RESEARCH ARTICLE

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Phylogenetic placement of the unusual jumping spider *Depreissia* Lessert, and a new synapomorphy uniting Hisponinae and Salticinae (Araneae, Salticidae)

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Abstract

The relationships of the unusual salticid spider *Depreissia* from central Africa and Borneo have been difficult to resolve, obscured by its highly modified ant-like body. Phylogenetic analysis of the gene 28S strongly supports its placement outside the major clade Salticinae and within the clade of cocalodines, spartaeines and lapsiines, with weaker support for a relationship with the cocalodines in particular. Excluding the genus from the Salticinae is supported also by the presence of a median apophysis on the male palp, and by the lack of a cymbial apical groove cradling the tip of embolus, which is newly presented here as a synapomorphy of Hisponinae plus Salticinae.

Keywords

Jumping spiders, Salticidae, phylogeny, systematics, Cocalodini

Introduction

The strange salticid spider *Depreissia* Lessert, 1942 is known from only a few specimens representing two species, *D. myrmex* Lessert, 1942 from Africa (Lessert 1942, Wesołowska 1997, Szűts and Wesołowska 2003) and *D. decipiens* Deeleman-Reinhold & Floren, 2003 from Borneo (Deeleman-Reinhold and Floren 2003). These species have been noted for their unusual structures, with an extraordinarily long pedicel and strange constrictions and dimples on the carapace (Lessert 1942, Wesołowska 1997, Szűts and Wesołowska 2003, Deeleman-Reinhold and Floren 2003, Deeleman-Reinhold et al. 2016), which given them the appearance of ants or wasps (Deeleman-Reinhold et al. in press). These autapomorphic features have not helped placing *Depreissia* phylogenetically, however. Both Lessert (1942) and Wesołowska (1997) suggested a relationship with *Leptorchestes* Thorell, 1870, although both expressed difficulty in placing *Depreissia* in any known group, and noted the unusual eye arrangement typical for lyssomanines and *Athamas* O. P.-Cambridge, 1877.

The major clade Salticinae (*sensu* Maddison in press), including over 90% of the species of jumping spiders, is delimited by several morphological synapomorphies, including the lack of a tarsal claw in the female palp, and is well supported by molecular data (Maddison and Hedin 2003, Maddison et al. 2014). Outside of it are the lineages known as "basal salticids", including hisponines, spartaeines, lapsiines, cocalodines, eupoines and lyssomanines (Wanless 1980, 1984, Maddison and Needham 2006, Maddison et al. 2007, Maddison 2009). Insofar as there are relatively few basal lineages, the recognition of a new one could be of special interest for interpreting the early evolution of salticids (see Maddison and Needham 2006: 38).

In this paper we present both molecular and morphological evidence that supports the placement of *Depreissia* outside the Salticinae, possibly as a close relative of the cocalodines. Deeleman-Reinhold et al. (2016) has independently discovered morphological evidence supporting the same placement.

Methods

Taxon sampling for molecular phylogeny

A juvenile of *Depreissia decipiens* (with labels "Kinabalu NP, My 6°5'N 116°33'E Poring Hot Springs, A. lagenocarpa 13 A. Floren. 16.9.2006. B 14", and "WPM DNA voucher d470") was supplied by Christa Deeleman-Reinhold. Data for 28S from this specimen was added to data from 72 taxa included in the analysis of Maddison et al. (2014), selected to cover the breadth of salticid diversity, and because their 28S sequences were fairly long. Information on those specimens and sequences can be found in Maddison et al. (2014) by following the voucher codes in brackets in the taxon names of Fig. 1.
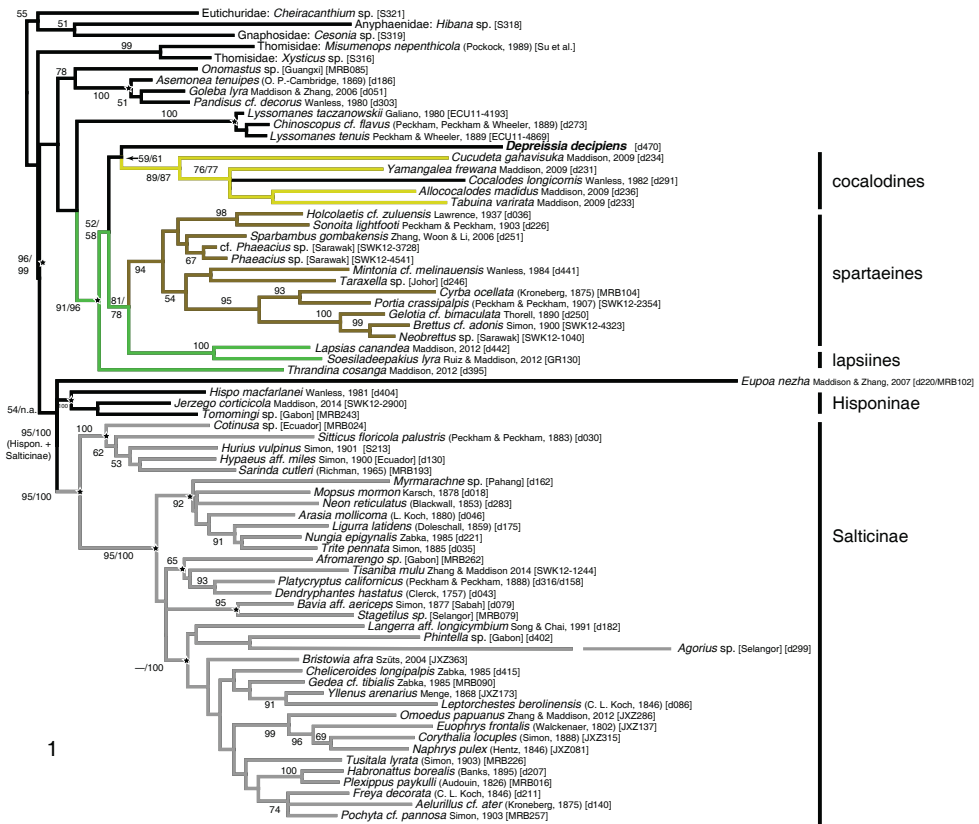
Figure 1. Maximum likelihood phylogenetic tree from 28S sequences, constrained as described in text. Branches labelled by bootstrap percentages from 500 replicates, with selected branches also showing (after "/") bootstrap percentages for analysis with *Eupoa* and *Agorius* removed. Branch length of *Agorius* abridged to 50% of its actual length. Voucher specimen codes appended in brackets. Cocalodine, spartaeine and lapsiine lineages are colored as in Maddison et al. (2014). Stars mark clades constrained except for the freedom of *Depreissia* and *Agorius*.

Sequencing

DNA was extracted from the entire body of a single immature male using a Qiagen DNeasy Blood and Tissue Kit. The specimen was not ground, but several holes were torn into the body wall to allow better penetration of buffers and enzymes. The fragment of 28S was amplified using the Polymerase Chain Reaction on an Eppendorf Mastercycler Thermal Cycler ProS, using TaKaRa Ex Taq and the basic protocols recommended by the manufacturer. Two PCR reactions were conducted, one with primers LS58F and LS998R, the other with primers NLF184/21 and LS1041R (Maddison 2012), both using cycling reaction CI in Maddison (2012: 573). The amplified

products were then cleaned, quantified, and sequenced at the University of Arizona's Genomic and Technology Core Facility using a 3730 XL Applied Biosystems automatic sequencer. Initial base calls and assembly of the four chromatograms into one fragment were made with Phred (Green and Ewing 2002) and Phrap (Green 1999) as orchestrated by Mesquite's Chromaseq package (Maddison and Maddison 2014, 2015) with subsequent modifications by Chromaseq and manual inspection.

Sequence alignment and phylogenetic analysis

Automatic multiple sequence alignment was performed by MAFFT (Katoh et al. 2002, 2005), run via the align package of Mesquite (Maddison and Maddison 2015). Alignment used the L-INS-i option (--localpair --maxiterate 1000).

Phylogenetic analyses using maximum likelihood were run using RAxML version 7.2.8alpha (Stamatakis 2006a, b). RAxML runs assuming the GTRGAMMAI model were performed with 100 search replicates, to seek maximum likelihood trees. In addition, likelihood bootstrap analysis was performed with 500 bootstrap replicates, each involving a single search replicate. We performed both constrained and unconstrained analyses. The unconstrained analyses used only the data at hand: the 28S gene in the 73 taxa. This unconstrained analysis has the flaw that it fails to consider data from other genes and other taxa, which have convincingly demonstrated the monophyly of many major clades of salticids. Because the gene 28S does not properly resolve some of the deeper relationships of the family (Maddison et al. 2014), this analysis places *Depreissia* on a faulty background. We therefore also performed analyses that constrained the tree to enforce monophyly of some groups, thus placing *Depreissia* on a well-supported salticid phylogeny. The full constraints analysis holds the following groups monophyletic as they are well supported by multigene analyses (Maddison et al. 2014): Salticidae, *Lyssomanes* + *Chinoscopus*, *Asemonea* + *Goleba* + *Pandisus*, spartaeines + cocalodines + lapsiines, Hisponinae, Salticinae, Amycoida, Salticoida, *Bavia* + *Stagetilus*, Astioida, Marpissoida, and Saltafresia. Relationships within those groups were free to vary, and the placements of *Depreissia* and *Agorius* Thorell, 1877 were free to move throughout the tree, including within the otherwise constrained clades. Thus, even though these clades were constrained, they could have had bootstrap percentages less than 100% if *Depreissia* or *Agorius* had wandered inside or outside them. Another less constrained analysis enforced the monophyly of only the Salticidae. Because *Eupoa* Żabka, 1985 and *Agorius* have unusual 28S genes and are unstable in analyses (Maddison et al. 2014), they were excluded in some variant analyses.

Morphology

Structures of *Depreissia myrmex* were studied from a specimen deposited in the HNHM (Hungarian Natural History Museum, curator Dr. László Dányi, label

data: Araneae-4515: *Depreissia myrmex* Lessert, 1942: Republic of Congo, Kindamba, Meya, Bangu forest, 1963., leg: J. Balogh & A. Zicsi, det.: Wanda Wesolowska („HNHM Nr. 325") 3 50'S, 14 30'E). The specimen was examined with an Olympus SZ60 microscope; images were taken with Leica DM2700 M, Nikon Eclipse and Zeiss JENAVAL microscopes. For examination of internal structures, the palp was immersed in absolute ethanol then temporarily cleared with a solution of methyl salicylate (synthetic version of wintergreen oil), fixed with a modified version of Coddington's temporary mount (Coddington 1983), and photographed with an attached Nikon D300S camera using Helicon Remote®. Multiple stacked images were montaged using the program Helicon Focus®.

Specimens illustrated in the figures are listed in the Appendix. Abbreviations for collections are UBC-SEM (University of British Columbia, Spencer Entomological Collection), HNHM (Hungarian Natural History Museum), CAS (California Academy of Sciences) and ZMUC (Zoological Museum, University of Copenhagen).

Data resources

The data underpinning the analyses reported in this paper, and the resulting trees, are deposited in the Dryad Data Repository at http://dx.doi.org/10.5061/dryad.gd501.

Molecular phylogenetic results

The new sequence for 28S for *Depreissia decipiens* has been deposited in GenBank with accession number KT462690.

The maximum likelihood phylogenetic tree found in the fully constrained analysis is shown in Fig. 1. *Depreissia* is placed as sister to the cocalodines, though the bootstrap support appears low. Its placement within the larger clade of cocalodines + spartaeines + lapsiines is, however, strongly supported (bootstrap percentage 91, 96 if the unstable *Eupoa* and *Agorius* are excluded from the analysis). The bootstrap support for the Salticinae is high, 95% (100% if *Eupoa* and *Agorius* are excluded), indicating that *Depreissia* is not a salticine.

The partially constrained analysis (only Salticidae enforced) gave considerably lower bootstrap values, with 62% support for *Depreissia* within the cocalodines, 63% for *Depreissia* within the larger clade of cocalodines + spartaeines + lapsiines, and 52% support for the Salticinae. However, a more detailed inspection of the trees from bootstrap replicates shows that support for placement of *Depreissia* remains strong. Of the 500 bootstrap replicates, 445 (89%) place *Depreissia* either with the cocalodines or with the broader group of cocalodines + spartaeines + lapsiines, in some with *Eupoa* included also. Of the remaining replicates, *Depreissia* is placed outside of the Salticinae (sensu Maddison in press) in 47. This leaves 11 replicates, of which 5 place *Depreissia* among other basal salticids (e.g., the lyssomanines). Five associate *Depreissia* with the

likewise ant-like *Agorius*, but that is a result of *Agorius* moving outside the Salticinae, not *Depreissia* moving inside. Only a single replicate places *Depreissia* inside the Salticinae, as sister to the amycoids. Thus, the bootstrap support for *Depreissia* being outside the Salticinae is 99.8%.

The unconstrained analysis also provides strong support for *Depreissia*'s placement, with 100% support for the exclusion of *Depreissia* from the Salticinae and 86% support for a placement near the cocalodines. Of the 500 bootstrap replicates, 429 place *Depreissia* either with the cocalodines or with the broader group of cocalodines + spartaeines + lapsiines, in some with *Eupoa* or *Hibana* Brescovit, 1991 included also. Of the remaining 71 replicates, 69 clearly place *Depreissia* among other non-salticine groups (sometimes the lyssomanines). The last 2 trees associate *Depreissia* with *Agorius*, with both being outside the Salticinae.

Morphological evidence

The embolus of *Depreissia* wraps around the round bulb, appearing merely as a peripheral black edge (Wesołowska 1997, Deeleman-Reinhold and Floren 2003, Szűts and Wesołowska 2003). In *D. myrmex* (Figs 2–6, 9–10), the embolus originates at about 6 o'clock (Figs 4, 5e'), then loops three times around the bulb to end near the origin (Fig. 5e"). The spermophore is fairly narrow throughout (Fig. 5s).

Many salticids outside of the Salticinae have a median apophysis on the palp, the loss of which is a synapomorphy of the Salticinae (Maddison and Needham 2006, Maddison et al. 2007, Maddison 2009, Maddison in press). The median apophysis arises from the tegulum, and is usually separated from it by a membrane (e.g., Maddison and Needham 2006, Maddison et al. 2007, Maddison 2009). On the tegulum of *Depreissia* is a large complex apophysis (Wesołowska 1997: fig. 3, Deeleman-Reinhold and Floren 2003: fig. 3), referred to as a tegular projection by Deeleman-Reinhold and Floren (2003). It arises from the middle of the face of the tegulum, expands to a bulbous projection, then narrows and twists at its heavily sclerotized tip (Figs 2–7, 10, ma). This projection is quite distinct from the tegulum, separated from it by a narrow waist (Figs 3, 6, 10, triangle), and is apparently surrounded by a membranous area (Figs 6, 7, 10, triangle). No tegular apophysis with these qualities is seen in salticids except the median apophysis of basal salticids. We therefore judge it to be a median apophysis, which places *Depreissia* outside the Salticinae.

Deeleman-Reinhold et al. (2016) also conclude that a median apophysis is present, but they interpret it to be a smaller sclerite. While we interpret the entire "tegular projection" to be the median apophysis, Deeleman-Reinhold et al. (2016) interpret the projection to be a lobe of the tegulum, and only the dark tip of the projection to be the median apophysis ("tip-only"). Our interpretation is based on the fact that the tegular projection is separated by a narrow and membranous neck

Figures 2–7. Male palp of *Depreissia myrmex* **2** Cleared palp, ventral view. **3** Retrolateral view **4** Dorsal view **5** Ventral view, highlighting the path of spermaphore (yellow) and embolus (black) **6** Left palp, prolateral view **7** Right palp, prolateral view. Abbreviations: **e'** = origin of embolus; **e''** = end of embolus; **ma** = median apophysis; **s** = spermophore; **t** = tegulum. Triangle marks base of median apophysis.
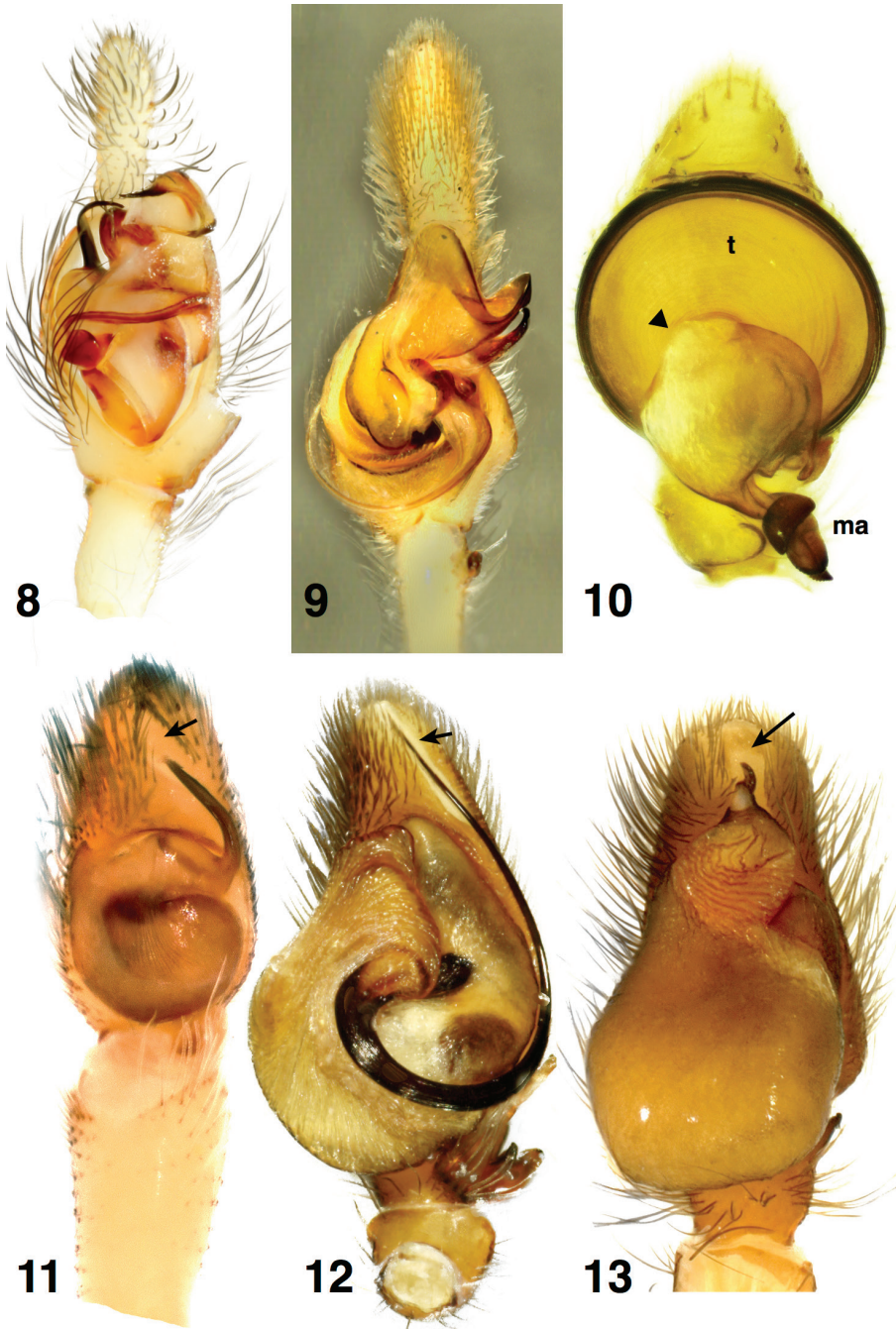
Figures 8–13. Male palps to show absence (**8–10**) or presence (**11–13**) of the cymbial apical groove (a depression in the cymbium that cradles the tip of the embolus, marked with an arrow) **8** *Lyssomanes taczanowskii* Galiano, 1980 **9** *Cocalodes papuanus* Simon, 1900 **10** *Depreissia myrmex* Lessert, 1942 **11** *Tomocyrba ubicki* Szűts & Scharff, 2009 **12** *Hispo sulcata* Wanless, 1981 **13** *Phidippus audax* (Hentz, 1845). Triangle marks base of median apophysis (**ma**).

from the rest of the tegulum, matching the quality of the tegulum-median apophysis boundary as seen in other salticids. We judge the "tip-only" interpretation as less parsimonious, because it implies a new distinct feature not seen in other salticids (an isolated ventral lobe of the tegulum) as well as a loss of the membrane at the base of the median apophysis.

