notal organ extended not beyond abdominal tergum IV **3**
2 Body generally black ..... ***N. setigera* sp. n.**
– Body generally yellowish brown ..... ***N. choui* Cheng**
3 Wing markings with broad apical band and pterostigmal band **4**
– Wing markings generally absent **5**
4 Abdominal segment VII–IX (A7–A9) dark brown ..... ***N. heii* Cheng**
– A7–A9 yellowish brown ..... ***N. chelata* Carpenter**
5 Vein R_2 trifurcated **6**
– Vein R_2 bifurcated **7**
6 Thorax generally brown; notal organ extended nearly to posterior margin of abdominal tergum IV, ended with a pointed apex ..... ***N. validpennis* Cheng**
– Thorax with a brown median band; notal organ extended not beyond the middle of abdominal tergum IV, ended with a truncated apex ..... ***N. taoi* Cheng**
7 A7–A9 yellowish brown ..... ***N. claripennis* Carpenter**
– A7–A9 uniformly black ..... ***N. nigritis* Carpenter**

Key to Sichuan species of *Neopanorpa* (females)

Females of the following species are unknown: *N. taoi* Cheng and *N. validpennis* Cheng.

1 Wings mostly unmarked **2**
– Wings with distinct apical or pterostigmal band **3**
2 Thorax with a brown median band; A7–A9 yellowish brown ..... ***N. claripennis* Carpenter**
– Thorax black; A7–A9 black ..... ***N. nigritis* Carpenter**
3 Thorax generally black or brown **4**
– Thorax with a brown median band **5**

4 Wing markings with pterostigmal band forked posteriorly..... ..... ***N. parva* Carpenter**
– Wing markings with pterostigmal band reduced to a stripe on pterostigma and three discrete spots lining diagonally ..... ***N. setigera* sp. n.**
5 Genital plate with axis not extended beyond main plate **6**
– Genital plate with axis extended beyond main plate for a short length **8**
6 Main plate of female genital plate protruded laterally on each side..... **7**
– Main plate of female genital plate not protruded laterally on each side .... ***N. heii* Cheng**
7 Genital plate with main plate bearing two processes basally .... ***N. banksi* Carpenter**
– Genital plate with main plate bearing no process basally..... ***N. varia* Cheng**
8 Posterior arms of female genital plate with V-shaped incisions apically..... ..... ***N. choui* Cheng**
– Posterior arms of female genital plate without V-shaped incision apically.... **9**
9 Rostrum uniformly yellowish brown..... ***N. chelata* Carpenter**
– Rostrum with a brown longitudinal stripe along clypeus.... ***N. latipennis* Cheng**

***Neopanorpa setigera* sp. n.**
http://zoobank.org/7205D935-75D9-4D2E-B633-227BB1DA5774
Figs 1–2

Type material. Holotype: CHINA: Sichuan: ♂, Shimian County (29°1.23'N, 102°23.65'E), 2000–2200 m, 02 July 2016, leg. Gui-Lin Hu and Wei Du, ME000285 (NWAFU). **Paratypes.** 18♂♂16♀♀, same data as holotype, ME000286–ME000320 (NWAFU).

Diagnosis. The new species can be readily recognized from its congeners by the following characters: body mostly black; wings slightly tinged with brown, wing markings only with greatly reduced apical band and a stripe on the pterostigma; notal process greatly elongated and extended beyond the posterior margin of abdominal tergum VI; postnotal organ well-developed, represented as three hirsute protruded areas on abdominal terga IV–VI respectively; male gonostylus bearing a cluster of long setae on central portion ventrally; female genital plate with a pair of parallel posterior arms slightly longer than axis.

Description of male (Fig. 1A). Forewing length 13.53 ± 0.40 mm, width 4.48 ± 0.18 mm; hindwing length 12.48 ± 0.38 mm, width 3.23 ± 0.10 mm (n = 10).

Head (Fig. 1C). Vertex and ocellar triangle black. Rostrum yellowish brown with two dark brown longitudinal stripes along clypeus.

Thorax (Fig. 1D). Pronotum black. Meso- and metascutum mostly blackish brown, grading to light brown laterally adjacent to wing base.

Wings (Fig. 1A). Slightly tinged with brown; R_2 bifurcated. Wing markings dark brown, mostly absent, only with apical band reduced to obscure markings at apical part of wings and pterostigmal band reduced to a slender stripe on pterostigma.