Our interpretation suggests that the median apophysis is unusually large, but cocalodines have remarkably large median apophyses (Maddison 2009), which may indeed be a synapomorphy uniting *Depreissia* with the cocalodines. Except for *Cucudeta gahavisuka* Maddison, 2009, cocalodines have a median apophysis whose length is as great as or greater than half the diameter of the bulb (see figures in Maddison 2009). Lapsiines, spartaeines, and hisponines have smaller median apophyses, with the exception of *Thrandina* Maddison, 2006 (Maddison 2012); the size in lyssomanines is variable (see e.g. Logunov 2014).

Another character that clearly supports the non-salticine status of *Depreissia* is the lack of a depression in the cymbium cradling the tip of the embolus (see Figs 8–13). In hisponines and salticines, the tip of the embolus falls in a consistent place over the tip of the cymbium, resting in a shallow, elongated groove in the tegulum (Figs 11–13, arrow). Among salticids outside the hisponines and salticines, the groove is absent (Figs 8–9). It is also lacking in *Depreissia* (Figs 2–4, 7, 10). Outside the salticids it is lacking in the apparently closely-related crab spiders (Ramírez 2003, 2014), but it is present in anyphaenids (Ramírez 2003) and castianieirines (Ramírez 2014). This groove, which occasionally extends to the dorsal side, was called the cymbial groove by Szűts and Scharff (2005), and is one of several cymbial grooves of Ramírez (2014), the cymbial apical groove. The presence of a cymbial apical groove cradling the embolus is concordant with molecular evidence that supports the clade consisting of hisponines plus salticines (Maddison et al. 2014). Its absence is therefore evidence that *Depreissia* is a non-salticine.

While the morphological data support *Depreissia* as a non-salticine, the morphological data neither rule out its being a cocalodine, nor give good support for its placement with the cocalodines in particular. This is not surprising, as there are no known unambiguous morphological synapomorphies either for the cocalodines (Maddison 2009) or for the larger group including lapsiines and spartaeines.

Conclusion

Based on both the morphological and molecular evidence, we conclude that *Depreissia* is outside the major clade Salticinae. Furthermore, the molecular evidence suggests that it can be provisionally associated with the cocalodines, and the morphological evidence permits this. Thus, *Depreissia* is the only known cocalodine outside of Australasia. Also, *Depreissia* is the first known non-salticine that strongly resembles ants or wasps.

We note that Deeleman-Reinhold et al. (2016) has also come to the conclusion, independently, that *Depreissia* is related to cocalodines.

Acknowledgments

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Appendix

Locality data for specimens studied morphologically (Figs 2–13).

Species	Locality	Deposited in	Specimen
Lyssomanes taczanowskii	Ecuador: Orellana, Yasuní, 0.675°S, 76.398°W	UBC-SEM	ECU11-4328
Cocalodes papuanus	New Guinea: Madang, Baiteta forest, 5.02°S 145.75°E	HNHM	
Depreissia myrmex	Republic of Congo: Kindamba, Meya, Bangu forest, 3.83°S, 14.5°E	HNHM	Araneae-4515
Tomocyrba ubicki	Madagascar: Antsiranana, Parc National de Marojejy, Manantenina River, 14.435°S, 49.76°E	CAS	CASENT9037517
Hispo sulcata	Madagascar: Fianarantsoa, Parc Nat. Ranomafana Vohiparara, 21.027°S, 47.45°E	ZMUC	

RESEARCH ARTICLE

Review of the genus *Laelaspisella* Marais & Loots, with the description of a new species from Iran (Acari, Laelapidae)

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Abstract

A new species of mite is described from Iran, *Laelaspisella elsae* **sp. n.** (Acari: Laelapidae). The new species was collected from bark of elm trees in Isfahan province. A revised diagnosis for *Laelaspisella*, as well as a key to the world species of the genus, are presented. Two species groups of *Laelaspisella* are proposed: those with seta *pd3* on genu I and those without *pd3* on genu I. *Pseudoparasitus* (*Gymnolaelaps*) *tonsilis* Karg, 1989a is transferred to *Laelaspisella*, based on its hypertrichous holodorsal shield, metasternal setae *st4* absent and genu IV with ten setae. The problems with *L. canestrinii* are explained and *L. canestrinii sensu* Berlese (1903), (1904) and Costa (1962) is provided with a new name, *Laelaspisella berlesei* Joharchi, **nom. n.**

Introduction

The genus *Laelaspisella* Marais & Loots, 1969 was described for two species found in soil in southern Africa. *Laelaspisella* was considered as a subgenus of *Hypoaspis sensu lato* by Karg (1989b), who also included *Hypoaspis* (*Laelaspisella*) *foramenis* Karg, 1989b and *Hypoaspis* (*Laelaspisella*) *cavitatis* Karg, 1982 in this genus. Then Karg (2013) considered *Laelaspisella* as genus of Hypoaspidinae Vitzthum, *sensu* Karg (2000) and regarded this genus as a sister genus of *Pneumolaelaps* Berlese.

The most recent taxonomic work on the genus was by Joharchi and Halliday (2013), who clarified the diagnosis of genus *Laelaspisella*, and transferred *Gymnolaelaps kabitae* Bhattacharyya, 1968 and *G. canestrinii* (Berlese) *sensu* Costa, 1962 to *Laelaspisella,* and excluded the two species described by Karg from *Laelaspisella*. Before the present study, only four species of *Laelaspisella* had been reported, *Laelaspisella macrodorsalis* Marais & Loots, 1969; *L. epigynialis* Marais & Loots, 1969; *Laelaspisella canestrinii* (Berlese) *sensu* Costa and *L. kabitae* (Bhattacharyya). A further new species is described and a key is presented for the identification of *Laelaspisella* species. One species is transferred from *Pseudoparasitus* (*Gymnolaelaps*) to *Laelaspisella*. Using these additional data, the genus *Laelaspisella* is redefined more precisely.

Materials and methods

Samples were collected from bark of elm trees over a period of two years (2002–2004), in Isfahan Province. Mites were removed from the bark by extraction using Tullgren funnels. Mites were cleared in Nesbitt's solution and mounted in Hoyer's medium (Walter and Krantz 2009). The line drawings and examinations of the specimens were performed with an Olympus BX51 phase contrast microscope equipped with a drawing tube. All measurements in the descriptions are given in micrometres (μm). Dorsal shield length and width were taken from the anterior to posterior margins along the midline, and at its broadest point, respectively. Length and width of the sternal shield were measured from the anterior point to the posterior point at the full length and broadest point, respectively. Genito-ventral shield length and width were measured along the midline from the posterior margin of the sternal shield to the posterior margin of the genito-ventral shield, and at the maximum, respectively. Leg lengths were measured from base of the coxa to the apex of the tarsus, excluding the pre-tarsus. Lengths for the fixed and movable cheliceral digits were taken from the base of the digits to their tips. The nomenclature used for the dorsal idiosomal chaetotaxy is that of Lindquist and Evans (1965), the leg chaetotaxy is that of Evans (1963), and names of other anatomical structures mostly follow Evans and Till (1979). We use the term "lyrifissures" to refer to slit-shaped sensilli, and "pore" for circular or oval-shaped cuticular openings of unspecified function. Holotype and paratypes of the new species are deposited in the Acarological collection, Department of Plant Protection, Yazd Branch, Islamic Azad University (YIAU); one paratype is deposited in the Jalal Afshar

Zoological Museum, College of Agriculture, University of Tehran, Iran (JAZM) and one paratype is also deposited in the Australian National Insect Collection, CSIRO Ecosystem Sciences, Canberra, Australia (ANIC).

Taxonomy

Genus *Laelaspisella* Marais & Loots, 1969
Laelaspisella Marais & Loots, 1969: 1.

Type species. *Laelaspisella epigynalis* Marais & Loots, 1969, by original designation.

 Notes on the genus. The presence of pre-sternal plates and an expanded epigynal shield suggests a superficial similarity to *Gymnolaelaps*. However, *Laelaspisella* has a hypertrichous dorsal shield, two ventral setae on genu IV, and lacks metasternal setae *st4*. *Gymnolaelaps* has a normal complement of 40 pairs of setae on the dorsal shield, one ventral seta on genu IV, and the metasternal setae are always present.

 Diagnosis. The genus is characterised by a well sclerotised hypertrichous holodorsal shield, (podonotal area hypertrichous or with normal chaetotaxy), convex dorsal shield and flat venter, and a large genito-ventral shield, expanded posterior to the genital setae, with strong reticulated ornamentation. Pre-sternal plates present (lightly sclerotised in the new species); female sternal shield deeply concave in posterior margin and lateral corners extended to the level of coxa III, with three pairs of simple sternal setae; endopodal shields between coxae II and III fused with sternal shield. Metasternal setae *st4* always absent; pores iv3 present on the posterolateral extensions of sternal shield; exopodal plate behind coxa IV triangular, more or less contiguous with but separate from peritrematal shields; peritrematal shield extending posteriorly well past coxae IV; genito-ventral shield with rounded posterior margin separate from anal shield, or with straight posterior margin touching anal shield; opisthogastric membrane with eight to nine pairs of smooth setae (r6 is not included), setae *Jv5* and *Zv5* longer than other opisthogastric area setae or normal (not longer than the other dorsal setae); anterior margin of epistome smooth or with irregular minute denticulation; chelicera with small and robust digits with few teeth, dorsal seta sometimes absent. Hypostomal groove with four to six rows of denticles. Corniculi well-sclerotised; palp tarsal claw with two pointed tines. Legs shorter than idiosoma, genu IV with ten setae (2 2/1 3/1 1), genu I with seta *pd3* absent (2 3/2 2/1 2) or present (2 3/2 3/1 2).

 These characters are variable within the genus *Laelaspisella*: (1) dorsal seta of chelicera present or absent; (2) podonotal shield hypertrichous or with normal chaetotaxy; (3) setae *Jv5* and *Zv5* expanded or normal; (4) seta *pd3* on genu I present or absent; (5) extra opisthogastric setae present or absent; (6) genito-ventral shield with rounded posterior margin separate from anal shield, or with straight posterior margin touching anal shield; (7) Anterior margin of epistome smooth or with irregular minute denticulation.

 To separate *Laelaspisella* from *Gymnolaelaps*, the following characters can be used: *Laelaspisella* has (1) opisthonotal area of dorsal shield hypertrichous; (2) metasternal

setae absent; (3) genu IV with two ventral setae; (4) pore iv3 on sternal shield. Gymnolaelaps has (1) opisthonotal area of dorsal shield not hypertrichous; (2) metasternal setae present; (3) genu IV with one ventral seta; (4) pore iv3 in soft skin.

Results
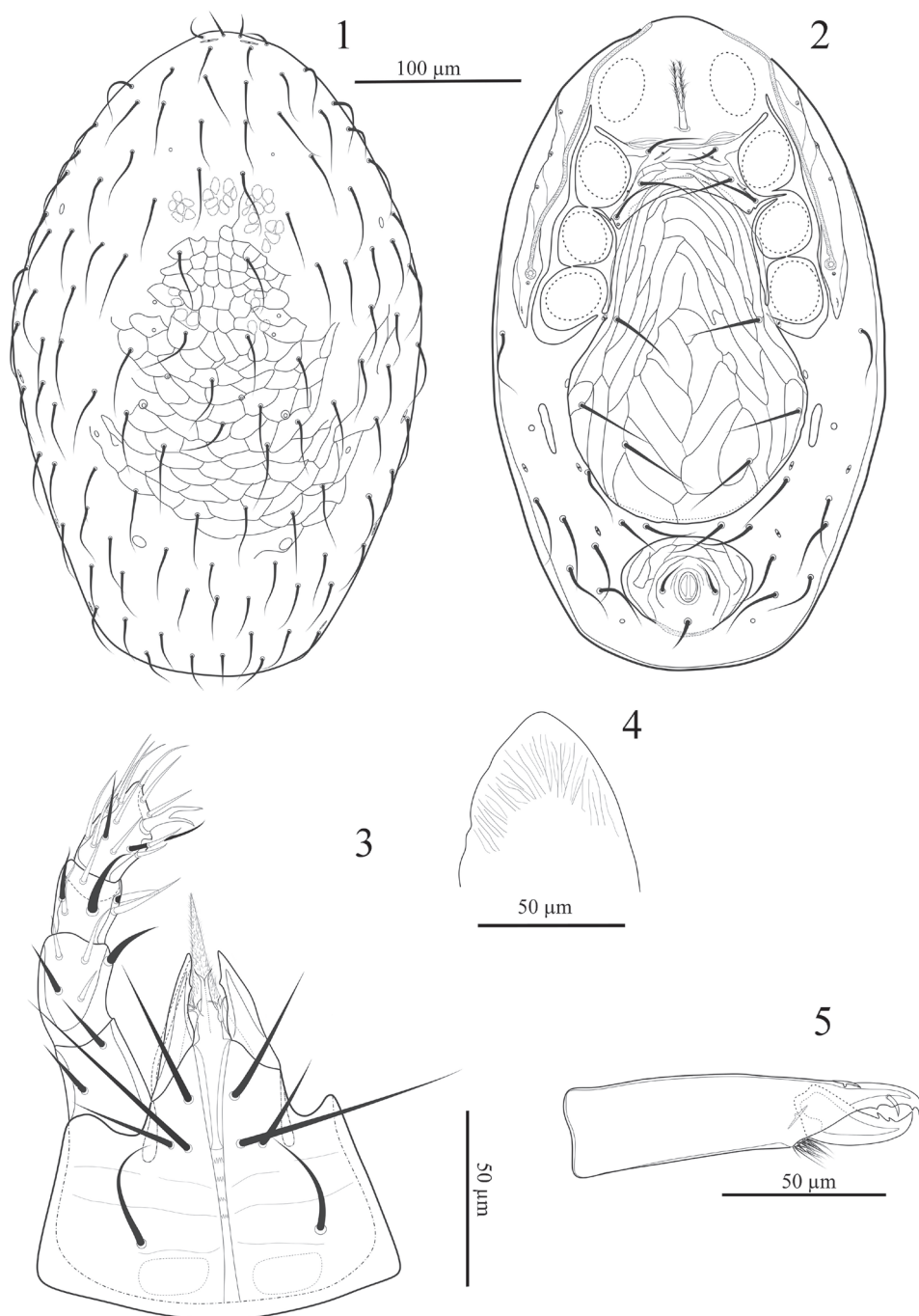
Laelaspisella elsae sp. n.
http://zoobank.org/E5F8EAC9-F6EF-4242-9B3C-BBACA0A9B0DB
Figures 1–9

Type material. Holotype, female, Iran, Isfahan, March-April 2002, A. Jalalizand coll., from bark of elm trees (in YIAU). Paratypes, five females same data as holotype (in YIAU, JAZM and ANIC).

Description of the female. *Dorsal idiosoma* (Fig. 1). Dorsal shield length 400–449, width 281–333 (n = 6). Shield oval shaped, convex, well-sclerotised, reticulated; with about 109–111 simple and long setae, with some unpaired and asymmetrical setae in opisthonotal area, setae similar in length (30–40) and thickness, most long enough to reach well past base of next posterior seta, except *j1* and *z1* (13–15) and some posterio-lateral setae (14–16). Shield with 12 pairs of pore-like structures, apparently including three pairs of gland pores and eight pairs of poroids; lyrifissures near the base of *z1* large and slit-like, others smaller and ovoid.

Ventral idiosoma (Fig. 2). Tritosternum with paired pilose laciniae (33–36), columnar base (12–13 × 5–6 wide); presternal area with transverse lightly sclerotised presternal lines. Sternal shield (length 35–43) narrowest between coxae II (99–100), widest at level between coxae II and III (120–128), with convex anterior margin; posterior margin deeply concave; shield bearing three pairs of smooth pointed setae (*st*1 27–32, *st*2 35–40, *st*3 40–43) and two pairs of lyrifissures, one pair adjacent to setae *st*1 and the other between *st*2 and *st*3; surface with distinct reticulate ornamentation. Metasternal setae *st*4 apparently absent but metasternal poroids present on the posterolateral extensions of sternal shield; endopodal plates II/III fused to sternal shield, endopodal plates III/IV elongate, narrow, curved, but not fused to large triangular podal shields posterior to coxae IV. Genito-ventral shield broad, length 258–267, maximum width 188–195, posterior edge rounded, reticulate throughout, bearing genital setae *st5* (50–55) and two additional pairs of setae on its surface, *Jv*1, *Zv1* (50–62), paragenital poroids present. Anal shield oval, large (64–73 × 82–88 wide), reticulate throughout, anal pores indistinct, para-anal setae (12) shorter than post-anal seta (20), cribrum relatively narrow. Opisthogastric skin with eight pairs of smooth setae (55–65) and four pair of pores; elongate metapodal plates (34–37 × 9–11) close to genito-ventral shield. Peritreme extending from mid-coxa IV to anterior level of coxa I, peritrematal shield wide, with a very wide outer margin, bearing three pairs of discernible pore-like structures, two pairs of poroids opposite coxae II–III and another pair opposite coxae I–II.

Figures 1–5. *Laelaspisella elsae* sp. n., female. **1** Dorsal shield **2** Ventral idiosoma **3** Hypostome **4** Epistome **5** Chelicera.

Gnathosoma. Hypostomal groove with four rows of denticles each bearing 2–5 small teeth (Fig. 3). Corniculi robust and hornlike. Internal malae complex, with two pairs of lobes, inner lobes narrow and long, with smooth edges, outer lobes very short, narrow, branched. Hypostome with four pairs of setae, internal posterior hypostomal setae *h3* longest (67–70), *h1* (42–45), *h2* (28–30), palpcoxal *pc* (32–35) (Fig. 3). Palp chaetotaxy: trochanter 2, femur 5, genu 6, tibia 14, tarsus 15, all setae smooth and needle-like; palp tarsal claw with two pointed tines of equal length, without any hyaline membranes (Fig. 3). Epistome somewhat subtriangular, with a smooth margin (Fig. 4). Fixed digit (40–41) of chelicera with two small pointed teeth (Fig. 5); pilus dentilis moderately thick, dorsal seta not detected, movable digit (36-38) with two large teeth; arthrodial membrane with a row of short filaments.

Legs. Legs II and III shorter (309-320, 302-310), I and IV longer (349-360, 431-447) (excluding pre-tarsus). Leg I: coxa 0 0/1 0/1 0, trochanter 1 0/2 1/1 1, femur 2 2/1 3/3 2, genu 2 3/2 3/1 2 (Fig. 6), tibia 2 3/2 3/1 2 (Fig. 6). Leg II: coxa 0 0/1 0/1 0, trochanter 1 0/2 0/1 1, femur 2 3/1 2/2 1, genu 2 3/1 2/1 2 (Fig. 7), tibia 2 2/1 2/1 2 (Fig. 7). Leg III: coxa 0 0/1 0/1 0, trochanter 1 0/2 0/1 1, femur 1 2/1 1/0 1, genu 2 2/0 2/1 0 (Fig. 8), tibia 2 1/1 2/1 1 (Fig. 8). Leg IV (Fig. 9): 0 0/1 0/0 0, trochanter 1 0/2 0/1 1, femur 1 2/1 1/0 1, genu 2 2/1 3/1 1, tibia 2 1/1 3/1 2; all setae fine and needle-like. Tarsi I-IV with 18 setae 3 3/2 3/2 3 + *mv*, *md*. All pre-tarsi with a pair of claws and a long thin membranous ambulacral stalk.

Insemination structures. Not seen, apparently unsclerotised.

Etymology. It is with great pleasure that we name this species after Elsa Joharchi, the new-born daughter of the first author.

Remarks. *Laelaspisella elsae* sp. n. differs from all other species in the genus in having the genito-ventral shield broad and bearing genital setae *st5* and two additional pairs of setae on its surface, hypostomal groove with four rows of denticles, genu I with seta *pd3* (2 3/2 3/1 2) and two ventral setae on genu IV (2 2/1 3/1 1), also dorsal seta of chelicera absent.

Laelaspisella tonsilis (Karg, 1989), comb. n.

Pseudoparasitus (*Gymnolaelaps*) *tonsilis* Karg, 1989a: 335.

Specimens examined. The paratype specimen of Karg's collection was examined by the first author and this information is as follows: Slide ZMB Kat. Nr. 41473, labeled *Pseudoparasitus tonsilis* Karg, 1989a, Nr. 3942♀, paratypus, St. Lucia, Antillen, Castries, Vigie point, Eins.: Dr. Mahunka, Budapest, 11.7.80.

Remarks. *Pseudoparasitus* (*Gymnolaelaps*) *tonsilis* shares all important character states with the genus *Laelaspisella* : dorsal shield hypertrichous, two ventral setae on genu IV (2 2/1 3/1 1), genu I (2 3/2 3/1 2) seta *pd3* present, lacks metasternal setae *st4*, seta *Jv5* long (Karg 1989a in his description named this seta as *Z5*). Therefore we consider *Pseudoparasitus* (*Gymnolaelaps*) *tonsilis* as a member of *Laelaspisella*.
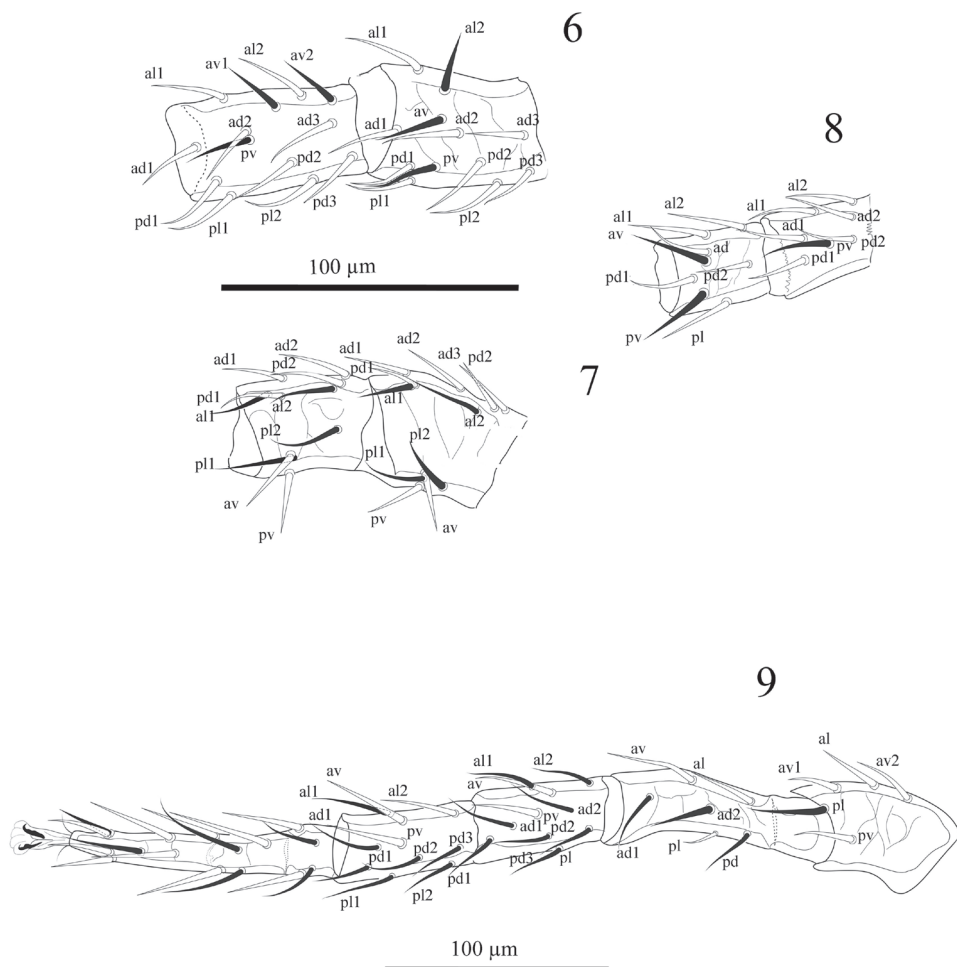
Figures 6–9. *Laelaspisella elsae* sp. n., female. **6** Genu and tibia I (dorsal aspect) **7** Genu and tibia II (dorsal aspect) **8** Genu and tibia III (dorsal aspect) **9** Leg IV (ventral aspect).

Laelaspisella berlesei Joharchi, nom. n.

Laelaps (*Eulaelaps*) *canestrinii* Berlese 1903: 13.
Laelaps (*Hypoaspis*) *canestrinii* Berlese 1904: 412.
Gymnolaelaps canestrinii (Berlese, 1903) sensu Costa, 1962: 491.

Remarks. The identity of *L. canestrinii* is very confused. In *Laelaps canestrinii* Berlese, 1892, the female has a very wide genito-ventral shield carrying four pairs of setae in addition to *st5*, and has a straight posterior margin. There are no setae between the genito-ventral and anal shields. The sternal shield has only two pairs of setae, the metasternal

plates and setae are absent, the anal shield is wider than long, and the movable digit of the chelicera has three teeth. In the male the anal shield is fused to the genito-ventral shield, with the fusion marked by a distinct line. Berlese (1903) referred to this species as *Laelaps* (*Eulaelaps*) *canestrinii*. Berlese (1904) then added some morphological information and illustrations for a species that he called *Laelaps* (*Hypoaspis*) *canestrinii*. In these illustrations the genito-ventral shield of the female carries only one pair of setae and has a rounded posterior margin. The anal shield is narrow, and there is a pair of setae between the genito-ventral shield and the anal shield. In the male, the anal shield is clearly separate from the genito-ventral shield. These descriptions appear to refer to two different species. Hunter (1967) referred to this problem but did not resolve it. *Laelaps canestrinii* does not belong to the genera *Laelaps* or *Hypoaspis*, and a solution to the identification of the true genus of *Laelaps canestrinii* Berlese, 1892 can only come from a detailed study of Berlese's specimens. The 1904 re-description is only a misidentification of the 1892 species. Costa (1962) re-described and illustrated a species he called *Gymnolaelaps canestrinii* (Berlese, 1903), but he did not mention *Laelaps canestrinii* Berlese, 1892. Costa was wrong about this species because only the 1892 description and illustrations refer to the true species of *canestrinii*. Therefore *L. canestrinii sensu* Berlese (1903), (1904) and Costa (1962) does not have a name. Therefore, we rename this species as *Laelaspisella berlesei* Joharchi, nom. n. (=*Laelaps* (*Eulaelaps*) *canestrinii* Berlese, 1903 = *Laelaps* (*Hypoaspis*) *canestrinii* Berlese, 1904 = *Gymnolaelaps canestrinii* (Berlese, 1903) *sensu* Costa, 1962) in honour of Antonio Berlese. In view of this confusion, it is difficult to determine the identity of the specimens cited under these names by other authors.

Discussion

All six species of *Laelaspisella* share four important diagnostic character states: (1) hypertrichous dorsal shield (in both the podonotal and opisthonotal region or only in the opisthonotal region); (2) two ventral setae on genu IV (2 2/1 3/1 1); (3) metasternal setae *st4* absent but metasternal poroids present on the posterolateral extensions of sternal shield; (4) Palp tarsal claw with two pointed tines.

Some of the diagnostic characters of the *Laelaspisella elsae* were unique within the known *Laelaspisella* species (such as: presternal area with transverse lightly sclerotised presternal lines, genito-ventral bearing genital setae *st5* and two additional pairs of setae on its surface and hypostomal groove with four rows of denticles each bearing 2-5 small teeth) but at the present time, creating a new monotypic genus to accommodate the new species would not help to clarify the taxonomic problems existing within the family Laelapidae. Therefore, this species is provisionally placed in *Laelaspisella* until a comprehensive revision of all these genera resolves its relationships.

The key below distinguishes the six species of *Laelaspisella*. In this key we recognise two distinct groups of species within the genus. All species group of *epigynalis* have 12 setae on genu I (2 3/2 2/1 2), with seta *pd3* absent. Group *elsae* species have 13 setae on genu I (2 3/2 3/1 2), with seta *pd3* present.

Key to species of *Laelaspisella*

1   Genu I with 12 setae (2 3/2 2/1 2) *pd3* absent *epigynalis* species group **2**
–   Genu I with 13 setae (2 3/2 3/1 2) *pd3* present *elsae* species group.............**3**
2   Genito-ventral shield tapered posteriorly, opisthogastric area with eight pairs of setae.........................***Laelaspisella macrodorsalis* Marais & Loots, 1969**
–   Genito-ventral shield rounded posteriorly, opisthogastric area with nine pairs of setae.. ***L. epigynialis* Marais & Loots, 1969**
3   Dorsal shield hypertrichous in both the podonotal and opisthonotal region ... **4**
–   Dorsal shield hypertrichous only in the opisthonotal region **5**
4   Post-stigmatal section of peritrematal shield elongate, extending well behind exopodal shield .... ***L. tonsilis* (Karg, 1989a)**
–   Post-stigmatal section of peritrematal shield short and wide.........................
      .... ***Laelaspisella kabitae* (Bhattacharyya, 1968)**
5.   Genito-ventral shield bearing genital setae *st5* and two additional pairs of setae on its surface, dorsal shield with long setae ....***Laelaspisella elsae* sp. n.**
–   Genito-ventral shield bearing only genital setae *st5* on its surface, dorsal shield with short setae..............................***Laelaspisella berlesei* Joharchi, nom. n.**

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RESEARCH ARTICLE

A new genus and species of Laelapidae from Iran with notes on *Gymnolaelaps* Berlese and *Laelaspisella* Marais & Loots (Acari, Mesostigmata)

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Abstract

Pogonolaelaps **gen. n.** a new genus of Laelapidae Berlese is erected and described based on *P. canestrinii* (Berlese), **comb. n.** as well as on specimens which were collected from soil and ant nests in different parts of Iran. Also, a new species *Pogonolaelaps beaulieui* **sp. n.** is described based on specimens collected from soil, litter and ant nests in various parts of Chaharmahal va Bakhtiari province, Iran. The genus *Gymnolaelaps* is revised considering species with some morphological deviations. *Gymnolaelaps reniculus* (Karg, 1981) and *Gymnolaelaps triquetrus* (Karg, 2003) are removed from this genus and placed in their original genus *Pseudoparasitus*. The characters of *Laelaspisella* Marais & Loots, 1969 are discussed in a detail along with a proposal of a new definition.

Keywords

Taxonomy, *Pogonolaelaps* gen. n., ant nest, *Gymnolaelaps*, *Laelaspisella*

Introduction

The Laelapidae Berlese comprises a multitude of morphologically and behaviorally diverse mite groups that are free-living or associated with arthropods, mammals and birds (e.g. Strong and Halliday 1994, Faraji and Halliday 2009, Lindquist et al. 2009). Hypotheses concerning the evolutionary history of this family and its relatives are minimally developed and the classification of the group is consequently inadequate (Casanueva 1993). This family is considered to include different subfamilies, genera and subgenera by different authors (Berlese 1903, 1923, Baker and Wharton 1952, Van Aswegen and Loots 1970, Karg 1978, 1979, 1982, 1993, 2000, Krantz and Ainscough 1990, Casanueva 1993, Krantz 1998). Lindquist et al. (2009) considered nine subfamilies for laelapid mites, based in part on a phylogenetic study of free-living and arthropod-associated taxa by Casanueva (1993), and the recently characterized subfamily Acanthochelinae (Radovsky and Gettinger 1999).

Gymnolaelaps was considered at different taxonomic levels: as a subgenus of *Hypoaspis* sensu lato (Berlese 1916, Evans and Till 1966, Hunter 1967), as a subgenus of *Pseudoparasitus* (Karg 1989, 1993) and as a distinct genus (Sellnick 1935, Evans and Till 1979, Joharchi et al. 2011; Joharchi and Halliday 2013). We herein consider *Gymnolaelaps* as a genus. The genus *Gymnolaelaps* has been collected in many parts of the world, mainly from ants' nests. The genus includes approximately 35 described species (Joharchi et al. 2011). So far, a total of eight species notwithstanding their validity were reported from Iran: *Gymnolaelaps canestrinii* (Berlese), *G. kabitae* Bhattacharyya, *G. laevis* (Michael), *G. messor* Joharchi et al., *G. myrmecophilus* (Berlese), *G. myrmophilus* (Michael) and *G. prestoni* Joharchi et al., *G. artavilensis* Joharchi & Halliday (Joharchi and Halliday 2013).

Laelaspisella was erected by Marais and Loots (1969) in Laelapinae to accommodate two new species: *Laelaspisella macrodorsalis* Marais & Loots and *L. epigynialis* Marais & Loots collected from forest soil in South Africa, Lesotho and Congo. Subsequently, this genus was considered as a subgenus of *Hypoaspis* sens. lat. by Karg (1989), who described two additional species, *Hypoaspis* (*Laelaspisella*) *foramenis* Karg, 1989 and *Hypoaspis* (*Laelaspisella*) *cavitatis* Karg, 1982 and as distinct genus by Joharchi and Halliday (2013). The latter authors considered *Laelaspisella canestrinii* and *L. kabitae* as two more species of this genus but excluded two mentioned species of Karg of *Laelaspisella* (Joharchi and Halliday 2013).

During our survey on Mesostigmata mites inhabiting soil and litter, *Pogonolaelaps canestrinii* (Berlese), comb. n. from different habitats and localities was discovered. Based on that species, a new genus, *Pogonolaelaps* gen. n. is proposed and described. Also, a new species of *Pogonolaelaps* found in Iran is described. Redescription of *Pogonolaelaps canestrinii* comb. n. is given along with additional information on the specimens of this species in Berlese collection. The definition of *Laelaspisella* is also revised.

Materials and methods

Mites were collected from soil and litter samples from different parts of Iran. Mites were extracted using Berlese funnels, placed in lactic acid at 55 °C for clearing and then mounted in Hoyer's medium on permanent microslides. Line drawings were made by the use of a drawing tube and figures were elaborated with Corel X-draw software, based on the scanned line drawings. All measurements are given in micrometers (μm). The dorsal setae notation, leg and palp chaetotaxy follows that of Lindquist and Evans (1965), Evans (1963a, b) and Evans and Till 1965 respectively. Terminology for idiosomal glands and lyrifissures follows Johnston and Moraza (1991). We have attempted to identify all pore-like structures, but we acknowledge that some may have been overlooked. The holotype and some of the paratypes (four females and two males) of the new species are deposited in the Acarological Laboratory, Department of Plant Protection, Agricultural College, Shahrekord University (APAS), Shahrekord, Iran. Three female paratypes are deposited in the Senckenberg Museum fur Naturkunde Görlitz, Am Museum, Görlitz, Germany; Natural History Museum Cromwell Road London SW7 5BD UK; and National Museum of Natural History (NMNH), Smithsonian Institute Washington D.C., 20013-7012 USA. One female paratype and one male are deposited in Poznan University of Life Sciences, Department of Forest Pathology Wojska Polskiego 71C, 60–625 Poznań, Poland. Redescription of *Pogonolaelaps canestrinii* comb. n. was based on the specimens in Acarological Laboratory, Department of Plant Protection, Agricultural College, Shahrekord University Shahrekord, Iran, which the figures have been compared with type specimens in the Berlese collection (Italy) by Dr. Roberto Nanelli.