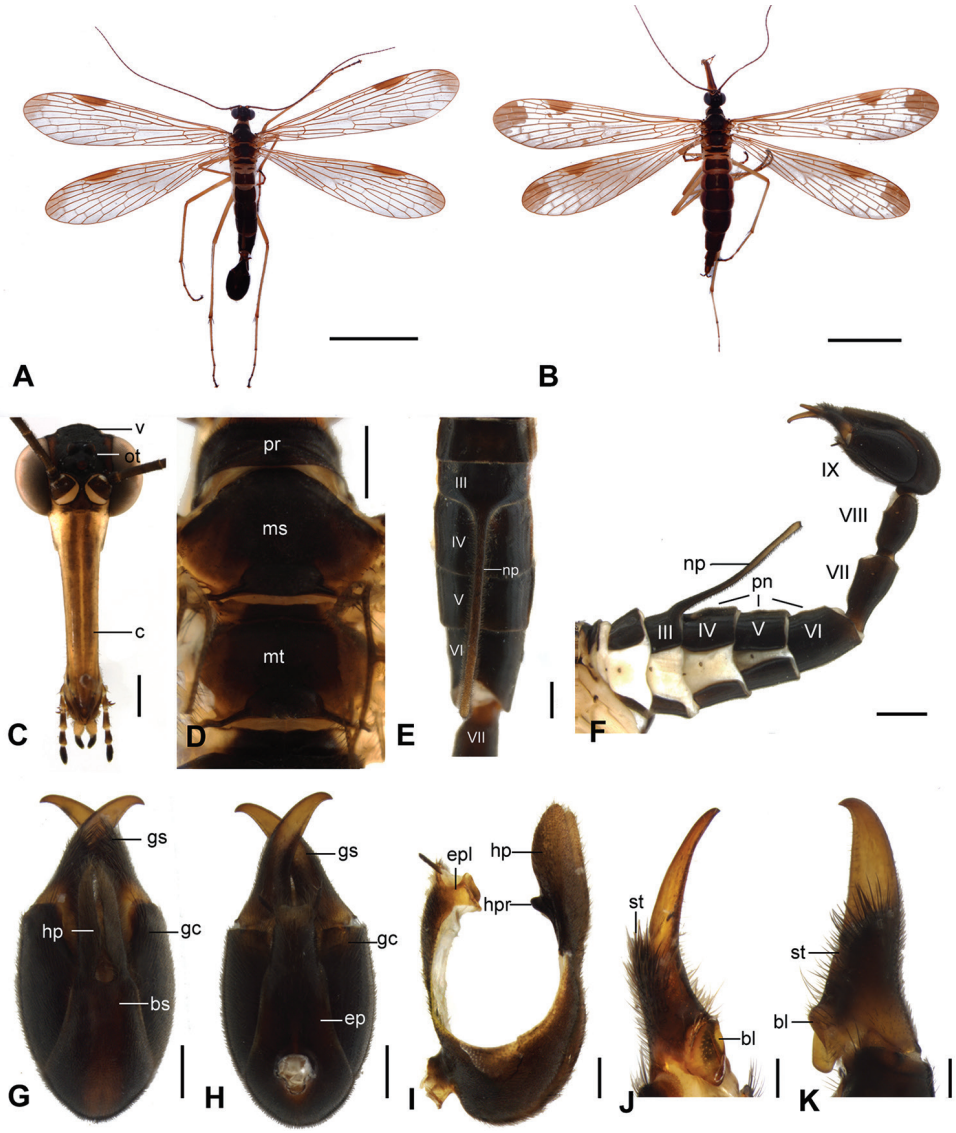


Figure 1. *Neopanorpa setigera* sp. n. **A** Male habitus, dorsal view **B** Female habitus, dorsal view **C** Head, frontal view **D** Thorax, dorsal view **E** Notal organ, dorsal view **F** Male abdomen, left lateral view **G** Male genital bulb, ventral view **H** Male genital bulb, dorsal view **I** Male 9th abdominal tergum and sternum, lateral view **J** Gonostylus, lateral view **K** Gonostylus, ventral view. Abbreviations: **bl** basal lobe **bs** basal stalk **c** clypeus **ep** epandrium **epl** epandrial lobe **gc** gonocoxite **gs** gonostylus **hp** hypovalve **hpr** hypandrial process **ms** mesoscutum **mt** metascutum **np** notal process **ot** ocellar triangle **pn** postnotal organ **pr** pronotum **st** setae **v** vertex. Scale bars: 5 mm (**A, B**); 0.5 mm (**C–E, G–H**); 0.2 mm (**I–K**); 1 mm (**F**).

Abdomen. Terga I–V black (Fig. 1A, E). Abdominal segment VI (A6) black, grading to brown at caudal end, A7–A8 blackish brown, constricted at base (Fig. 1F). Notal process on tergum III triangular at base, extending caudally as a long setiferous