Systematics

Genus *Pogonolaelaps* gen. n.
http://zoobank.org/94CC5068-5F2C-4222-8D3B-54DD32D3216D

Type species. *Laelaps canestrinii* Berlese, 1903, by original designation.

   Genus diagnosis. Female with a three-tined palp tarsal claw; the dorsal seta of the chelicerae present, epistome smooth, corniculi horn-like, internal malae free medially and densely fringed with very elongate hairs, in addition possess two detachments of densely and very elongate hairs at basal part of each internal mala; *st*4 absent; genital shield large, abutting anal shield, with *st*5 on shield and three pairs of setae adjacent to the lateral edges; scimitar-shaped dorsal setae with small knob at their base, dorsal shield with holotrichous status on podonotal and hypertrichous on opisthonotal part, plus 0-3 unpaired setae between *J* series and 7-9 pairs of long tick setae on lateroposterior part of opisthonotal region; genu and tibia I with normal chaetotaxy (2 3/2 3/1 2), and genu IV with ten setae including two ventral setae (*av* and *pv*). Male with separate anal shield and strong spine-like seta on femur II.

Description. *Idiosomal dorsum.* Dorsal shield oval shaped, well sclerotized, nearly wraps around and overlaps onto the ventral idiosoma, podonotal part with holotrichous and opisthonotal with hypertrichous condition, shield with 51-55 pairs of setae, 28-32 pairs on opisthonotal region, plus 0-3 *Jx* setae between *J* series (usually with 3), *rx* seta present on podonotal part, setae increasing in length from anterior to posterior and from dorso-central to dorso-lateral part, latero-posterior part of opisthonotal region with 7-9 pairs of long, thick, barbed setae (Figs 11, 15), dorsal setae with a small basal knob (Fig. 17). Dorsal shield generally with six pairs of large slit-like lyrifissures (Figs 11, 15).

Idiosomal venter. Tritosternum with columnar base and paired free pilose laciniae; pre-sternal plates weakly sclerotized and ornamented with transverse lines (Figs 1, 2, 12, 16a). Sternal shield widest between coxae II and III, anterior margin sinuate, convex medially, posterior margin deeply concave (Figs 1, 2, 16a). With three slit-like *iv1-3*, all located on the surface of sternal shield (Fig. 16a); *st4* absent (Figs 2, 16a). Endopodal plates II/III fused to lateral margins of sternal shield, endopodal plates III/IV elongate, curved. Large crescent-shape podal plates surrounding coxae IV, fused with contiguous exopodal plates and extended to the anterior level of coxae II (Figs 1, 16a).

Genital shield broad, abutting anal shield, with one pair of setae (*st5*) on shield and three pairs of setae adjacent to lateral edges (Figs 1, 3, 16a); circular paragenital pores (*iv5*) located on soft integument between coxa IV and pair of minute narrow platelets (Figs 1, 16a). Anal shield subtriangular. Opisthogastric surface with: one pair of elongate metapodal plates, two pairs of minute platelets, 10-11 pairs of long setae, *r6*, *Jv1-5* and *Zv1-5* usually present. Peritreme extending from coxa IV to anterior level of coxa I (Fig. 16a), peritrematal shield wide, with two pairs of post-stigmatal pores, one pair of small pores anterior to stigmata and two pairs of pores (*ip*, *gp*) at level of coxae II/III (Fig. 16a at left side).

Gnathosoma. Deutosternal groove with six rows of denticles, corniculi horn-like, internal malae free medially and densely fringed, in addition possess two detachments of densely and very elongate hairs at basal part of each internal mala; labrum elongate, densely pubescent (Figs 7, 13, 18). Epistome sub-triangular with smooth antero-lateral margins (Figs 8, 19). Chelicerae chelate-dentate with prominent dorsal seta, lyrifissure, arthrodial processes and moderately robust setaceous pilus dentilis, movable digit with two teeth (Figs 9, 20). Digit-like male spermatodactyl simple and free distally (Figs 14, 28). Palp chaetotaxy normal (sensu Evans and Till 1965), numbers of setae on palp trochanter-tarsus: 2, 5, 6, 14 and 15 with aciculate and smooth setae, except *al1-2* of palp genu aciculate and slightly thickened; palp-tarsal apotele three-tined, basal tine smaller (Figs 21–22).

Legs. Tarsi I–IV with claws and ambulacra (Figs 1, 10, 23–26). Leg chaetotaxy as follows: **leg I:** (Fig. 23) coxa 0 0/1 0/1 0, trochanter 1 1/2 0/1 1, femur 2 3/2 2/2 2, genu 2 3/2 3/1 2, tibia 2 3/2 3/1 2. **Leg II:** (Fig. 24) coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/2 1, genu 2 3/1 2/1 2, tibia 2 2/1 2/1 2, tarsus 3,3/2,3/2,3 + *mv*, *md*. **Leg III:** (Fig. 25) coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 1 2/0 1/1 1, genu 2 2/1 2/ 1 1, tibia 2 1/1 2/1 1, tarsus 3 3/2 3/2 3 + *mv*, *md*. **Leg IV:** (Fig. 26)

coxa 0 0/1 0/0 0, trochanter 1 0/1 0/2 1, femur 0 2/1 1/1 1, genu 2 2/1 3/1 1 (Figs 6, 10, 26), tibia 2 1/1 3/1 2, tarsus 3 3/2 3/2 3 + *mv, md.*

Etymology. The name of the new genus is derived from the Greek word *pogon* (beard), and refers to the unusually long internal malae (gender masculine).

Note on subfamily placement of new genus. Evans and Till (1966) proposed six subfamilies for laelapid mites. We consider our new genus as a member of Laelapinae subfamily (*sensu* Evans and Till 1966) based on the presence of attributes of the subfamily: presternal area in the female reticulated or with pre-endopodal shields, deutosternum with five to seven (usually six) transverse rows of denticles, chelicerae in the female chelate-dentate or rarely chelate-edentate, pilus dentilis present, in the male chelate-dentate with spermadactyl free anteriorly or partially fused with the movable digit, hypertrichy of dorsal shield when present usually restricted to the region of the *J* series of setae, male with holoventral shield or with discrete sternito-genito-ventral and anal shields.

This subfamily contains seven genera: *Ololaelaps*, *Androlaelaps*, *Ondatralaelaps*, *Laelaps*, *Hyperlaelaps*, *Pseudoparasitus* and *Hypoaspis* sensu lato with nine subgenera for the latter like: *Hypoaspis* (*Hypoaspis*), *H.* (*Alloparasitus*), *H.* (*Stratiolaelaps*), *H.* (*Cosmolaelaps*), *H.* (*Penumolaelaps*), *H.* (*Gymnolaelaps*), *H.* (*Holostaspis*), *H.* (*Laelaspis*) and *H.* (*Gaeolaelaps*), which are considered as full generic status presently (Trägårdh 1952, Hunter 1966, Lindquist et al. 2009, Rosario 1981, Beaulieu 2009, Joharchi et al. 2011).

Remarks. Members of *Pogonolaelaps* gen. n. in general appearance may be similar to those genera of Laelapinae *sensu* Evans & Till (1966), which possess a broad epigynal shield such as *Laelaspis*, *Gymnolaelaps*, *Pseudoparasitus*, and due to the absence of *st4* and presence of hypertrichy on dorsal shield to *Laelaspisella* (was considered in this subfamily by Marais and Loots 1969) and for its special shape of dorsal setae with small knob at their base to *Cosmolaelaps* genera.

Pogonolaelaps may be similar to *Laelaspis* but it can be distinguished readily by the following characters. In *Laelaspis* palptarsal claw is two-tined (three tined in *Pogonolaelaps*); genital shield in *Laelaspis* with characteristic ornamentation including two distinct Λ-shaped lines; with two pairs of setae on extreme edges of shield in addition to *st5* (in *Pogonolaelaps* without this special ornamentation and with only one pair of setae on the shield margin); *Laelaspis* usually lacks pre-sternal shield (present in *Pogonolaelaps*, but not markedly sclerotized). *Laelaspis* genu IV with nine setae including one ventral seta (*Pogonolaelaps* with ten setae including two ventral setae: *av* and *pv*); male of *Laelaspis* with holoventral shield (*Pogonolaelaps* with separate sub-triangular anal shield); dorsal shield in *Laelaspis* lacks hypertrichy (*Pogonolaelaps* with hypertrichy on opisthonotal part); *Laelaspis* members with *st4* and pore-like *iv3* on integument posterior to sternal shield (*Pogonolaelaps* lacks *st4* and *iv3* located on posterolateral extension of sternal shield near *st3*).

Pseudoparasitus and *Gymnolaelaps* members have *st4* and pore-like *iv3* on integument posterior to sternal shield, conspicuous denticulate epistome, genu IV with one ventral seta (*av*), and holotrichous dorsal shield with acicular setae; known males have holoventral shield and lack large spine or spur-like setae on femur II. *Pseudoparasitus*

has large genital shield with 4–5 pairs of setae including two pairs on the shield surface; however, all of those in *Gymnolaelaps* are located on the lateral margin of shield. *Pogonolaelaps* lacks *st4* and *iv3* located on posterolateral extension of sternal shield near *st3*, with smooth sub-triangular epistome, large genital shield with only one pair of setae (*st5*) on the lateral margin, genu IV with two ventral seta (*av* and *pv*), dorsal shield possesses setae with small knob at their base, opisthonotal part with hypertrichous condition, males have separate anal shield and have large spine-like seta (*pv*) on femur II.

   Laelaspisella (*L. macrodorsalis* and *L. epignialis*) (Marais and Loots 1969) has dorsal shield hypertrichous for both the podonotal and opisthonotal parts, and with very small acicular setae, setae *Jv5* and *Zv5* are spatulate and pilose, chelicera lacks dorsal seta, the setation of genu I is deficient in one postero-dorsal seta (2 3/2 2/1 2), while *Pogonolaelaps* has dorsal setae with small knob at their base, hypertrichous condition only of opisthonotal region, setae *Jv5* and *Zv5* acicular, chelicerae possess dorsal setae; the setation of genu I is typical with three *pd* setae (2 3/2 3/1 2). Differences among *Pogonolaelaps* gen. n. and other related genera such as *Laelaspis*, *Gymnolaelaps*, *Pseudoparasitus*, *Laelaspisella* and *Cosmolaelaps* are mentioned in Table 1.

Pogonolaelaps canestrinii (Berlese, 1903), comb. n.
Figures 1–14

Laelaps canestrinii Berlese, 1892: LXIX, 1.
Laelaps (*Eulaelaps*) *canestrinii* Berlese, 1903: 13.
Hypoaspis canestrinii. — Oudemans 1902: 24; Oudemans 1903; 129; Buitendijk
    1945: 295.
Laelaspis (*Hypoaspis*) *canestrinii*. — Berlese 1904.
Gymnolaelaps canestrinii. — Vitzthum 1929: 25; Sellnick 1931: 695; Costa 1962: 491:
    Costa 1966: 74; Bhattacharyya 1968: 539; Joharchi et al. 2011: 23.
Laelaps canestrinii. — Tipton 1960: 290.
Hypoaspis (*Gymnolaelaps*) *canestrinii*. — Hunter 1967: 99; Bregetova 1977: 523.
Pseudoparasitus (*Gymnolaelaps*) *canestrinii*. — Karg 1981: 218; Karg 1989, 334; Karg
    1993: 135.
Hypoaspis (*Cosmolaelaps*) *canestrinii*. — Karg 1979: 71.
Laelaspisella canestrinii. — Joharchi and Halliday 2013: 46; Moreira 2014: 316.

   Specimens examined. Khuzestan province: Ahwaz (31°19'22"N, 48°40'50"E, H: 16 m), nest of unknown ant, two females, coll. A. Nemati, 2012; Baghmalek (31°31'22"N, 49°53'8"E, H: 707m), soil, one female and one male, coll. A. Nemati, 2012; Ghaletol (31°37'55"N, 49°53'20"E, H: 885 m), soil and nest materials of unknown ant, one female, coll. A. Nemati, 2012; Izeh (31°49'52"N, 49°52'9"E, H: 845 m), soil, two females, coll. A. Nemati, 2012 and Masjed-Soleiman (31°56'11"N, 49°18'14"E, H: 251 m), soil, one female, coll. A. Nemati, 2011. Chaharmahal Va Bakhtiari province: Shahrekord (32°19'39"N, 50°51'35"E, H: 2206 m), soil, three females, coll. A. Nemati, 2009, Lordegan (31°30'30"N, 50°49'39"E, H: 1594 m), soil,

Table 1. Comparison among *Pogonolaelaps* gen. n. and other related laelapid genera.

	Laelaspis	Gymnolaelaps	Pseudoparasitus	Laelaspisella	Cosmolaelaps	Pogonolaelaps
Type species	*Laelaps astronomicus* Koch, 1839	*Laelaps myrmecophilus* Berlese, 1892	*Laelaps meridionalis* G & R Canestrini, 1882	*Laelaspisella epignialis* Marais & Loots, 1969	*Laelaps claviger* Berlese, 1883	*Laelaps canestrinii* Berlese, 1903
Palp tarsal claw	two-tined	three tined, third tine occasionally reduced, rarely absent	three-tined, posterior tine small	two-tined	two-tined	three-tined
Two distinct Λ-shaped lines on genital shield	present	absent	absent	absent	absent	absent
Posterior margin of genital shield	rounded	straight	straight	nearly rounded or tapered	usually rounded	rounded
Setae on genital shield	all on edges of shield	all on edges of shield	at least two pairs well inside edges of shield	with only $st5$ on the margin of shield	with only $st5$ on the margin of shield	all on edges of shield
Pre-sternal plates	absent	present	present	present	usually present	present and not so discernable
Podal plates behind coxae IV	present	usually present	present	medium size, rounded	absent	medium size, rounded
Epistome	nearly always smooth	denticulate	denticulate	smooth	denticulate	smooth
Hypertrichy of dorsal shield	absent	absent	absent	present on whole dorsum	absent	present only on opisthonotal part
Dorsal shield setae	nearly always scimitar-shaped with small knob at their bases	acicular	acicular	acicular	with different shaped but never acicular	with small knob at their bases
Setae *av* and *pv* on genu IV	only with *av*	only with *av*	only with *av*	with *av* and *pv*	only with *av*	with *av* and *pv*
Seta *pd3* on tibia I	present	present	present	absent	present	present
Male holoventral shield	present	present	present	?	nearly always present	absent, with separate sub-triangular anal shield
Large spine or spur-like seta(e) on male leg II	absent	absent	absent	?	absent	present

	Laelaspis	Gymnolaelaps	Pseudoparasitus	Laelaspisella	Cosmolaelaps	Pogonolaelaps
Seta st4	present	present	present	absent	present	absent
Spatulate elongate Jv5 and Zv5	absent	absent	absent	present	absent	absent
Cheliceral dorsal seta	present	present	present	absent	present	present
Internal malae with elongate densely hairs	absent	absent	absent	present	absent	present
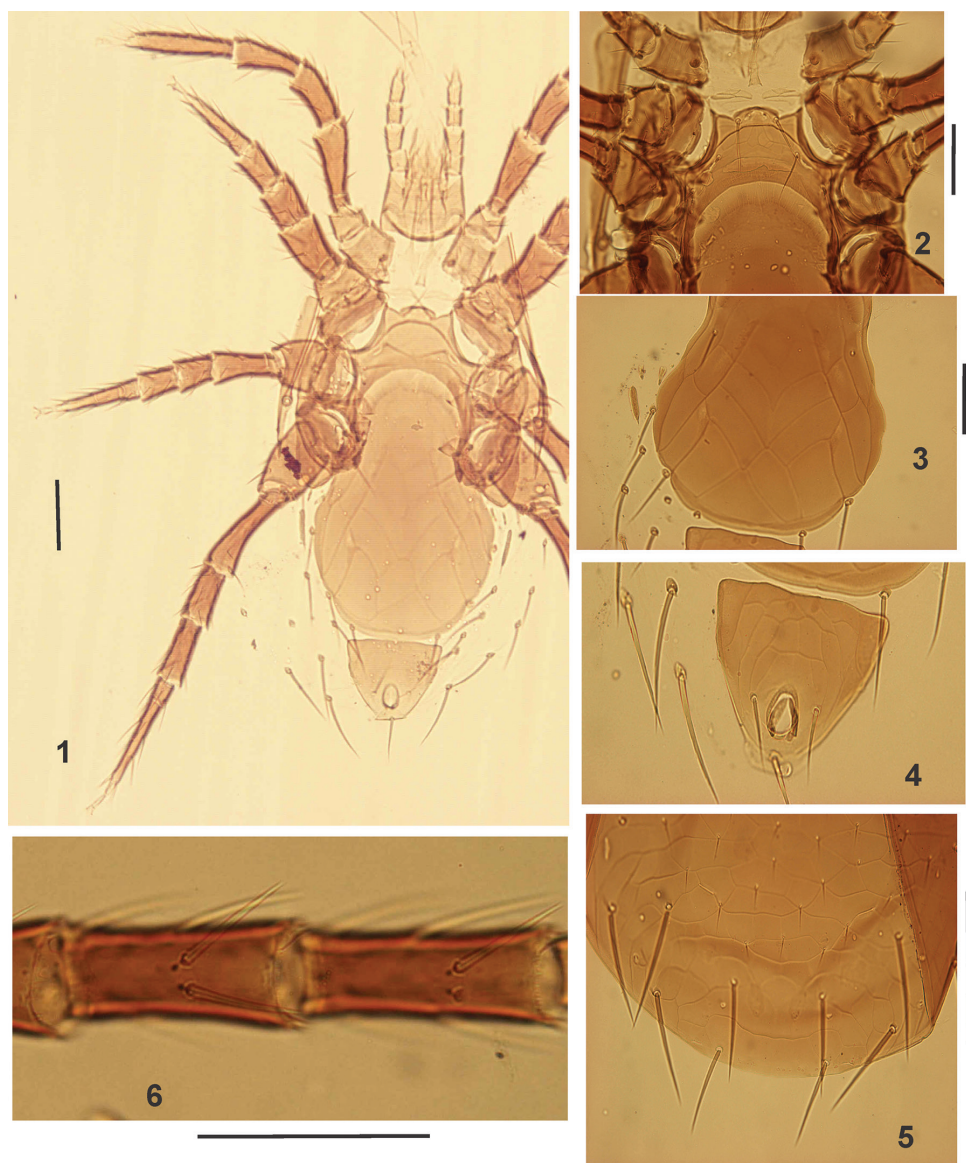
Figures 1–6. *Pogonolaelaps canestrinii* (Berlese). (Female): **1–2** Ventral idiosoma **3** Epigynal shield **4** Anal shield **5** End part of dorsal shield **6** Genu and tibia IV (ventral view). Scale bars: 100 μm.

three females and two males, coll. A. Nemati, 2012; Naghan (31°56'19"N, 50°44'54"E, H: 2219 m), soil, one female, coll. M. Mohseni, 2010. Ben (32°32'32"N, 50°43'48"E, H: 2203 m), soil, four females and one male, coll. A. Nemati, 2011. Esfahan province: Esfahan (32°39'37"N, 51°41'22"E, H: 1608 m), soil, coll. A. Nemati, 2011. Kashan, soil, five females, coll. M. Fahiminezhad, 2006. Shahreza, soil, one female (32°07'N, 51°55'E, alt. 1725 m), 22 August 2010; one female (32°01'N, 51°53'E, alt. 1800 m),

20 March 2011; one female (32°01'N, 51°53'E, alt. 1806 m), 4 April 2011; three females (32°02'N, 51°51'E, alt. 1827 m), 11 June 2011; five females and two males (31°39'N, 51°55'E, alt. 2220 m), 9 July 2011; one female and one male (32°00'20"N, 51°52'54"E, alt. 1823 m), 17 July 2011; two females (31°56'N, 51°44'E, alt. 1963 m), 4 August 2011. Microslides were deposited in APAS.