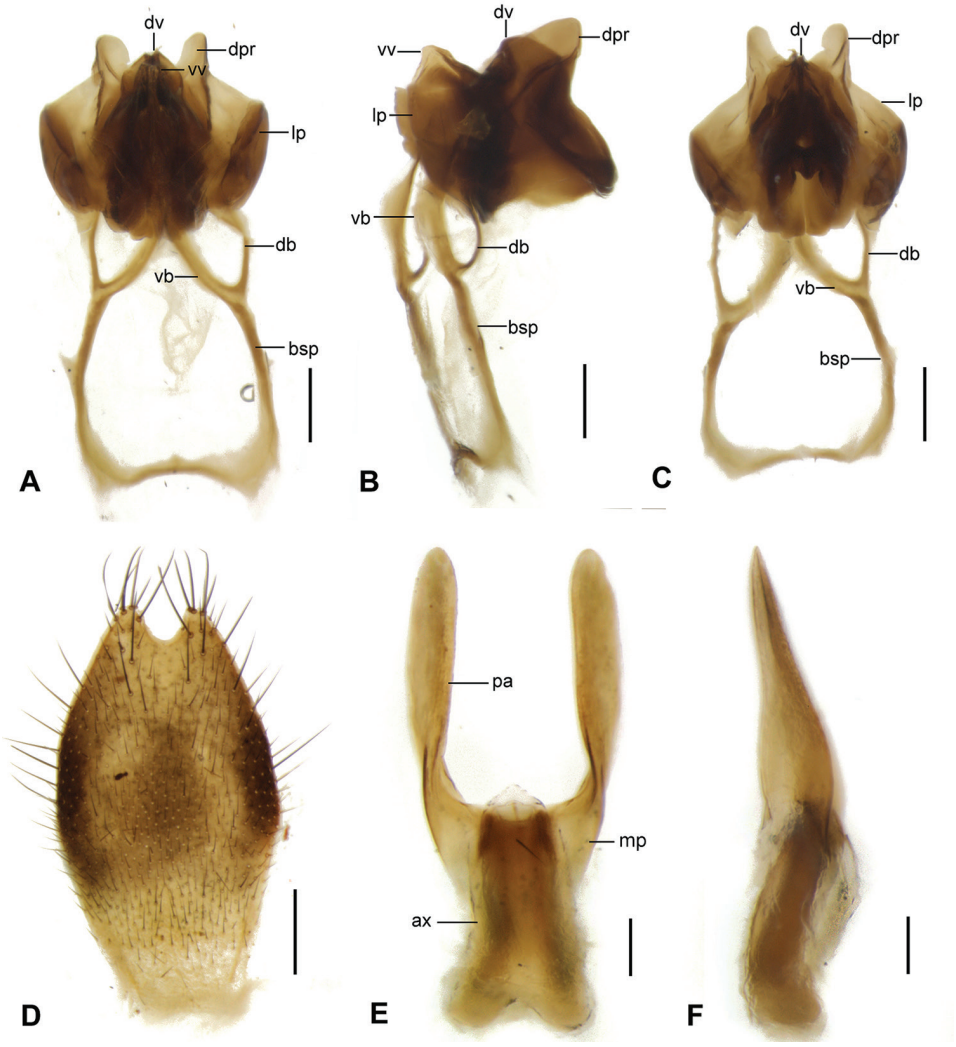


Figure 2. *Neopanorpa setigera* sp. n. **A** Aedeagal complex, ventral view **B** Aedeagal complex, lateral view **C** Aedeagal complex, dorsal view **D** Subgenital plate, ventral view **E** Genital plate, ventral view **F** Genital plate, lateral view. Abbreviations: **ax** axis **bsp** basal stalk of paramere **db** dorsal branch of paramere **dpr** dorsal process **dv** dorsal valve **lp** lateral process **mp** main plate **pa** posterior arm **vb** ventral branch of paramere **vv** ventral valve. Scale bars 0.2 mm (**A–D**); 0.1 mm (**E, F**).

stick beyond the posterior margin of tergum VI; postnotal organ represented as three discontinuous hirsute protruded areas on terga IV–VI, respectively (Fig. 1F).

Male genitalia (Fig. 1G–H). Generally black. Hypandrium with broad basal stalk for nearly half length; basal stalk black on lateral areas and brown mesally; hypovalves slender, tapering toward membranous setiferous apices, extending to middle of gonostylus (Fig. 1G); in lateral aspect, hypovalves expanded dorsally at apical half into broad elliptical lobes, with conical hypandrial processes projected dorsally at basal third

(Fig. 1I). Epandrium broad, tapering toward apex, with lateral margins abruptly narrowed at apical third, ended with truncate membranous apex; epandrial lobes subrectangular, yellowish brown (Fig. 1I). Gonostylus stout, strongly concave at outer margin near base (Fig. 1K), furnished with a cluster of black long setae ventrally in central part; median tooth barely raised; basal lobe large, flat, greatly concaved mesally (Fig. 1J, K).

Aedeagal complex (Fig. 2A–C). Strongly sclerotized. Ventral valves expanded ventrally into broad lobes, tapering toward apices; dorsal valves large, slightly longer than ventral valves (Fig. 2A, B). Paramere Y-shaped, with very long basal stalk; the stalks fused basally as large subrectangular frame; paramere forked distally into ventral branch and dorsal branch; ventral branch slender basally but broad-lobed, membranous apically and extended to the middle of ventral valves (Fig. 2A); dorsal branch slender, arc-shaped (Fig. 2B); lateral process greatly developed, broadly expanded in the same length with ventral valves, curved ventro-mesally, with apex rounded and projected distally; dorsal process large, auriculate (Fig. 2A–C).

Description of female (Fig. 1B). Forewing length 14.43 ± 0.40 mm, width 3.34 ± 0.12 mm; hindwing length 13.28 ± 0.35 mm, width 3.18 ± 0.11 mm (n = 10). Same pattern as in the male. Female with more extensive wing markings. In forewings, apical band more extensive with pterostigmal band represented as a wide stripe at pterostigma and three little discrete spots lining diagonally. Abdomen black.

Female genitalia. Subgenital plate (Fig. 2D) long elliptical, with deep V-shaped emargination at apex, central part and median lateral margin blackish brown, the remainder yellowish brown, bearing long setae along margins. Genital plate (Fig. 2E, F) with axis extending anteriorly beyond main plate for half length, forked slightly proximally; posterior arms greatly developed, spatulate, extended caudally in parallel, slightly longer than axis, strongly constricted near base, rounded at apices; in lateral aspect, posterior arms greatly expanded ventrally at base and axis slightly curved dorsally.

Distribution. China (Sichuan).

Etymology. The specific epithet is derived from the Latin, *setigera* meaning setiferous, referring to the cluster of long dense setae on the male gonostyli.

Remarks. *N. setigera* sp. n. resembles *N. nigritis* Carpenter, 1938 from Sichuan in black body and absence of wing markings. However, the extremely long notal organ of *N. setigera* sp. n. makes it easy to distinguish from *N. nigritis*. In addition, *N. choui* Cheng, 1949 in Sichuan has the similar lengthened notal organ. However, these two species differ greatly in body coloration. *N. choui* is yellowish brown, while *N. setigera* sp. n. is mostly black.

Habitat. Adult specimens were captured on lower broad-leaved herbs or shaded vegetation under trees in lush evergreen forests. The environment is enclosed and moist.

Discussion

Neopanorpa setigera sp. n. is similar to the Chinese species *N. choui*, *N. longiprocessa*, and *N. moganshanensis* Zhou & Wu by bearing an elongate notal organ extending beyond

abdominal tergum VI. Compared with those species, the new species is unusual due to its greatly developed postnotal organ. The postnotal organ is barely raised, yet represented as a long stripe of hirsute area in *N. choui*, extending from the anterior margin to the posterior margin of abdominal tergum IV. Alternatively, the postnotal organs are both represented as a raised process with dense setae on abdominal tergum IV in *N. moganshanensis* and *N. longiprocessa* (Zhong and Hua 2013). The postnotal organ is limited on abdominal tergum IV in all the other species, but consists of three protruded areas with dense setae on abdominal terga IV–VI in *N. setigera* sp. n., respectively. *N. setigera* sp. n. displays the most developed postnotal organ in the extant species of Panorpidae.

The developmental degree of notal organ is closely related with mating behavior and implies different mating strategies (Thornhill 1980; Zhong et al. 2015b). The mating behavior of *N. longiprocessa* suggests that the highly developed notal process is a plausible sign of coercive mating because it can greatly reinforce the male control to the female wings (Zhong and Hua 2013). Therefore, we may assume that the greatly developed postnotal organ of *N. setigera* sp. n. also can increase the control to the female wings during copulation. In this case, the new species is likely to employ forced mating strategy without nuptial gifts during copulation, as in *N. longiprocessa*, although this needs to be confirmed in the future.