Explanation concerning Berlese' specimens were cited in the following text under notes on the male of *Pogonolaelaps canestrinii*.

Diagnosis. Podonotal region with 23 pairs of thin small setae with small knobs at their base (except for *j1* and *z1*); opisthonotal region with 32 pairs of setae, three un-paired setae between *J* series and seven pairs of long barbed setae; pre-sternal area with a pair of indistinct poorly sclerotized plates; *iv1-3* slit-like and located on the sternal shield surface; peritremes long, extending to coxa I anteriorly; internal malae densely fringed. Epistome with smooth anterior margin. Palp apotele three-tined; genu IV with 10 setae, including two ventral setae (*av* and *pv*).

Description of the female (n = 7)**.** Figures 1–10.

Dorsal idiosoma. Dorsal shield oval-shaped, length 624–723, width at level of setae *r3* 425-465; reticulation more distinct on opisthonotal part; podonotal region with 23 pairs of thin small setae with small knobs at their base (except for *j1* and *z1*); opisthonotal region with 32 pairs of setae, three unpaired setae between *J* series and seven pairs of long barbed setae (Fig. 5). Dorsal setae short (26–36) except for longer setae on opisthonotal part (52–83). Dorsal idiosoma with 19 pairs of lyrifissures and pore-like structures.

Ventral idiosoma (Figs 1–4)**.** Tritosternum with tubular base (39–47) and pilose laciniae (65–80). Pre-sternal area with a pair of indistinct poorly sclerotized plates (Figs 1, 2). Sternal shield (Figs 1, 2) reticulate anteriorly and laterally, smooth posteriorly, 80–96 long, 107–122 wide, anterior margin sinuate, convex medially, posterior margin deeply concave, sternal setae smooth, *st1* (46–67), *st2* (47–50), *st3* (44–57), *iv1* slit-like, located slightly anterior to *st1*; *iv2* slit-like, between *st2-st3*, *iv3* slit-like, located on postero-lateral corners of sternal shield; *st4* absent. Genital shield (Figs 1, 3) broad, well orna-mented, 346–374 long (including hyaline flap at the base of posterior margin of sternal shield), 177–195 wide at level of *st5* and widest (239–260) near setae *Zv1*, abutting anal shield, bearing one pair of setae (*st5* 44–49); paragenital pores (*iv5*) on soft integument posterior to genital setae. Anal shield (Fig. 4) sub-triangular, reticulated, 99–109 long, 177–195 wide, post-anal seta (43–45) slightly longer than para-anal setae (36–42). Cri-brum extending laterally to level of post-anal seta. Opisthogastric surface with: one pair of elongate metapodal plates plus two pairs of platelets (Figs 1, 3); 10–11 pairs of setae, 36–49 μm long; and seven pairs of pore-like structures, plus one pair (*gv3*) on lateral margin of anal shield. Stigmata surrounded by narrow, pointed stigmatal plate, which extends posteriorly past level of mid-coxae IV. Peritremes long, extending to anterior of coxa I. Endopodal, podal and exopodal plates as in genus.

Gnathosoma. Hypostome (Fig. 7) with three pairs of similar smooth simple setae (*h1*:69–79, *h2*: 21–30, *h3*: 72–84) plus one pair of palpcoxal setae (40–47). Deuto-sternal groove with six rows of denticles; corniculi normal, horn-like, reaching mid-level
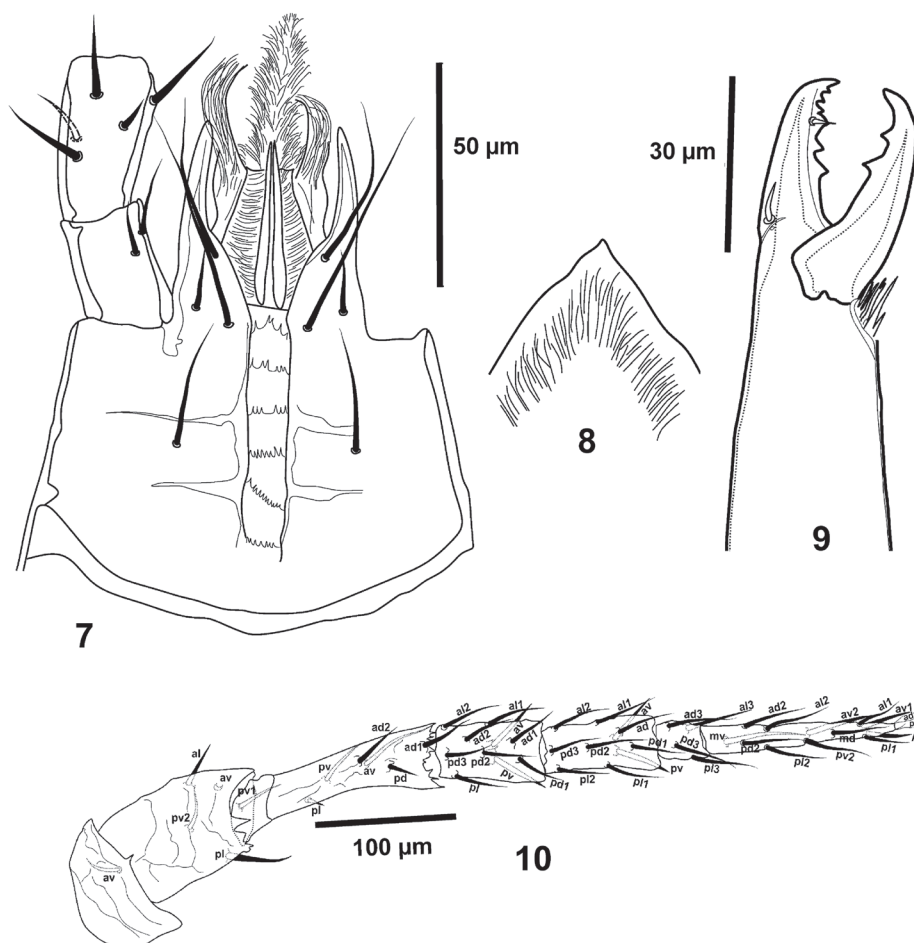
Figures 7–10. *Pogonolaelaps canestrinii* (Berlese). (Female): **7** Hypostome **8** Epistome **9** Chelicera **10** Leg IV.

of palp femur; internal malae densely fringed with very elongate hairs. Epistome (Fig. 8) with smooth anterior margin. Arthrodial processes of chelicerae (Fig. 9) developed, movable digit (47–49) with two teeth, middle article (174–187), fixed digit with six teeth, setaceous pilus dentilis small. Palp attributes as in the genus.

Legs. Tarsi I–IV with claws and ambulacra. Legs I (559–580) and IV (587–605), longer than legs II (429–450) and III (429–455). Genu IV (Figs 6, 10) with 10 setae, including two ventral setae (*av* and *pv*).

Description of the male (n = 5). Figures 11–14.

Dorsal idiosoma (Fig. 11). Dorsal shield 512–540 long, 300–315 wide, dorsal chaetotaxy as for female, except setae that are slightly shorter.

Ventral idiosoma (Fig. 12). Presternal area with transverse lines, not well scle-rotised; sternito-genito-ventral shield, 351–357 long, 213–234 wide, reticulated
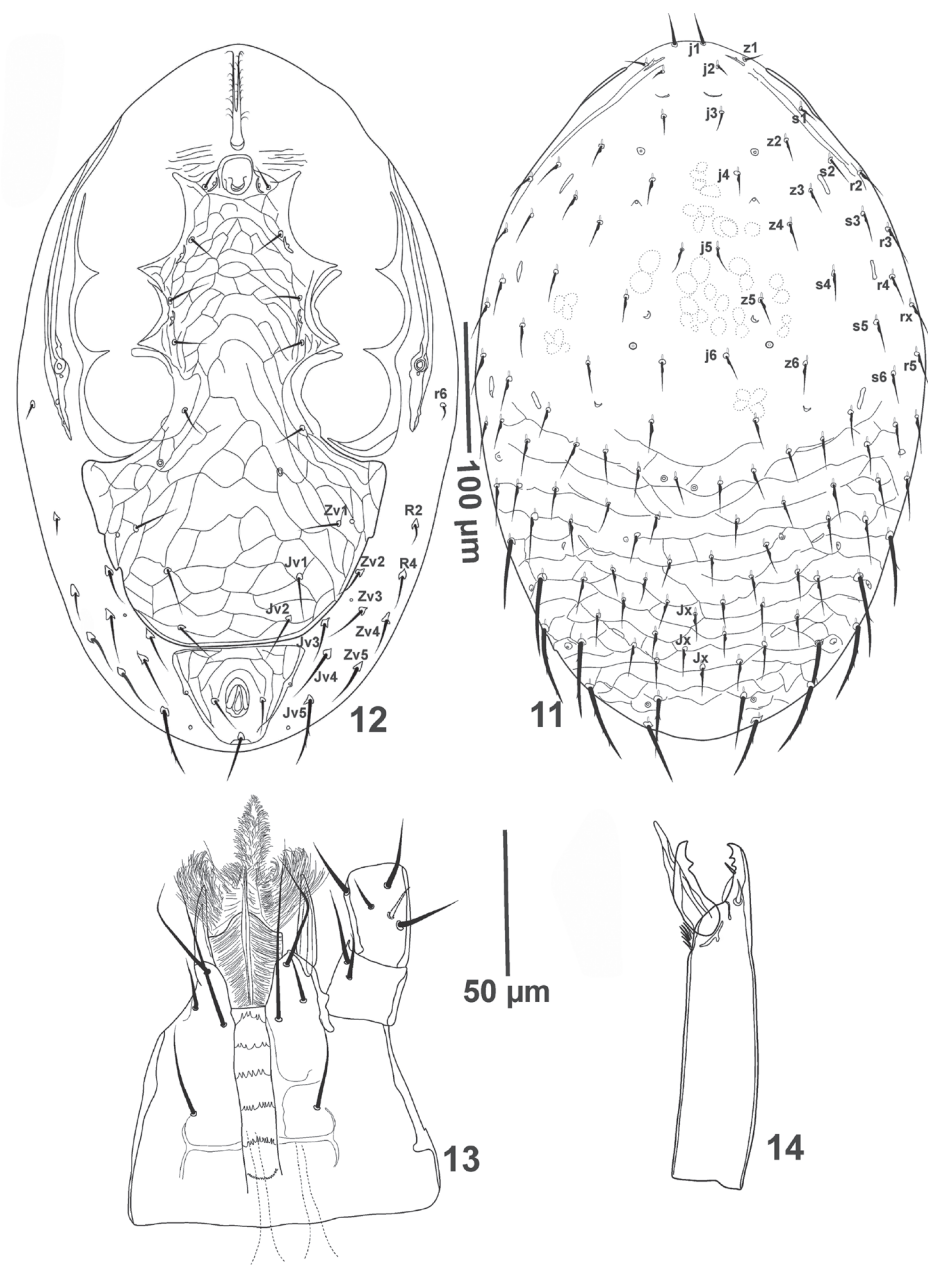
Figures 11–14. *Pogonolaelaps canestrinii* (Berlese). (Male): **11** Dorsal shield **12** Ventral idiosoma **13** Hypostome **14** Chelicera.

throughout, bearing eight pairs of simple pointed setae, *st1-st5* (26–36), *Zv1* and *Jv1–2* (36–45); with separate reticulated anal shield, 60–75 long, 94–106 wide; without metapodal plates. Soft cuticle with ten pairs of pointed, barbed setae.

Gnathosoma. As in female (Fig. 13); chelicerae (Fig. 14) with middle segment (122–130), fixed digit (34–36) bearing two teeth. Pilus dentilis setiform. Movable digit (34) with one tooth; spermatodactyl (41–44).

Legs. Tarsi I-IV with claws and ambulacra. leg I (490–556), leg II (354–400), leg III (387–411), leg IV (569–577), legs I and IV longer than legs II and III. Structure and chaetotaxy as in female, except femur II, which bears a spine-like *pv1* seta.

Notes on the male of *Pogonolaelaps canestrinii* (Berlese), comb. n. The described males of *Gymnolaelaps* have a holoventral shield. Some confusion about the state of the male ventral shields in *Pogonolaelaps canestrinii* (Berlese), comb. n. exist as Berlese (1892) originally showed the anal shield not separated, but later Berlese (1904) illustrated the species with a separate anal shield. Costa (1962) and Hunter (1967) regarded the species as having a separate anal shield, and here we confirm this by checking the type specimens of *P. canestrinii* comb. n. kindly examined by Dr. Roberto Nanelli, and the type information is as follows:

Slide 4 Myrm./45 labeled *Laelaps canestrinii* Berl., 1 female, type, nidi formiche, Portici; (nests of ant, Portici: a locality near the city of Naples, Italy); Slide 4 Myrm./46 labelled *Laelaps canestrinii* Berl., 1 female, nidi formiche, Portici; Slide 4 Myrm./47 labelled *Laelaps canestrinii* Berl., 3 females, type, nidi formiche, Portici; Slide 4 Myrm./48 labelled *Laelaps canestrinii* Berl., 1 male, type, nidi formiche, (without locality of collection) (perhaps Portici); Slide 221/31 labelled *Hypoaspis* (*Gymnolaelaps*) *canestrinii* Berl., female, Spalato, libero nell'humus; (free, vacant in humus); The specimens are in poor condition but it is possible to see that the female's dorsal shield has short setae, plus seven long thickened posterior setae, very similar to that shown in Figures 1, 11, 12. The slides labelled Myrm.= associated with ant, myrmecophilous.

Berlese (1892) described female and male specimens of *Laelaps canestrinii*, and according to his figures the female possesses a very wide epigynal shield with four pairs of setae in addition to *st5* and with straight posterior margin, lacks setae between the epigynal and anal shields, sternal shield only with two pairs of setae, lacks the metasternal plates and setae, the movable digit of the chelicera with three teeth, and male without separate anal shield. Berlese (1904) redescribed *Laelaps* (*Hypoaspis*) *canestrinii* as epigynal shield of the female posteriorly rounded, carries only *st5*, possess one pair of setae between the epigynal and anal shields. In the male, the anal shield is clearly separate from the genito-ventral shield. The examination of the type material of *P. canestrinii* and figures by Berlese (1904) confirm the identity of specimens redescribed in this study.

Pogonolaelaps beaulieui gen. n., sp. n.

http://zoobank.org/F2A5A9D9-2409-4AF1-ACE7-3572A4463DAF
Figures 15–29

Specimens examined. Holotype, female, Chaharmahal va Bakhtiari province, Shahrekord (32°19'39"N, 50°51'35"E, H: 2206 m), soil, 2009; coll. A. Nemati; Chaharmahal va Bakhtiari province, Saamaan, Cham-Khalifeh (32°30'35"N, 50°52'12"E,

H: 1875 m), Walnut rooting wood, 13 June 2012, three females, coll. A. Nemati; Saamaan (32°30'36"N, 50°53'13"E, H: 1873 m), rooting wood, three females and two males, 27 May 2012, coll. A. Nemati; Shahrekord, Shahrekord University, nest materials of unknown ant, one female and one male, 31 August 2007, coll. A. Nemati; Shahrekord, Shahrekord University, nest materials of unknown ant, two females, August 2006, coll. H. Maleki.

Diagnosis. *iv3* slit-like located posterior to *st3* on postero-lateral corners of sternal shield, with large crescent-shaped podal shield posterior to coxa IV; dorsal shield with 23 pairs of setae on podonotal (*rx* seta present on podonotal part), and 28 pairs on opisthonotal part, plus 1-3 unpaired setae between *J* series; 7–9 pairs of thickened, elongated, and barbed opisthonotal setae; genu I with normal chaetotaxy (2 3/2 3/1 2), and genu IV with ten setae including two ventral setae (*av* and *pv*).

Description of the female (n = 7)**.** Figures 15–26.

Dorsal idiosoma (Fig 15)**.** Dorsal shield length 728–780, width 517–560, oval shaped, wraps around and flaps onto the ventral idiosoma; reticulation more distinct on opisthonotal part, with 51 pairs of setae, 23 pairs on podonotal, 28 pairs on opisthonotal region, plus 1–3 *Jx* setae between *J* series (usually with three); setae increasing in length from anterior to posterior and from dorso-central to dorso-lateral part, dorso-central setae length on podonotal (23–42) and dorso-lateral setae (50–80), lateral opisthonotal setae tend to reach well past base of next posterior setae, lateral opisthonotal part with 7–9 pairs of long, thick, barbed setae (98–130), length of central opisthonotal setae 31–52, lateral opisthonotal setae 62–75. Dorsal setae scimitar-shaped with a small basal knob (Fig. 17). Dorsal shield with 19 pairs of pore-like structures, nine pairs on podonotal and ten pairs on opisthonotal (six pairs of those are large and slit-like) (Fig. 15).

Ventral idiosoma (Fig. 16a, b)**.** Tritosternum with columnar base (19–26) and paired pilose laciniae (85–93); pre-sternal plates weakly sclerotized and ornamented with transverse lines. Sternal shield with reticulate anterior and lateral margins, smooth posteriorly, 86–94 long, narrowest between coxae II (146–156), widest between coxae II and III (213–221), anterior margin sinuate, convex medially, posterior margin deeply concave. Sternal setae smooth, *st1* (75–83), *st2* (62–70) and *st3* (62–78), *iv1* slit-like, located slightly anterior to *st1*; *iv2* slit-like, between *st2* and *st3*, *iv3* slit-like located posterior to *st3*, on postero-lateral corners of sternal shield; *st4* absent. Endopodal plates II/III fused to lateral margins of sternal shield, endopodal plates III/IV elongate, curved. Genital shield broad, 377–395 long (including hyaline flap at the base of posterior margin of sternal shield), 208–226 wide at level of *st5* and widest (260–273) near setae *Zv1*, abutting anal shield, well ornamented, with one pair of setae (*st5* = 73–75) on shield and three pairs of setae adjacent to lateral edges; circular paragenital pores (*iv5*) located on soft integument between coxa IV and pair of minute narrow platelets. Anal shield subtriangular, 125–133 long, 151–156 wide, reticulated, post-anal seta (65–75) slightly longer than para-anal setae (52–60). Cribrum in a strip form of teeth, extending antero-laterally to level of post-anal seta. Opisthogastric surface with: one pair of elongate metapodal plates, two pairs of minute platelets (Fig. 16a), 12 pairs of long setae
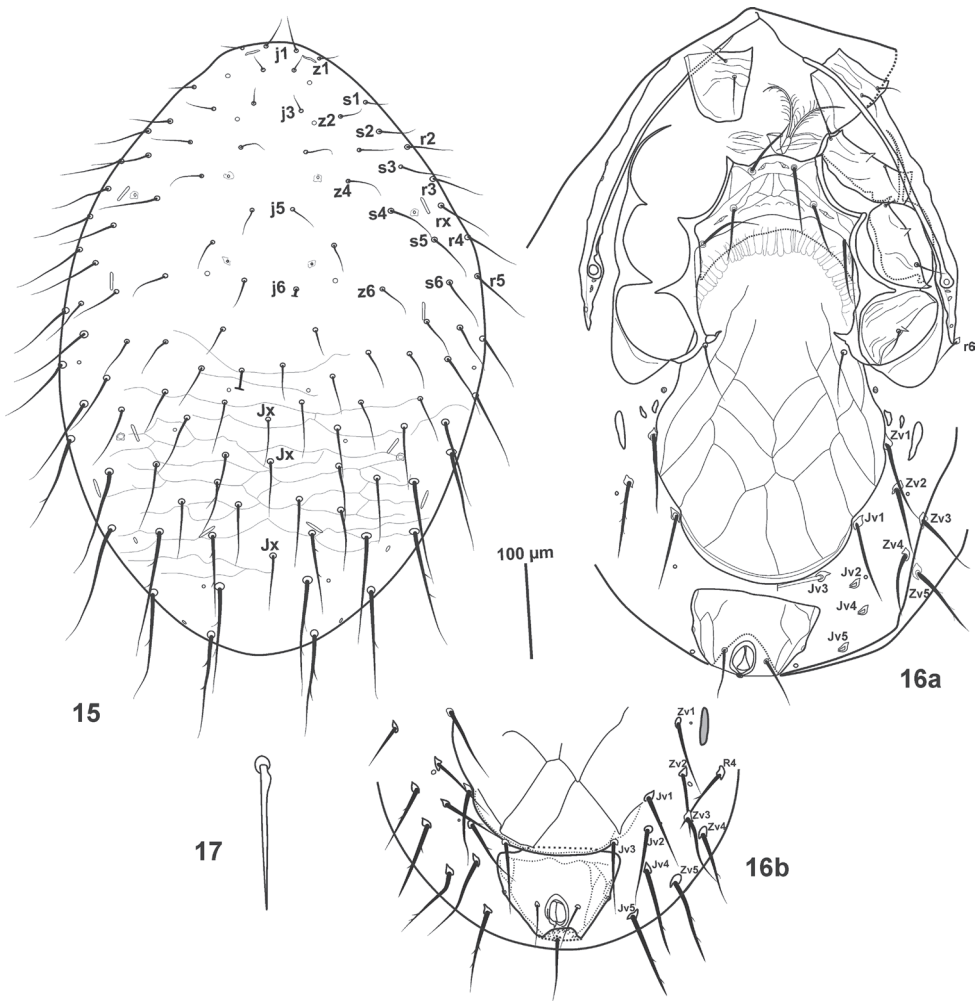
Figures 15–17. *Pogonolaelaps beaulieui* Nemati & Gwiazdowicz, gen. n., sp. n. (Female): **15** Dorsal shield **16a, b** Ventral idiosoma **17** An example of dorsal shield setae.

(Figs 16a,b) (*Jv1* 91–93, *Jv2* 83–88, *Jv3* 78–86, *Jv4–5* 98–104, *Zv1* 96–99, *Zv2–3* 88, *Zv4–5* 98–104), and four pairs of pore-like structures, plus one pair of adanal gland pores *gv3* on lateral margin of anal shield (Figs 16a, b). Endopodal, podal and exopodal plates are as in genus. Peritreme extending from coxa IV to anterior level of coxa I, peritrematal shield wide, with two pairs of post-stigmatal pores, one pair of small pores anterior to stigmata and two pairs of pores (*ip*, *gp*) at level of coxae II/III.

Gnathosoma. Hypostome with three pairs of smooth simple setae: *h1*, *h3* (70–75), *h2* (23–26). Palpcoxal setae 36–39. Deutosternal groove with six rows of denticles, each bearing 7–9 small teeth except first row with three larger teeth; corniculi normal, horn-like, reaching beyond of mid-level of palp femur; internal malae free medially and densely fringed with elongate threads (Fig. 18). Epistome sub-triangular
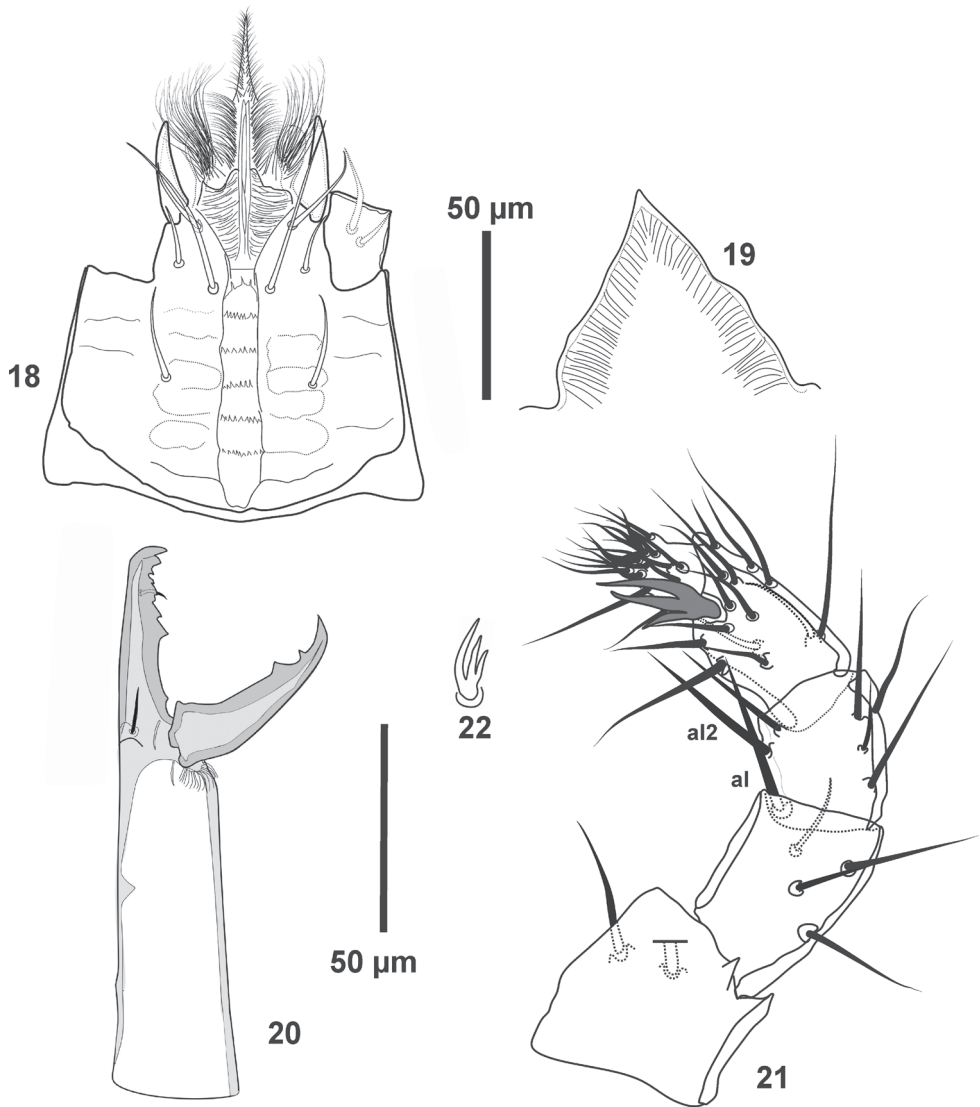
Figures 18–22. *Pogonolaelaps beaulieui* Nemati & Gwiazdowicz, gen. n., sp. n. (Female): **18** Hypostome **19** Epistome **20** Chelicera **21** Palp **22** Apotele.

with smooth antero-lateral margins (Fig. 19). Chelicera with dorsal seta, lyrifissure and developed arthrodial processes (Fig. 20), movable digit (44) with two teeth, middle article (182–190), fixed digit with two moderately large teeth proximal to pilus dentilis, followed by four minute teeth and a small offset tooth subapically, setaceous pilus dentilis moderately robust. Palp chaetotaxy normal (*sensu* Evans and Till 1965) and as in genus, with simple setae except *al* on femur, and *al2* of genu slightly thickened (Fig. 21), palp apotele three-tined (Figs 21, 22).
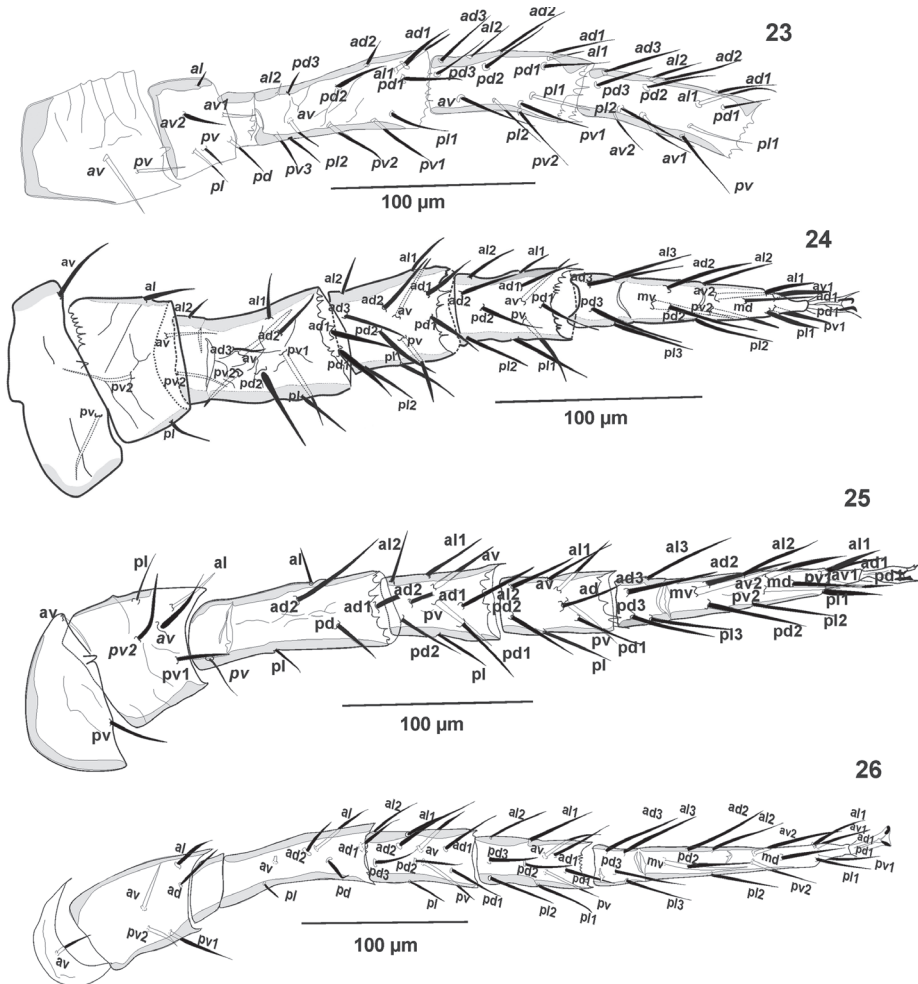
Figures 23–26. *Pogonolaelaps beaulieui* Nemati & Gwiazdowicz, gen. n., sp. n. (Female): **23** Leg I **24** Leg II **25** Leg III **26** Leg IV.

Legs. Tarsi I–IV with claws and ambulacra. Legs I (595–647) and IV (699–704), longer than legs II (455–486) and III (478–509) (excluding pre-tarsus). Leg chaetotaxy as follows: **leg I:** (Fig. 23) coxa 0 0/1 0/1 0, trochanter 1 1/2 0/1 1, femur 2 3/2 2/2 2, genu 2 3/2 3/1 2, tibia 2 3/2 3/1 2. **Leg II:** (Fig. 24) coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/2 1, genu 2 3/1 2/1 2, tibia 2 2/1 2/1 2, tarsus 3,3/2,3/2,3 + *mv*, *md*. **Leg III:** (Fig. 25) coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 1 2/0 1/1 1, genu 2 2/1 2/ 1 1, tibia 2 1/1 2/1 1, tarsus 3 3/2 3/2 3 + *mv*, *md*. **Leg IV:** (Fig. 26) coxa 0 0/1 0/0 0, trochanter 1 0/1 0/2 1, femur 0 2/1 1/1 1, genu 2 2/1 3/1 1, tibia 2 1/1 3/1 2, tarsus 3 3/2 3/2 3 + *mv*, *md*.

Insemination structures. Not seen, apparently unsclerotised.

Description of the male (n = 3)**.** Figures 27–29.
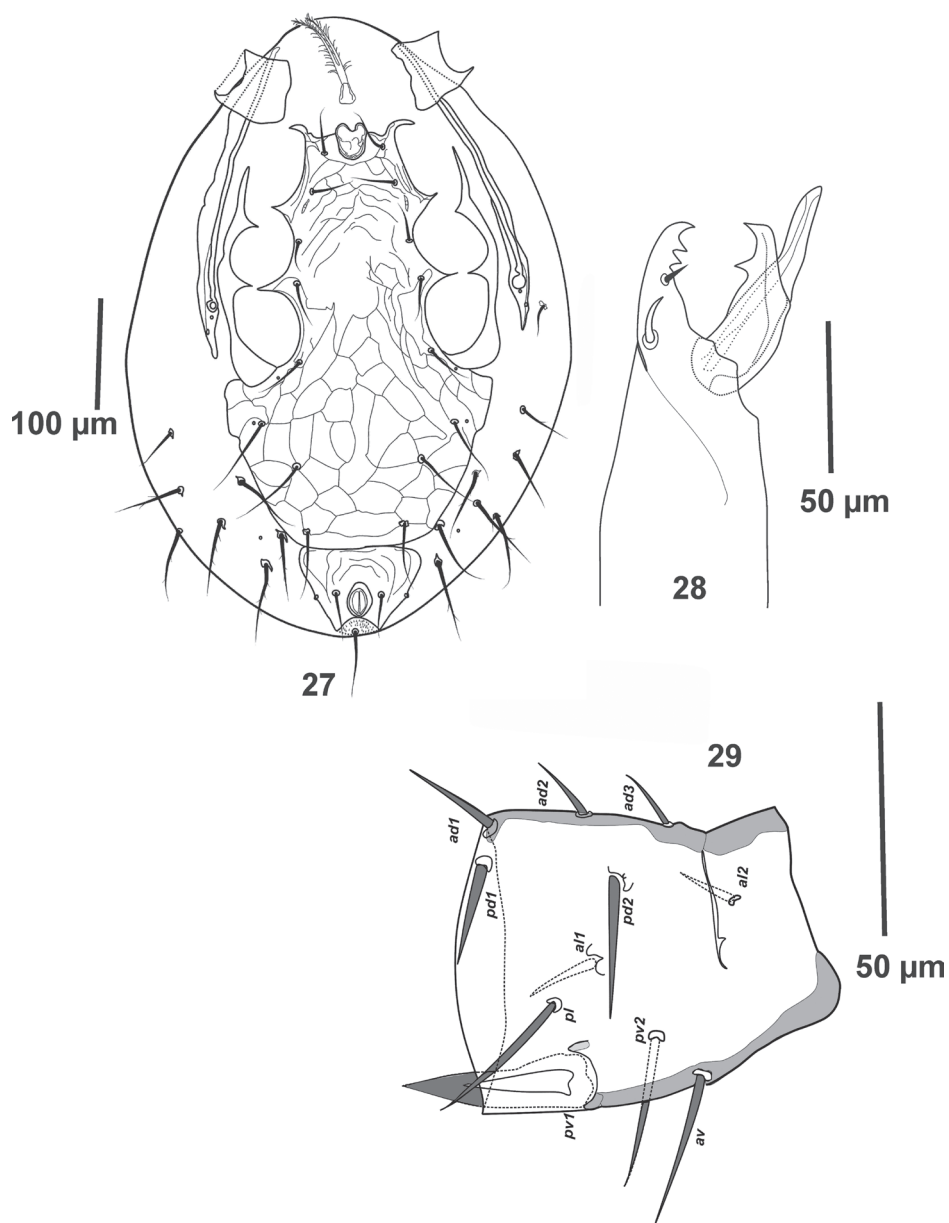
Figures 27–29. *Pogonolaelaps beaulieui* Nemati & Gwiazdowicz gen. n., sp. n. (Male): **27** Ventral idiosoma **28** Chelicera **29** Femur II (lateral view).