Another peculiar character of this new species is that it bears a cluster of black long setae on the central portion of male gonostylus ventrally. This feature is rarely found in Panorpidae. In *N. brisi* (Navás) and *N. effusa* (Navás), the male gonostylus only bears setae along the outer margin, but is glabrous on the ventral surface (Rust and Byers 1976). Although the male gonostylus is furnished with dense setae ventrally and along its outer margin in *N. pendula* Qian & Zhou, the setae are much shorter and less striking than those in *N. setigera* sp. n. Only the Indian species *N. hirsuta* (Crampton) has similarly prominent long dense setae on the gonostylus (Carpenter 1931b; Rust and Byers 1976). However, the gonostylus is furnished with black setae for nearly two-thirds in *N. hirsuta*, while is only furnished with dense setae on the central portion in *N. setigera* sp. n. Apart from the similar gonostyli, these two species differ greatly in other characters, such as wing markings, male genitalia, and female genital plate.

Acknowledgements

We are indebted to Gui-Lin Hu and Wei Du for collecting specimens. This research was financially supported by the National Natural Science Foundation of China (grant nos. 31672341 and 31172125).

References

Byers GW, Thornhill R (1983) Biology of the Mecoptera. Annual Review of Entomology 28: 203–228. https://doi.org/10.1146/annurev.en.28.010183.001223

Carpenter FM (1931a) The biology of the Mecoptera. Psyche 38: 41–55. https://doi.org/10.1155/1931.43706

Carpenter FM (1931b) *Neopanorpa hirsuta* (Crampton). Psyche 28: 184–185. https://doi.org/10.1155/1931.29379

Carpenter FM (1938) Mecoptera from China, with descriptions of new species. Proceedings of the Entomological Society of Washington 40: 267–281.

Carpenter FM (1945) Panorpidae from China (Mecoptera). Psyche 52: 70–78. https://doi.org/10.1155/1945.69797

Cheng FY (1949) New species of Mecoptera from northwest China. Psyche 56: 139–173. https://doi.org/10.1155/1949/36572

Cheng FY (1957) Revision of the Chinese Mecoptera. Bulletin of the Museum of Comparative Zoology 116: 1–117.

Gao C, Ma N, Hua BZ (2016) *Cerapanorpa*, a new genus of Panorpidae (Insecta: Mecoptera) with descriptions of three new species. Zootaxa 4158: 93–104. https://doi.org/10.11646/zootaxa.4158.1.5

Jiang L, Hua BZ (2015) Morphological comparison of the larvae of *Panorpa obtusa* Cheng and *Neopanorpa lui* Chou & Ran (Mecoptera: Panorpidae). Zoologischer Anzeiger 255: 62–70. https://doi.org/10.1016/j.jcz.2015.02.004

Hu GL, Yan G, Xu H, Hua BZ (2015) Molecular phylogeny of Panorpidae (Insecta: Mecoptera) based on mitochondrial and nuclear genes. Molecular Phylogenetics and Evolution 85: 22–31. https://doi.org/10.1016/j.ympev.2015.01.009

Ma N, Cai LJ, Hua BZ (2009) Comparative morphology of the eggs in some Panorpidae (Mecoptera) and their systematic implication. Systematics and Biodiversity 7: 403–417. https://doi.org/10.1017/s1477200009990107

Ma N, Liu SY, Hua BZ (2011) Morphological diversity of male salivary glands in Panorpidae (Mecoptera). European Journal of Entomology 108: 493–499. https://doi.org/10.14411/eje.2011.064

Mickoleit G (1971) Zur phylogenetischen und funktionellen Bedeutung der sogenannten Notalorgane der Mecoptera (Insecta, Mecoptera). Zeitschrift für Morphologie der Tiere 69: 1–8. https://doi.org/10.1007/BF00294385

Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403: 853–858. https://doi.org/10.1038/35002501

Rust MK, Byers GW (1976) The Mecoptera of India and adjacent regions. The University of Kansas Science Bulletin 51: 19–90.

Thornhill R (1980) Rape in *Panorpa* scorpionflies and a general rape hypothesis. Animal Behaviour 28: 52–59. https://doi.org/10.1016/S0003-3472(80)800078

Thornhill R, Sauer KP (1991) The notal organ of the scorpionfly (*Panorpa vulgaris*): an adaptation to coerce mating duration. Behavioral Ecology 2: 156–164. https://doi.org/10.1093/beheco/2.2.156

Wang JS, Hua BZ (2017) An annotated checklist of the Chinese Mecoptera with description of male *Panorpa guttata* Navás, 1908. Entomotaxonomia 39: 24–42. https://doi.org/10.11680/entomotax.2017003

Zhong W, Hua BZ (2013) Mating behaviour and copulatory mechanism in the scorpionfly *Neopanorpa longiprocessa* (Mecoptera: Panorpidae). PLoS ONE 8: e74781. https://doi.org/10.1371/journal.pone.0074781

Zhong W, Ding G, Hua BZ (2015a) The role of male's anal horns in copulation of a scorpionfly. Journal of Zoology 295: 170–177. https://doi.org/10.1111/jzo.12194

Zhong W, Qi ZY, Hua BZ (2015b) Atypical mating in a scorpionfly without a notal organ. Contributions to Zoology 84: 305–315. http://www.ctoz.nl/vol84/nr04/a03

ZooKeys 750: 141–149 (2018)
doi: 10.3897/zookeys.750.23382
http://zookeys.pensoft.net

RESEARCH ARTICLE

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

Two new species of the genus *Xanthochlorus* from China (Diptera, Dolichopodidae, Xanthochlorinae)

Qilemoge[1], Wencheng Chang[2], Ding Yang[1]

1 *Department of Entomology, College of Plant Protection, China Agricultural University, Beijing 100193, China* **2** *Shanghai Agricultural Technology Extension and Service Centre, Shanghai 201103, China*

Corresponding author: *Ding Yang* (dyangcau@126.com; yangding@cau.edu.cn)

Academic editor: *M. Ivković* | Received 3 January 2018 | Accepted 5 April 2018 | Published 18 April 2018

http://zoobank.org/C79EBAE1-6A65-4887-A992-EE4A5696E702

Citation: Qilemoge, Chang W, Yang D (2018) Two new species of the genus *Xanthochlorus* from China (Diptera, Dolichopodidae, Xanthochlorinae). ZooKeys 750: 141–149. https://doi.org/10.3897/zookeys.750.23382

Abstract

The subfamily Xanthochlorinae comprises a single genus *Xanthochlorus,* and is rare in collections. Previously, there were four known species in the genus *Xanthochlorus* from China. In this paper, the species of the *Xanthochlorus* from China are reviewed. The following two species from Gansu Province of China are described as new to science: *Xanthochlorus gansuensis* **sp. n.** and *Xanthochlorus tewoensis* **sp. n.** A key to species of the *Xanthochlorus* from China is provided.

Keywords

China, Diptera, Dolichopodidae, new species, Xanthochlorinae, *Xanthochlorus*

Introduction

The subfamily Xanthochlorinae comprises only the single genus *Xanthochlorus* Loew. Compared to the other subfamilies of Dolichopodidae, most of which have high diversity, the genus *Xanthochlorus* has a low species number. There are presently 18 known species of *Xanthochlorus* in the world (Yang et al. 2006, 2011, Grichanov 2017), with only four species known in China: *Xanthochlorus chinensis* Yang & Saigusa, *X. nigricilius* Olejníček, *X. henanensis* Wang, Yang & Grootaert and *X. tibetensis* Xi, Wang & Yang (Olejníček 2004, Yang and Saigusa 2005, Wang et al. 2008, Yang et al. 2011, Xi et al. 2015). They have been reported from Shaanxi, Henan, and Tibet, which are, respectively, in the northwest and middle of China.

Gansu Province (32°31'–42°57'N, 92°13'–108°46'E) is located in the northwest of China and lies between the Tibetan Plateau and the Loess Plateau. The topography here is quite complicated, with mountains, basins, and deserts intersecting each other, which consequently also brings a complexity of the climates to this region. Due to a lack of precipitation, the northern part of Gansu province is dry and harsh all year round. However, the climate in the south of Gansu province is wet and mild, which leads to an abundant vegetation. These various environments contribute to the high species diversity of Gansu province. However, the investigation of the long-legged fly fauna here is still underway. In this paper two new species of the *Xanthochlorus* from Gansu province of China are reported and a key to the males of *Xanthochlorus* in China is provided. This is also the first time *Xanthochlorus* has been reported from Gansu province.

Materials and methods

The specimens upon which this study is based, were collected from Gansu province of China in 2015 by sweeping nets. All specimens are deposited in the Entomological Museum of China Agricultural University (**CAU**), Beijing. Morphological terminology for adult structures mainly follows McAlpine (1981). Terms for the structures of the male genitalia follow Cumming and Wood (2009). The following abbreviations are used: **oc** = ocellar bristle (s), **vt** = vertical bristle (s), **pvt** = postvertical bristle (s), **acr** = acrostichal bristle (s), **ad** = anterodorsal bristle (s), **av** = anteroventral bristle (s), **dc** = dorsocentral bristle (s), **h** = humeral bristle (s), **npl** = notopleural bristle (s), **pa** = postalar bristle (s), **pd** = posterodorsal bristle (s), **ph** = posthumeral bristle (s), **sa** = supraalar bristle (s), **sc** = scutellars, **LI** = fore leg, **LII** = mid leg, **LIII** = hind leg. **CuAx ratio** = length of m-cu / length of distal portion of CuA, **hyp** = hypandrium, **epn** = epandrium, **sur** = surstylus, **cer** = cercus.

Taxonomy

Key to species (males) of *Xanthochlorus* from China

1 Mid-posterior area of mesonotum and mid-basal area of scutellum blackish; CuAx less than 0.47 ..... **2**

– Mid-posterior area of mesonotum and mid-basal area of scutellum yellow, without blackish area; CuAx equal to 0.47 ..... ***X. tewoensis* sp. n.**

2 First flagellomere nearly quadrate (Fig. 4); cercus not serrated apically **3**

– First flagellomere semicircular; cercus serrated apically ..... ***Xanthochlorus chinensis* Yang & Saigusa**

3 First flagellomere blunt apically; acr absent **4**

– First flagellomere with acute apical corner (Yang et al. 2011: p 1540, fig 988a); 3–4 acr ..... ***X. henanensis* Wang, Yang & Grootaert**

4 Squama with brown hairs; hypandrium long, without short strip-like lateral protuberance..... **5**

– Squama with black hairs; hypandrium short, with short strip-like lateral protuberance (Figs 8–9) ..... ***X. gansuensis* sp. n.**

5 Arista brown; hypandrium basally with short hook-like lateral protuberance ***X. tibetensis* Xi, Wang & Yang**

– Arista yellow; hypandrium basally without short hook-like lateral protuberance ..... ***X. nigricilius* Olejníček**

Xanthochlorus Loew, 1857

Xanthochlorus Loew, 1857: 42. Type species: *Leptopus ornatus* Haliday, 1832.

Diagnosis. Thorax and abdomen mainly yellow. Face narrower than frons, vertex flat, pvt absent. Antennal scape without hair, first flagellomere wider than long. Mid-posterior area of mesonotum flat. Mid and hind femora without preapical bristles. CuAx ratio 0.35–0.47. Male genitalia rather large and mostly exposed; cercus various, apically with hairs.

Xanthochlorus chinensis Yang & Saigusa, 2005

Xanthochlorus chinensis Yang & Saigusa, 2005: 754. Type locality: China, Shaanxi.

Diagnosis. First flagellomere semicircular, distinctly wider than long (Yang et al. 2011: p 1539, fig 987a). Dorsal lobe of surstylus acute and curved apically, ventral lobe of surstylus irregularly furcated apically; cercus serrated apically; hypandrium with long lateral protuberance, strongly curved apically (Yang et al. 2011: p 1539, fig 987b).