Dorsal idiosoma. Dorsal shield length 585–606 long, width 457–470, dorsal chaetotaxy as for female, except setae which are slightly shorter.

Ventral idiosoma (Fig. 27). With weakly sclerotised presternal shields; sterniti-genito-ventral shield, 413–420 long, 247–257 wide, reticulated throughout, bearing eight

pairs of simple, pointed setae, *st1-st5* (38–42), *Zv1* and *Jv1–2* (58–63); with separate reticulated anal shield, 99–105 long, 110–122 wide, post-anal seta (55–59) longer than para-anals (40–44); without metapodal plates, apparently fused to the lateral margin of sterniti-genito-ventral shield. Soft cuticle with eight pairs of pointed, mostly barbed setae.

Gnathosoma. As in female; chelicerae (Fig. 28) with middle segment (133–141), fixed digit (38–40) bearing two teeth. Pilus dentilis setiform. Movable digit (35–37) with one tooth; spermatodactyl (45) relatively straight.

Legs. Tarsi I-IV with claws and ambulacra. Leg I (510–525), leg II (390–401), leg III (438–445), leg IV (582–603), legs I and IV longer than legs II and III. Structure and chaetotaxy as in female, except for femur II, which bears a spine-like and thickened *pv1* seta (Fig. 29).

Etymology. This species is named in honor of Dr. Frederic Beaulieu (Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada, Ottawa, Canada).

Remarks. *Pogonolaelaps beaulieui* gen. n., sp. n. is similar to *P. canestrinii* comb. n. and can be readily distinguished from it by the presence of 28 pairs of setae on opisthonotal region plus 1–3 unpaired setae (32 pairs in *P. canestrinii* plus 3 unpaired setae between *J* series); the dorsal setae of *P. beaulieui* gen. n., sp. n. are much longer than those of *P. canestrinii* comb. n. (see text), and the genital shield in *P. beaulieui* gen. n., sp. n. [377–395 long, 208–226 wide at level of *st5* and widest (260–273) near setae *Zv1*] is longer and wider than that of *P. canestrinii* comb. n. [346-374 long, and 177-195 wide at level of *st5* and widest (239-260 μm) near setae *Zv1*].

Discussion

Karg (1989) considered *Gymnolaelaps* as a subgenus of *Pseudoparasitus* based on the presence of a three-tined apotele, developed podal shields posterior to coxa IV, epistome with denticulate anterior margin and the presence of 1-3 pairs of setae on lateral edges of an expanded genital shield. Other authors defined *Gymnolaelaps* at the genus level, with diagnoses provided by Hunter (1967), Hunter and Costa (1971) and, most recently, Joharchi et al. 2011 and Joharchi and Halliday 2013. According to these last authors the genus is defined by: genu IV with nine setae including one ventral seta; the metasternal setae always present; dorsal shield covering dorsum and even extending ventrally, has a normal complement of 40 pairs of setae, often with paired *Zx* setae between *J* and *Z* setae, unpaired *Jx* setae also often present; dorsal shield setae distally pointed, smooth or slightly serrated, not long and whip-like; and *Zv1*, *Jv1-2* setae (additional to *st5*) are on the margin of the shield. The only character that separates *Gymnolaelaps* from *Pseudoparasitus* seems to be the given: in *Pseudoparasitus*, at least two pairs of ventro-genital setae are set well inside the edges of the shield (Joharchi et al. 2011, Joharchi and Halliday 2013).

The generic definition of *Gymnolaelaps* does not apply for all species that are assigned to this genus nowadays, as there are several characters not taken into account and excluded by the diagnosis of Joharchi et al. (2011) and Joharchi and Halliday

(2013). These exceptions occur in the genito-ventral shield of female, the number of the apotele tines, the form of the anterior margin of the epistome, leg and dorsal chaetotaxy, and the form of the podal shield posterior to coxa IV.

Gymnolaelaps shealsi Hunter & Costa, 1971 has a genito-ventral shield that does not extend to the anal shied, lacks an expanded podal plate behind coxa IV and the epistome is triangular with smooth margins. *Gymnolaelaps viennensis* Sellnick is similar to *G. shealsi* in the shape of genital shield. *Gymnolaelaps krantzi* (Hunter, 1967) has a two-tined apotele and the epistome has a smooth rounded anterior margin. *Gymnolaelaps unospinosus* (Karg, 1978) has thickened seta on femur II (not included in the diagnosis of Joharchi et al. 2011 and Joharchi and Halliday 2013) and has a very narrow podal plate behind coxa IV.

Notes on *Pseudoparasitus reniculus* Karg, 1981 and *P. triquetrus* Karg, 2003

Pseudoparasitus (*Gymnolaelaps*) *reniculus* Karg, 1981 has four pairs of setae on genital shield, of which *Jv1-2* inserted away from the shield margins and lacks the holotrichous condition on dorsal shield (slightly hypertrichous) on the opisthonotal part. According to our definition of *Gymnolaelaps* and the difference between *Gymnolaelaps* and *Pseudoparasitus* genera, we consider this species in its original genus *Pseudoparasitus* not in *Gymnolaelaps* as proposed by Joharchi et al. (2011) and Moreira (2014).

Pseudoparasitus (Gymnolaelaps) triquetrus was described by Karg (2003) in Ecuador, as a species in *Gymnolaelaps* (as subgenus) in which the genital shield expands behind coxa IV and *Zv1*, *Jv1-2* located on the surface of genital shield far from the edges. Based on these characters, it is also considered as a species in its original genus *Pseudoparasitus* and not in *Gymnolaelaps* as proposed by Moreira (2014).

Notes on *Laelaspisella* Marais & Loots

Laelaspisella was originally described by Marais and Loots (1969) by discussing several morphological characters (Marais and Loots 1969). Joharchi and Halliday (2013) have defined *Laelaspisella* by considering three main characters: dorsal shield hypertrichy; absence of metasternal setae and genu IV bearing two ventral setae; however none of those are apomorphic characters for this genus. In addition to *Laelaspisella macrodorsalis* Marais & Loots, and *L. epigynialis* Marais & Loots, *Gymnolaelaps canestrinii* and *G. kabitae* were also transferred to *Laelaspisella* (Joharchi and Halliday 2013).

The new species here (*P. beaulieui*), has hypertrichous dorsal shield (but in opisthonotal part), absent metasternal setae and genu IV with two ventral setae, which in accordance with the idea of Joharchi and Halliday (2013) puts it in genus *Laelaspisella*. However when considering some other characters within genus mentioned above, several problems would arise assigning this new species and *P. canestrinii* to *Laelaspisella*. Herein we discussed it below.

First, *Laelaspisella* (*L. macrodorsalis* and *L. epigynialis*) (Marais and Loots 1969) has ovoid pre-endopodal plates reticulated and well sclerotised but in *P. canestrinii* and *P. beaulieui* gen. n., sp. n. the pre-endopodal plates are not so sclerotized. In *Gymnolaelaps* the posterior half of the pre-endopodal plate is usually strongly sclerotized, and the anterior half is less sclerotized. The pre-endopodal plates of *L. macrodorsalis*, and *L. epigynialis* are not described in sufficient detail, but according to the illustrations these ovoid plates are conspicuous and with line ornamentations.

Second, the sternal shield of *Laelaspisella* has two pairs of poroids or lyrifissures, *iv1* and *iv2*. The metasternal pores *iv3* apparently are absent (Marais and Loots 1969). *Pogonolaelaps canestrinii* comb. n. and *P. beaulieui* gen. n., sp. n., have slit-like *iv3* on the surface of postero-lateral corners of sternal shield. However Marais and Loots didn't mention about *iv3* in *Laelaspisella*, but according to their illustrations *iv3* are not present in *L. macrodorsalis* and *L. epigynialis*. Species of *Gymnolaelaps* have poroid *iv3* posterior to sternal shield on soft integument.

Third, Joharchi and Halliday (2013) have cited the absence of *st4* as one of the three main characters of *Laelaspisella* genus (*L. macrodorsalis* and *L. epigynialis*), but metasternal setae are also absent in some other taxa like genus *Reticulolaelaps* Costa, 1968 and some species of *Hypoaspis sens. lat.*, such as *Hypoaspis* (*Hypoaspis*) *metapodalis* Karg, 1978; *H.* (*H.*) *eugenitalis* Karg, 1978; *H.* (*Alloparasitus*) *pycnosis* Karg, 1982 and *H.* (*Holostaspis*) *tridentata* Karg, 1982 (These scientific names are mentioned here as in the related literature). This character could not be considered as apomorphic for *Laelaspisella* due to the presence in different genera and species. *Pogonolaelaps beaulieui* gen. n., sp. n. and *P. canestrinii* comb. n. lack *st4*.

Fourth, the genito-ventral shield in *Laelaspisella* (*L. macrodorsalis* and *L. epigynialis*) (Marais and Loots 1969) is not reaching the anal shield and there are two pairs of setae between genito-ventral and anal shields. This shield has one pair of setae (*st5*), widened slightly behind the genital setae and is rounded or tapered posteriorly. This condition was observed in *L. macrodorsalis* (posterior edge distinctly tapered), *L. epigynialis* (posterior edge rounded or slightly tapered), but *P. canestrinii* comb. n. and *P. beaulieui* gen. n., sp. n. have genital shield broad, strongly widened posterior to genital setae, posterior edge rounded, and abutting anal shield. Such condition can be seen in some species of *Gymnolaelaps*.

Fifth, setae *Jv5* and *Zv5* are spatulate and pilose in *Laelaspisella* (*L. macrodorsalis* and *L. epigynialis*) (Marais and Loots 1969) and it is suspected to represent an apomorphic character. Setae *Jv5* and *Zv5* are acicular in *P. canestrinii* comb. n., and *P. beaulieui* gen. n., sp. n. (with small barbs), and all known species of *Gymnolaelaps*.

Sixth, in species of *Laelaspisella* (*L. macrodorsalis* and *L. epigynialis*), and some species of *Gymnolaelaps* like, *G. krantzi* (Hunter) and *G. obscuroides* (Costa) the palp apotele has two tines. In *Gymnolaelaps*, there is a variation of the palp apotele and most species have the apotele 3-tined, but in a few species the third tine is reduced or lost. Maybe this represents a secondary loss of the third tine in some species. In *P. canestrinii*, and *P. beaulieui* gen. n., sp. n. it is 3-tined.

Seventh, *Laelaspisella* species (*L. macrodorsalis* and *L. epigynialis*) lacks dorsal seta of chelicerae, but *Gymnolaelaps* members and also *P. beaulieui* gen. n., sp. n. and *P. canestrinii* have this seta.

Eighth, the anterior margin of the epistome is smooth and sharply mucronated in *L. macrodorsalis* and *L. epigynialis*. In *P. canestrinii*, and *P. beaulieui* gen. n., sp. n. the anterior margin is smooth and pointed but not as sharply mucronate as in former. The most species of *Gymnolaelaps* have denticulate epistome.

Ninth, species of *Laelaspisella* (*L. macrodorsalis* and *L. epigynialis*) have the dorsal shield hypertrichous in both the podonotal and opisthonotal region with very small and acicular setae. Hypertrichous condition can be seen in the other laelapid mites like genus *Reticulolaelaps* (on whole dorsal shield), some species of *Pneumolaelaps*, and *Gaeolaelaps ciconia* (Karg, 1982): with this character in opisthonotal and opisthogastric regions, *Gaeolaelaps ardoris* (Karg, 1993): on both podonotal and opisthonotal parts. In *P. canestrinii*, and *P. beaulieui* gen. n., sp. n. dorsal shield is hypertrichous only in the opisthonotal region and dorsal setae possess small knob at their base. The podonotal region with holotrichous situation and *rx* located on the shield. *Gymnolaelaps* species have holotrichous condition with acicular setae pointed distally, and lack *rx* on the shield.

Tenth, in *Laelaspisella* species (*L. macrodorsalis* and *L. epigynialis*) the setation of genu I is deficient in one postero-dorsal seta (2 3/2 2/1 2). According to the Evans and Till (1965) and Lee (1970) it can be stated that the chaetotaxy of genu I is more stable than genu IV in mesostigmatid mites. Evans and Till (1965) noted some exceptions to the normal chaetotaxy of genu I (2 3/2 3/1 2) in some taxa of Dermanyssoidea such as *Pseudolaelaps doderoi*, *Dermanyssus* spp. and *Ornithonyssus* spp., that have been excluded from Laelapidae and at present are members of Pachylaelapidae, Dermanyssidae and Macronyssidae, respectively (Evans and Till 1965, Lindquist et al. 2009). For this reason, genu I in laelapid mites has normal chaetotaxy. *Laelaspisella* (*L. macrodorsalis* and *L. epigynialis*) has unique chaetotaxy in genu I with only two postero-dorsal setae (2 3/2 2/1 2), so this can be considered as an apomorphic character for *Laelaspisella* (*L. macrodorsalis* and *L. epigynialis*). *Gymnolaelaps* species, as most other free-living laelapids, have three postero-dorsal setae (2 3/2 3/1 2) on genu I. *Pogonolaelaps beaulieui* gen. n., sp. n. and *P. canestrinii* are no exception with a typical set of setae.

Eleventh, in *Laelaspisella* species (*L. macrodorsalis* and *L. epigynialis*) the chaetotaxy of genu IV deviates from the normal (2 2/1 3/0 1) due to the presence of a postero-ventral seta (2 2/1 3/1 1).

Joharchi and Halliday (2013) emphasized the presence of two ventral setae on genu IV as one of the three main characters of *Laelaspisella* species (*L. macrodorsalis* and *L. epigynialis*). The greatest diversity of leg segments chaetotaxy in laelapid mites has been observed in genu IV. In addition to normal pattern (2 2/1 3/0 1), three other types of chaetotaxy have been observed (Evans and Till 1965): in *Laelaps agilis* (2 2/1 3/1 2); *L. echidninus*, *L. hilaris*, *L. muris*, *Hyperlaelaps amphibian*, *Hyperlaelaps microti*, *Eulaelaps stabularis*, *Eulaelaps nova*, *Haemolaelaps casalis*, *H. fahrenholzi*, *Euandrolaelaps sardoa* and *Laelaspulus flexuosus* (2 2/1 3/0 2); *Pneumolaelaps* genus, and *Melittiphis*

alvearius (2 2/1 3/1 1). This means that there are some genera in laelapid mites that have two kinds of genu IV chaetotaxy with 9 or 10 setae, including one or two ventral setae. *Pogonolaelaps canestrinii*, and *P. beaulieui* gen. n., sp. n. have two ventral setae on genu IV. *Gymnolaelaps* has one ventral seta on genu IV.

Laelaspisella can be defined as laelapid mites with the following characters:

There are two pairs of pores on the sternal shield, *iv3* apparently absent; the metasternal setae are absent; the genital shield slightly widened behind the genital setae and is rounded or somewhat tapered posteriorly, but never touching the anal shield; setae *Jv5* and *Zv5* are spatulated and pilose; the palptarsal claw two tined; chelicerae lacks dorsal seta; the anterior margin of the epistome is smooth and sharply mucronated; the whole dorsal shield with hypertrichous condition; the setation of genu I is deficient for one postero-dorsal seta (2 3/2 2/1 2); the chaetotaxy of genu IV deviates from the normal (2 2/1 3/0 1) due to the presence of a postro-ventral seta (2 2/1 3/1 1). Finally, according to the explanations above the genus *Laelaspisella* comprises two species *L. macrodorsalis* and *L. epigynialis* at present.

Notes

Gymnolaelaps tonsilis (Karg, 1989)

Pseudoparasitus (*Gymnolaelaps*) *tonsilis* Karg, 1989: 335.
Gymnolaelaps tonsilis. — Farrier and Hennessey 1993: 74; Moreira 2014: 281.

Specimens examined. *Pseudoparasitus tonsilis* Karg, 1989, Chel. Nr. 3947♂, paratypus, ZMB Kat. Nr. 41478, St. Lucia, Antillen, Gastries, Vigie, Point Eins.: Dr. Mahunka, Budapest, 21 .7.80; Chel. Nr. 3944♀, ZMB Kat. Nr. 41475 (paratypes); Nr. 3945♀, ZMB Kat. Nr. 41476 (paratypes); Nr. 4440 ♀, ZMB Kat. Nr. 42589 (holotypus); Nr. 3943♀, ZMB Kat. Nr. 41474 (paratypes); Nr. 3946♂, ZMB Kat. Nr. 41477 (paratypes): with the same data as above on 11.7.80.

Gymnolaelaps kabitae Bhattacharyya, 1968

Gymnolaelaps kabitae Bhattacharyya, 1968: 537.
Pseudoparasitus (*Gymnolaelaps*) *kabitae*. — Karg 1989: 334.
Laelaspisella kabitae. — Joharchi and Halliday 2013: 47; Moreira 2014: 317.

Specimens examined. Ghaletol, Khuzestan province, nest materials of unknown ant, two females and two males, 2012-2013, coll. A. Nemati; Shahrekord, Chaharmahal va Bakhtiari province, nest materials of unknown ant, one female, 2014, coll. A. Nemati; Izeh,, Khuzestan province, nest of *Pheidole pallidula* (Hym., Formicidae), two females, one male, coll. A. Nemati. All specimens were deposited in APAS.

Psedoparasitus (*Gymnolaelaps*) *tonsilis* Karg, 1989 and *Gymnolaelaps kabitae* Bhattacharyya, 1968 possess denticulate epistome, two tined apotele, internal malae normal and lack very elongate setae and barbed, chelicera with dorsal seta, sternal shield with *iv1-3*, lack *st4*, genital shield rounded posteriorly and bear one pair of setae, ventral setae acicular, with hypertrichous condition in whole dorsal shield (based on personal observation of first author on type materials of *G. tonsilis* and in spite of its original description in Karg 1989) and with simple acicular setae, males with separate sternito-genital and anal shields and without spine like setae on leg II, genu IV with two ventral setae (*av* and *pv*), genu I with three *pd* setae (*pd1-3*). Those are differed from *Laelaspisella* by having denticulate epistome, presence of dorsal seta on fixed digit of chelicera, genu I with *pd1-3*, opisthogastric setae simple acicular, internal malae without elongate setae. These species also differed from *Pogonolaelaps* gen. n. by having simple acicular dorsal setae, hypertrichy on whole dorsal shield, denticulate epistome, two tined apotele, and the absence of spine like setae on leg II of male, internal malae without very elongate setae.