Distribution. Palaearctic: China (Shaanxi).

Xanthochlorus tewoensis sp. n.

http://zoobank.org/3F0FA83D-7185-4A83-B8F7-6AEFF946C077

Figs 1, 4–6

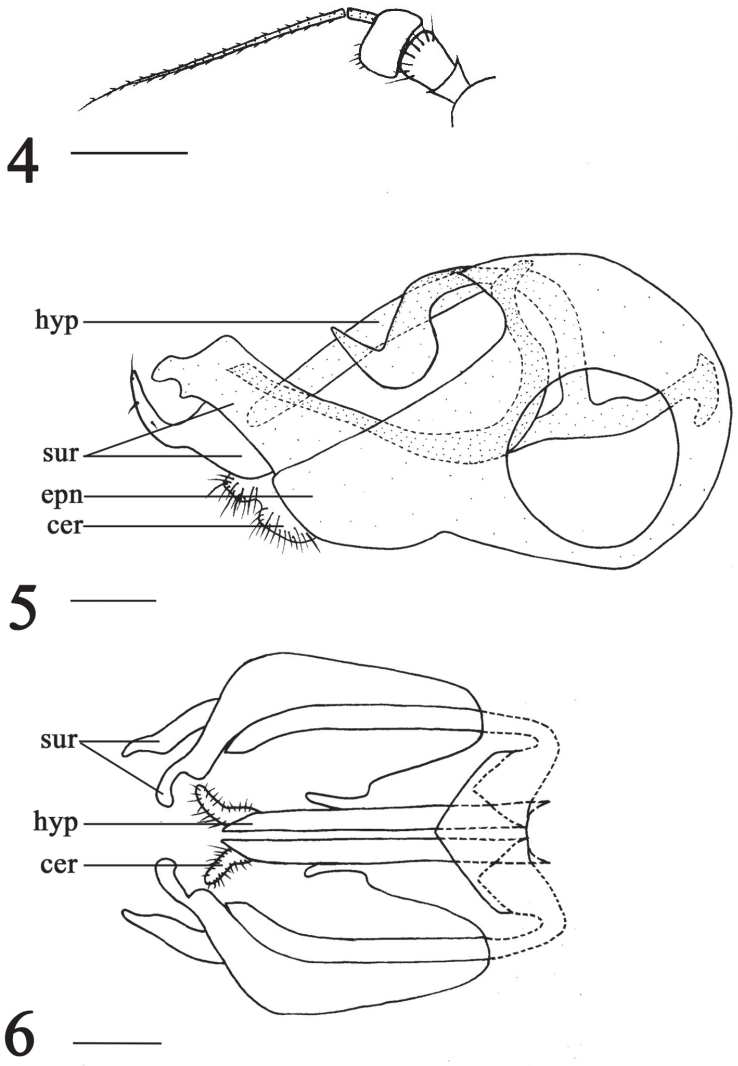
Diagnosis. First flagellomere nearly quadrate. Mid-posterior area of mesonotum yellow. Mid-basal area of scutellum yellow. 1st to 4th tergites of abdomen pale yellow. Dorsal lobe of surstylus wide basally and sharp towards tip, with one bristle apically; ventral lobe of surstylus wide basally, with two apical protuberances; cercus small, nearly quadrate, weakly concave at middle dorsally; hypandrium straight, round apically.

Description. Male (Fig. 1). Body length 3.0–3.2 mm. Wing length 3.3–3.8 mm. Head: metallic green with pale gray pollen. Hairs and bristles on head black. Face

Figures 1–3. Habitus, lateral view. **1** *Xanthochlorus tewoensis* sp. n. Male. **2** *Xanthochlorus gansuensis* sp. n. Male. **3** *Xanthochlorus gansuensis* sp. n. Female. Scale bars: 1 mm.

brown with pale gray pollen, width of face equal to length of first flagellomere. Postocular bristles all yellow. Two oc, two vt. Antenna (Fig. 4) yellow; first flagellomere nearly quadrate, 0.57 times as long as wide; arista brown, basal segment 0.09 times as long as apical segment. Proboscis yellow with yellow hairs; palpus yellow with yellow hairs.

Thorax yellow with pale gray pollen. Hairs and bristles on thorax black. Pteropleuron and latero-tergite each with a single black spot. Five strong dc, acr absent, one strong h, two strong npl, one strong su, one strong prsu, one strong sa, one strong pa; scutellum with a pair of sc. Propleuron with white hairs and a long yellow bristle on



Figures 4–6. *Xanthochlorus tewoensis* sp. n., male. **4** Antenna **5** Genitalia, lateral view **6** Genitalia, ventral view. Abbreviations: hyp = hypandrium, epn = epandrium, sur = surstylus, cer = cercus. Scale bars: 0.2 mm.

lower portion. Legs yellow. Hairs and bristles on legs black. Fore coxa with six bristles; middle and hind coxae each with a single black outer bristle. Fore tibia without distinct bristle; middle tibia with one ad, one pd, and four apical bristles; hind tibia with two apical bristles. Mid and hind femora without preapical bristles. Relative lengths of tibia and 5 tarsomeres LI 6.0 : 4.0 : 1.6 : 1.2 : 0.8 : 0.7; LII 6.0 : 4.0 : 1.6 : 1.2 : 0.8 : 0.7; LIII 9.4 : 2.8 : 1.9 : 1.2 : 0.8 : 0.6. Wing hyaline, veins brown; costal callus indistinct; M gently bent apically, M and R_{4+5} parallel apically; CuAx ratio 0.47. Squama yellow with yellow hairs. Halter yellow.

Abdomen yellow with pale gray pollen, tergites 1–4 pale yellow. Hairs and bristles on abdomen black. Male genitalia (Figs 4–6): Epandrium longer than wide; dorsal lobe of surstylus yellow, basally wide, nearly quadrate, apically sharp with one bristle; ventral lobe of surstylus pale brown, wide, apically with two protuberances; cercus small, nearly quadrate with distinct bristles, but weakly concave at middle dorsally; hypandrium light brown, straight, round apically.

Female. Unknown.

Types. Holotype male, CHINA, Gansu, Tewo, Lazikoulinchang, Laolazi, collected by sweeping nets in grassland, 2015.VII.26, Qingxia Zhou (CAU). Paratypes: two males, collecting information same as the holotype (CAU).

Distribution. Palaearctic: China (Southern wet part of Gansu).

Remarks. The new species is somewhat similar to *X. chinensis* Yang and Saigusa, but can be separated from the latter by the quadrate first flagellomere, the yellow mid-posterior area of the mesonotum and the two protuberances on the ventral lobe of the surstylus. In *X. chinensis*, the first flagellomere is semicircular, the mid-posterior area of the mesonotum is black, and the ventral lobe of the surstylus is irregularly furcated at tip (Yang and Saigusa 2005, Yang et al. 2011: p 1539, fig 987b).

Etymology. The specific name refers to the type locality of Tewo.

***Xanthochlorus gansuensis* sp. n.**

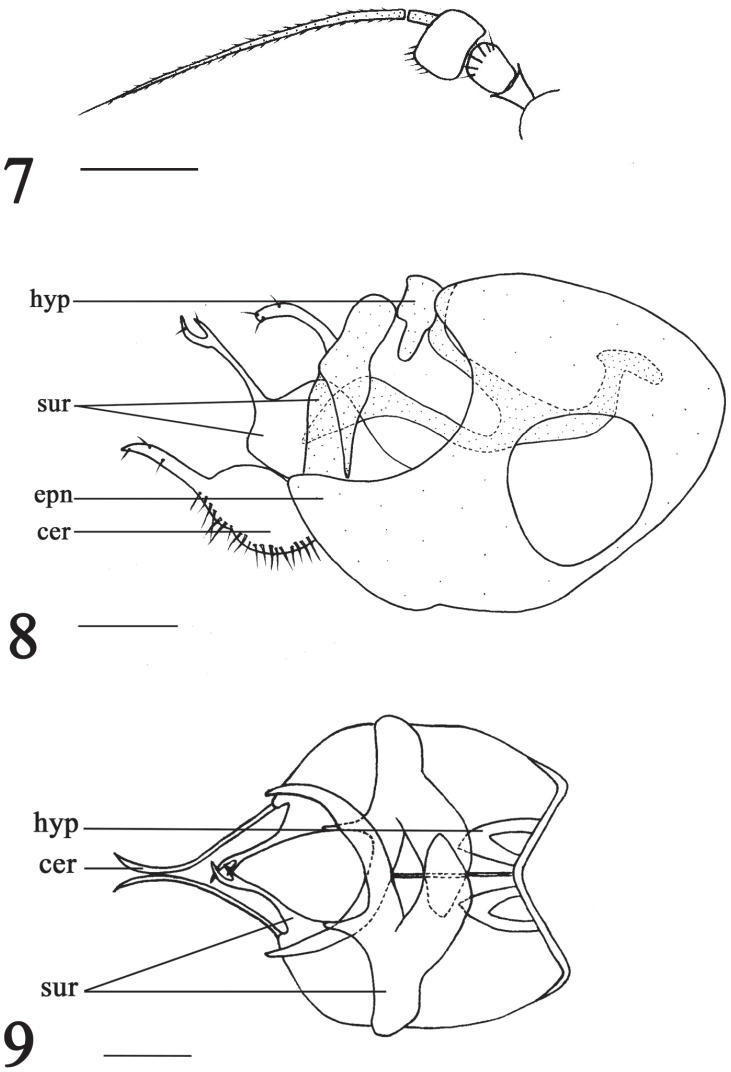
http://zoobank.org/2274D456-2FB4-452F-AD14-69DB88178347

Figs 2–3, 7–9

Diagnosis. First flagellomere nearly quadrate. Mid-posterior area of mesonotum blackish. Mid-basal area of scutellum blackish. Dorsal lobe of surstylus wide basally, nearly quadrate, apically concaved with two bristles; ventral lobe of surstylus wide basally, band-like, apically rounded with two bristles; cercus ovate basally, apically finger-like with bristles; hypandrium rather short with short strip-like lateral protuberance.

Description. Male (Fig. 2). Body length 2.3–2.6 mm. Wing length 2.6–2.9 mm. Head: metallic green with pale gray pollen. Hairs and bristles on head black. Face brown with pale gray pollen, width of face equal to length of first flagellomere. Postocular bristles all yellow.Two oc, two vt. Antenna (Fig. 7) yellow; first flagellomere nearly quadrate, 0.6 times as long as wide; arista pale brown, basal segment 0.1 times as long as apical segment. Proboscis yellow with pale brown hairs; palpus yellow with pale brown hairs.

Thorax yellow with pale gray pollen. Hairs and bristles on thorax black. Mid-posterior area of mesonotum blackish; mid-basal area of scutellum blackish; pteropleuron and latero-tergite each with one black spot. 5 strong dc, acr absent, one strong h, two strong npl, one strong su, one strong prsu, one strong sa, one strong pa; scutellum with one pair of sc. Propleuron with white hairs and one long yellow bristle on lower portion. Legs yellow. Hairs and bristles on legs black. Fore coxae with 5–6 bristles; middle and hind coxae each with one outer bristle. Fore tibia without distinct bristles; middle tibia with two ad, one pd, and four apical bristles; hind tibia with three apical bristles. Mid and hind femora without preapical bristle. Relative lengths of tibia and 5 tarsomeres LI 3.0 : 1.5 : 0.8 : 0.6



Figures 7–9. *Xanthochlorus gansuensis* sp. n., male. **7** Antenna **8** Genitalia, lateral view **9** Genitalia, ventral view. Abbreviations: hyp = hypandrium, epn = epandrium, sur = surstylus, cer = cercus. Scale bars: 0.2 mm.

: 0.4 : 0.4; LII 3.8 : 1.7 : 0.7 : 0.5 : 0.4 : 0.4; LIII 4.5 : 1.4 : 1.0 : 0.7 : 0.4 : 0.4. Wing hyaline, veins brown; costal callus indistinct; M gently bent apically, M and R_{4+5} parallel apically; CuAx ratio 0.38. Squama yellow with black hairs. Halter yellow.

Abdomen yellow with pale gray pollen. Hairs and bristles on abdomen black. Male genitalia (Figs 7–9): Epandrium longer than wide; dorsal lobe of surstylus yellow, wide basally, nearly quadrate, apically concaved with two bristles; ventral lobe of surstylus pale brown, wide basally, band-like, apically rounded with two bristles; cercus ovate basally, apically finger-like with bristles; hypandrium brown, rather short with short strip-like lateral protuberance.

Female (Fig. 3). Body length 2.6 –2.8 mm. Wing length 2.7–2.9 mm.

Types. Holotype male, CHINA, Gansu, Tianshui, Dangchuan Linchang, Maicaogou; collected by sweeping nets in grassland, 2015.VII.17, Xiaoli Li (CAU). Paratypes: nine males, 13 females, collecting information same as the holotype (CAU).

Distribution. Palaearctic: China (Southern wet part of Gansu).

Remarks. The new species is somewhat similar to *X. henanensis* Wang, Yang and Grootaert, but can be separated from the latter by the first flagellomere apically without acute corner and by the lack of acrostichals. In *X. henanensis*, the first flagellomere has an acute lower apical corner and 3–4 acrostichals are present (Wang et al. 2008, Yang et al. 2011: p 1540, fig 988a).

Etymology. The specific name refers to the type locality Gansu.

Xanthochlorus henanensis Wang, Yang & Grootaert, 2008

Xanthochlorus henanensis Wang, Yang & Grootaert, 2008: 253. Type locality: China, Henan.

Diagnosis. First flagellomere slightly wider than long, nearly quadrate, acute apically (Yang et al. 2011: p 1540, fig 988a). Mesonotum with 3–4 acrostichals. Scutellum metallic green with brownish margin. Mid tarsomere one longer than tarsomeres 2–5 combined, with two rows of ventral bristles. Dorsal lobe of surstylus long and wide, apically hook-like, ventral lobe of surstylus short, furcated apically; cercus nearly rounded; hypandrium with short lateral protuberance, irregularly furcated apically (Yang et al. 2011: p 1540, fig 988b).

Distribution. Palaearctic: China (Henan).

Xanthochlorus nigricilius Olejníček, 2004

Xanthochlorus nigricilius Olejníček, 2004: 9. Type locality: China, Shaanxi.

Diagnosis. Antenna and arista wholly yellow. First flagellomere as long as wide, nearly quadrate (Olejníček 2004: p 10, fig 1). Mid-posterior area of mesonotum and basal area of scutellum black. Dorsal lobe of surstylus apically acute and strongly curved (Olejníček 2004: p 10, figs 2–3).

Distribution. Palaearctic: China (Shaanxi).

Xanthochlorus tibetensis Xi, Wang & Yang, 2015

Xanthochlorus tibetensis Xi, Wang & Yang, 2015: 315. Type locality: China, Tibet.

Diagnosis. Bristles on head mostly yellow, but those on thorax black. First flagellomere nearly quadrate. Mid tarsomere one with two short weak av. Dorsal surstylus

acute and curved apically, ventral surstylus wide, furcated apically; cercus bent, wide basally and finger-like apically; hypandrium basally with short hook-like lateral protuberance, apically deeply incised with lateral protuberance, slightly curved (Xi et al. 2015: p 315, fig 5).

Distribution. Palaearctic: China (Tibet).

Acknowledgments

We are very grateful to Ms. Xiaoli Li and Ms. Qingxia Zhou (Beijing) for collecting the specimens. Thanks to Dr. Daniel J. Bickel for his help in writing in English. Two anonymous reviewers are thanked for providing useful comments on an earlier draft of this paper. The data in this research comes from the database of National Digital-Museum of Animal Specimens; this project was supported by key project of Science-technology basic condition platform from the Ministry of Science and Technology of China (No.2005DKA21402).

References

Cumming JM, Wood DM (2009) Adult morphology and terminology. In: Brown BV, Borkent A, Cumming JM, Wood DM, Woodley NE, Zumbado MA (Eds) Manual of Central American Diptera, Vol. 1. NRC Research Press, Ottawa, 9–50.

Grichanov IY (2017) Alphabetic list of generic and specific names of predatory flies of the epifamily Dolichopodidae (Diptera). Plant Protection News Supplements 23: 541–542.

McAlpine JF (1981) Morphology and terminology – adults. In: McAlpine JF, Peterson BV, Shewell GE, Teskey HJ, Vockeroth JR, Wood DM (Eds) Manual of Nearctic Diptera Vol. 1. Agriculture Canada Monograph 27: 9–63.

Olejníček J (2004) *Xanthochlorus nigricilius* spec. n. (Diptera, Dolichopodidae) from China. Studia Dipterologica 11: 9–11.

Wang MQ, Yang D, Grootaert P (2008) New species of Dolichopodidae (Diptera) from China. Bulletin de l'Institut Royal des Sciences Naturelles de Belgique Entomologie 78: 251–257.

Xi YQ, Wang BH, Yang D (2015) *Xanthochlorus* (Diptera: Dolichopodidae) newly found in Tibet with description of a new species. Florida Entomologist 98: 315–317. https://doi.org/10.1653/024.098.0150

Yang D, Saigusa T (2005) Diptera: Dolichopodidae. In: Yang XK (Ed.) Insect Fauna of Middle-West Qinling Range and South Mountains of Gansu Province. Science Press, Beijing, 740–765.

Yang D, Zhang LL, Wang MQ, Zhu YJ (2011) Fauna Sinica Insecta Vol. 53. Diptera Dolichopodidae. Science Press, Beijing, 1536–1543.

Yang D, Zhu YJ, Wang MQ, Zhang LL (2006) World catalog of Dolichopodidae (Insecta: Diptera). China Agricultural University Press, Beijing, 521–522.