Acknowledgements

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RESEARCH ARTICLE

Mysmenidae, a spider family newly recorded from Tibet (Arachnida, Araneae)

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Abstract

The spider family Mysmenidae is reported from Tibet for the first time. Two new species, *Chanea voluta* **sp. n.** (male and female) and *Mysmena lulanga* **sp. n.** (male and female) are found in eastern Tibet in high altitude. Morphological descriptions, diagnoses and comparative photos are provided for the two new species.

Keywords

Introduction

The eastern Tibet Plateau is one of the biodiversity hotspots in the world (Lei et al. 2015). The geographical location at the junction of different biogeographical realms, the wide range of habitats and climates along the extensive elevational range, the com-

plex topography and the distinct geological history of this region have probably contributed to the evolution of an exceptionally species-rich and endemic-rich, specialized montane fauna. However, the lack of adequate research especially invertebrate results in multitudinous unknown new species to be discovered.

In a recent collection tour to eastern Tibet Plateau we yield a big number of spiders, including several new species. In this paper we described two new species of the family Mysmenidae. Mysmenidae includes 13 genera and 135 species worldwide (World Spider Catalog 2015). Of these mysmenid members elevation distribution drop from highest to lowest is nearly 3,300 meters. For example, *Tamasesia marplesi* was found at 3 meters off the coast of the jungle, in New Caledonia Island (Brignoli 1980). *Maymena roca* lives in the high mountain 3,300 meters above sea level, in Peru (Baert 1990). The new species described in this paper, i.e., *Chanea voluta* sp. n. collected from elevation between 2,140–3,060 meters and *Mysmena lulanga* sp. n. from elevation between 3,480–3,530 meters. The latter should be new highest record of elevation for spiders of the family Mysmenidae.

According to Li and Lin (2015) 4,282 species spider are recorded from China that belongs to 735 genera and 69 families. Of them, 37 mysmenid species of 8 genera (one Chinese mysmenid species, *Calodipoena cornigera*, is transferred to *Mysmena*, owing to *Mysmena* Simon, 1894 considered a senior synonym of *Calodipoena* Gertsch & Davis, 1936 by Lopardo and Hormiga 2015) are reported from Beijing, Chongqing, Guangxi, Guizhou, Hainan, Liaoning, Sichuan, Taiwan and Yunnan. The two new species described in this paper is the first record of the family Mysmenidae from Tibet.

Material and methods

Specimens were examined and measured under a Leica M205 C stereomicroscope. Further details were studied under an Olympus BX43 compound microscope. Male palps and female genitalia were examined and photographed after they were dissected and detached from the spiders' bodies. Vulvae were removed and treated in lactic acid before taking photos. To reveal the course of the spermatic duct, male palps were also treated in lactic acid and mounted in Hoyer's Solution. All type specimens and preserved in 95% ethanol solution. Photos were taken with a Canon EOS 60D wide zoom digital camera (8.5 megapixels). The images were montaged using Helicon Focus 3.10.3 software (Khmelik et al. 2006).

All measurements are in millimeters, with leg measurements given in the following sequence: total length (femur, patella, tibia, metatarsus, and tarsus). The terminology mostly follows Lopardo et al. (2011) and Miller et al. (2009). The abbreviations used in text including: ARE – anterior eye row; ALE – anterior lateral eye; AME – anterior median eye; PRE – posterior eye row; PLE – posterior lateral eye; PME – posterior median eye. All specimens are deposited in the Institute of Zoology, Chinese Academy of Sciences (IZCAS) in Beijing.

Taxonomy

Family Mysmenidae Petrunkevitch, 1928
Genus *Chanea* Miller, Griswold & Yin, 2009

Chanea Miller, Griswold & Yin, 2009: 54. Type species by original designation *Chanea suukyii* Miller, Griswold & Yin, 2009: 54.

Composition. *Chanea suukyii* Miller, Griswold & Yin, 2009 and *C. voluta* sp. n.

Distribution. China (Yunnan, Tibet)

Comments. The genus *Chanea* was previously described in 2009 as monotypic (Miller et al. 2009). The type species, *Chanea suukyii*, was known only from the type locality in the Gaoligongshan Mountains, Yunnan Province, China. This spider species mainly live in leaf litter of the subtropical evergreen broadleaf forest. According to Miller et al. (2009), the diagnostic features of this genus differs from other mysmenids by the long embolus coiled into at least 5 loops encircles the conductor and subtegulum (figs 49A, 51B; Figs 2A–B, 3A–B), the entire distal part of the cymbium (fig. 49A; Fig. 3C–D), the widely spaced anterior median eyes (fig. 52B; Fig. 1A) and pair of macrosetae on the clypeus in male (fig. 52B), and the long copulatory ducts coiled around the fertilization ducts or coiled around fertilization ducts no less than 10 loops in female (fig. 49C; Fig. 4C–D). Miller et al. (2009) mentioned that the presence of a pair of clypeal marcosetae in male is also treated as one of the generic characters. But these are lacking from *C. voluta* sp. n. (Figs 1A, 1C). Therefore, we think that the extremely long, coiled embolus and the long, coiled copulatory ducts and/or fertilization ducts may be the main diagnoses for this genus. The paired macrosetae on the clypeus in male may just be an identifying character to this type species.

Chanea voluta sp. n.

http://zoobank.org/52473655-9A0D-46CC-9C8C-81BD373E7384
Figs 1–4, 10

Type material. *Holotype*: male (IZCAS), CHINA: Tibet Autonomous Region, Nyingchi Prefecture, Bomi County, the Road of Bomi to Medog, near the village of Baqiong (29°52.194'N, 95°43.505'E; Elevation: 2880 m), 19 July 2013, L.H. Lin & X.Z. Cao leg. *Paratypes*: 1 male and 9 females (IZCAS), same data as holotype; 1 male and 3 females (IZCAS), Nyingchi County, Bayi Town, Biri Holy Mt., Winding hill roads (29°51.334'N, 94°47.941'E; Elevation: 2900), 11 July 2013, L.H. Lin leg.; 5 males (IZCAS), Nyingchi Prefecture, the south of Mainling County (29°12.316'N, 94°12.649'E; Elevation: 3060 m), 13 August 2013, L.H. Lin leg.; 5 females (IZCAS), Nyingchi Perfecture, Bomi County, near Zhamo Town (29°50.859'N, 95°45.861'E; Elevation: 2800 m), 17 July 2013, L.H. Lin leg.; 2 males (IZCAS), Nyingchi Prefec-
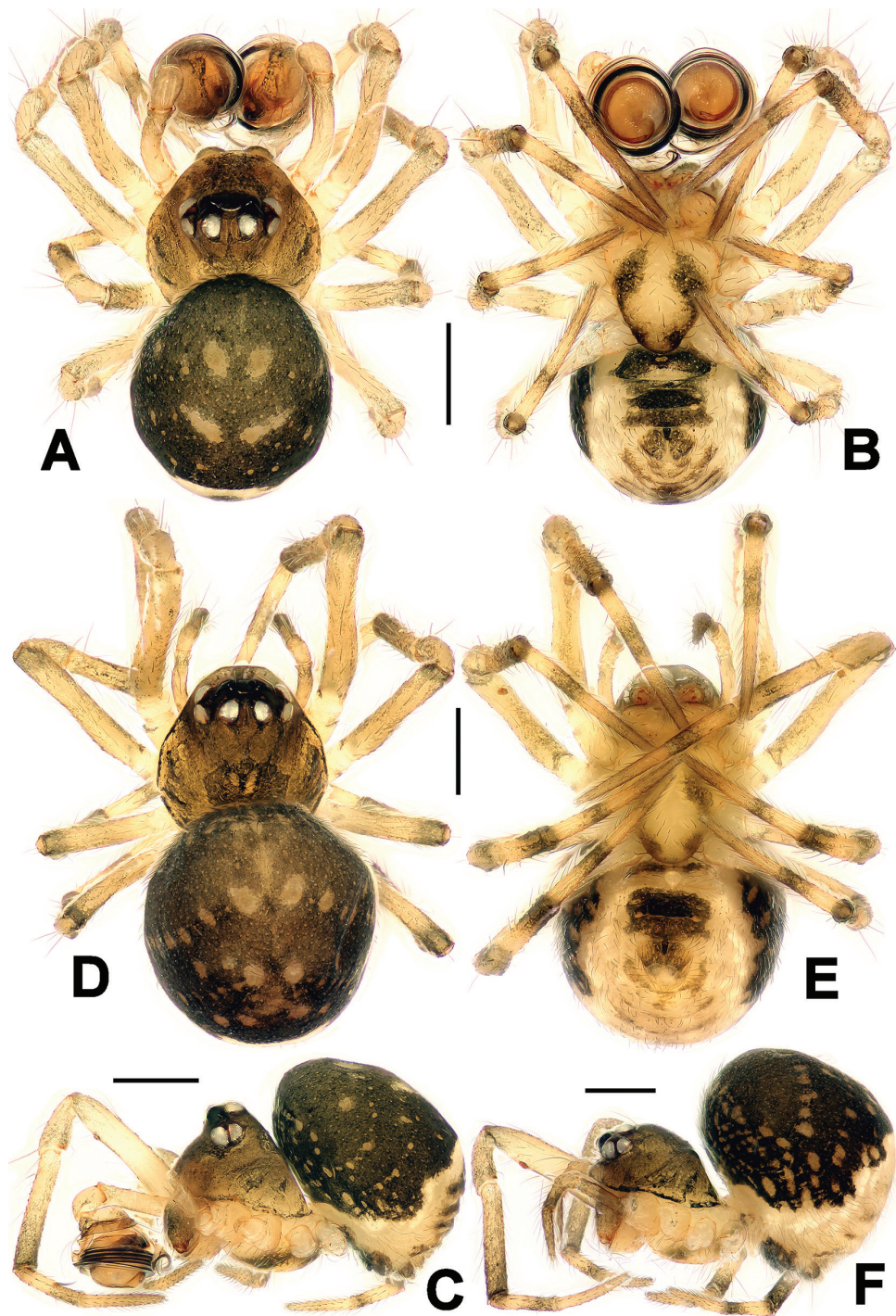
Figure 1. *Chanea voluta* sp. n., male holotype (**A–C**) and female paratype (**D–F**). **A, D** Habitus, dorsal **B, E** Habitus, ventral **C, F** Habitus, lateral. Scale bars = 0.20 mm.
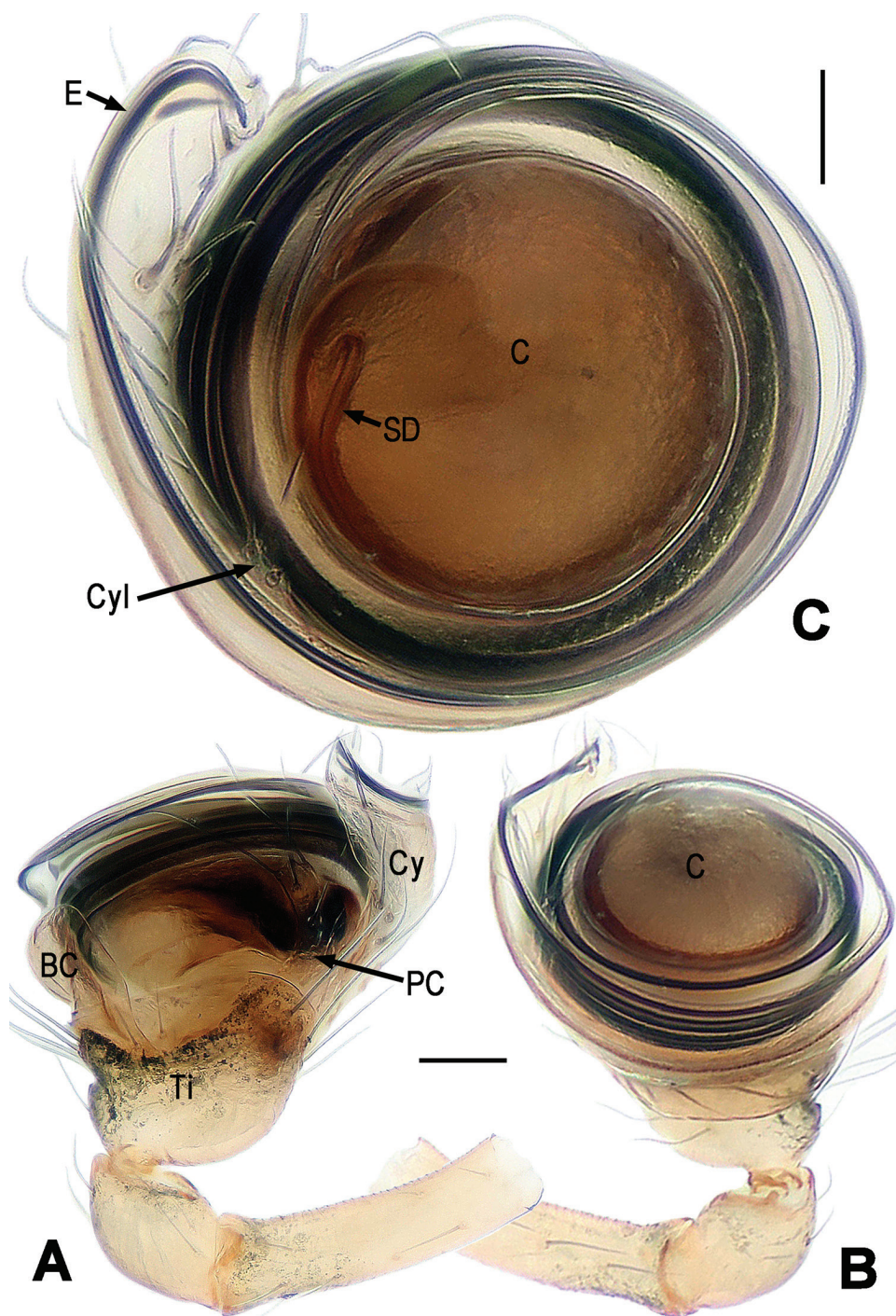
Figure 2. *Chanea voluta* sp. n., male holotype. **A** Left palp, prolateral **B** Left palp, retrolateral **C** Left palp, apical. Abbrs.: BC = base of cymbium; C = conductor; Cy = cymbium; Cyl = cymbial lobe; E = embolus; PC = paracymbium; SD = spermatic duct; Ti = tibia. Scale bars = 0.05 mm.
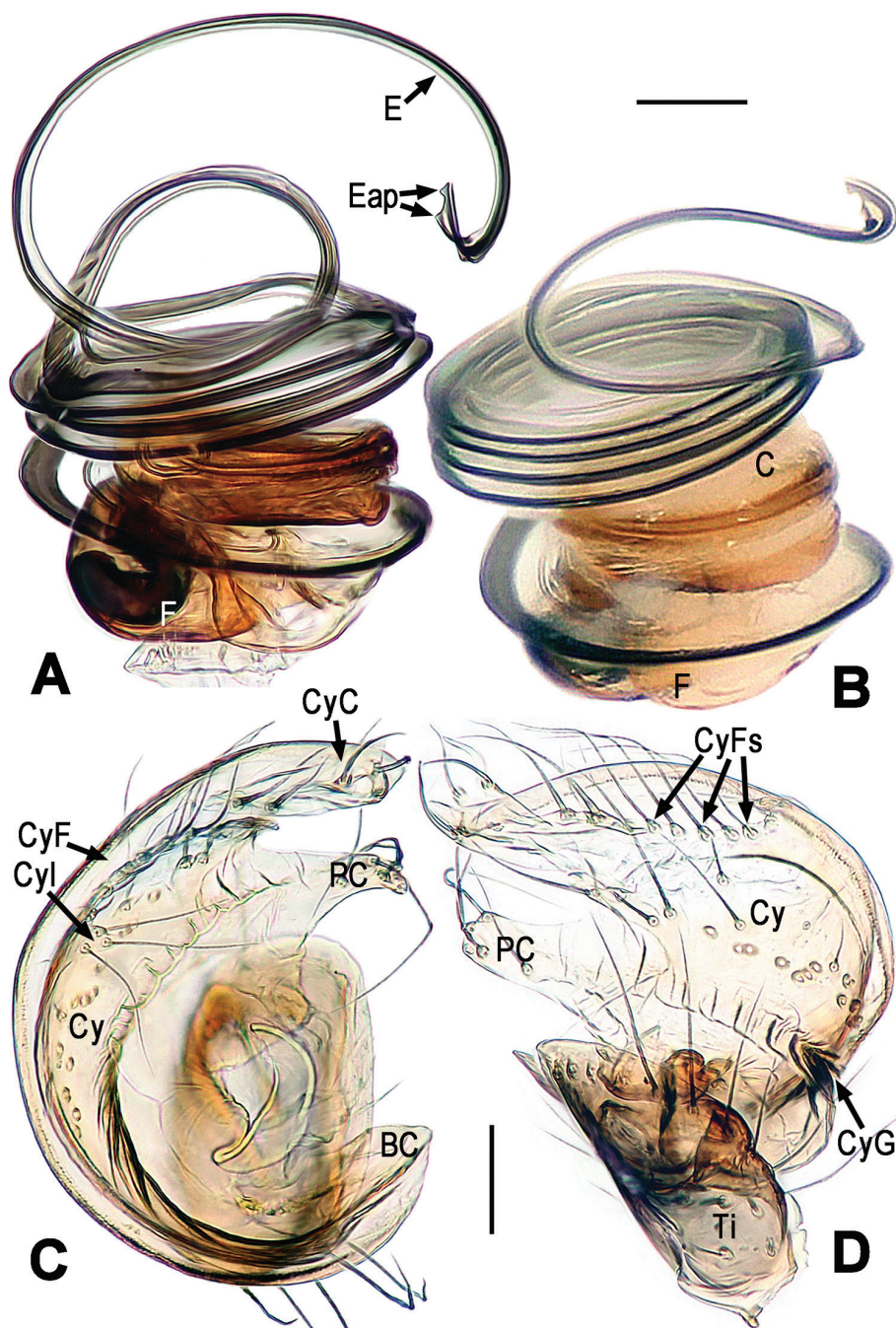
Figure 3. *Chanea voluta* sp. n., male holotype. **A, B** Palpal bulb, retrolateral **C** Cymbium, apical **D** Cymbium and palpal tibia, dorsal. **A, C–D** lactic acid-treated. Abbrs.: BC = base of cymbium; C = conductor; Cy = cymbium; CyC = cymbial conductor; CyF = cymbial fold; CyFs = setae on cymbial fold; CyG = cymbial groove; Cyl = cymbial lobe; E = embolus; Eap = embolar apophysis; F = fundus; PC = paracymbium; Ti = tibia. Scale bars = 0.05 mm.
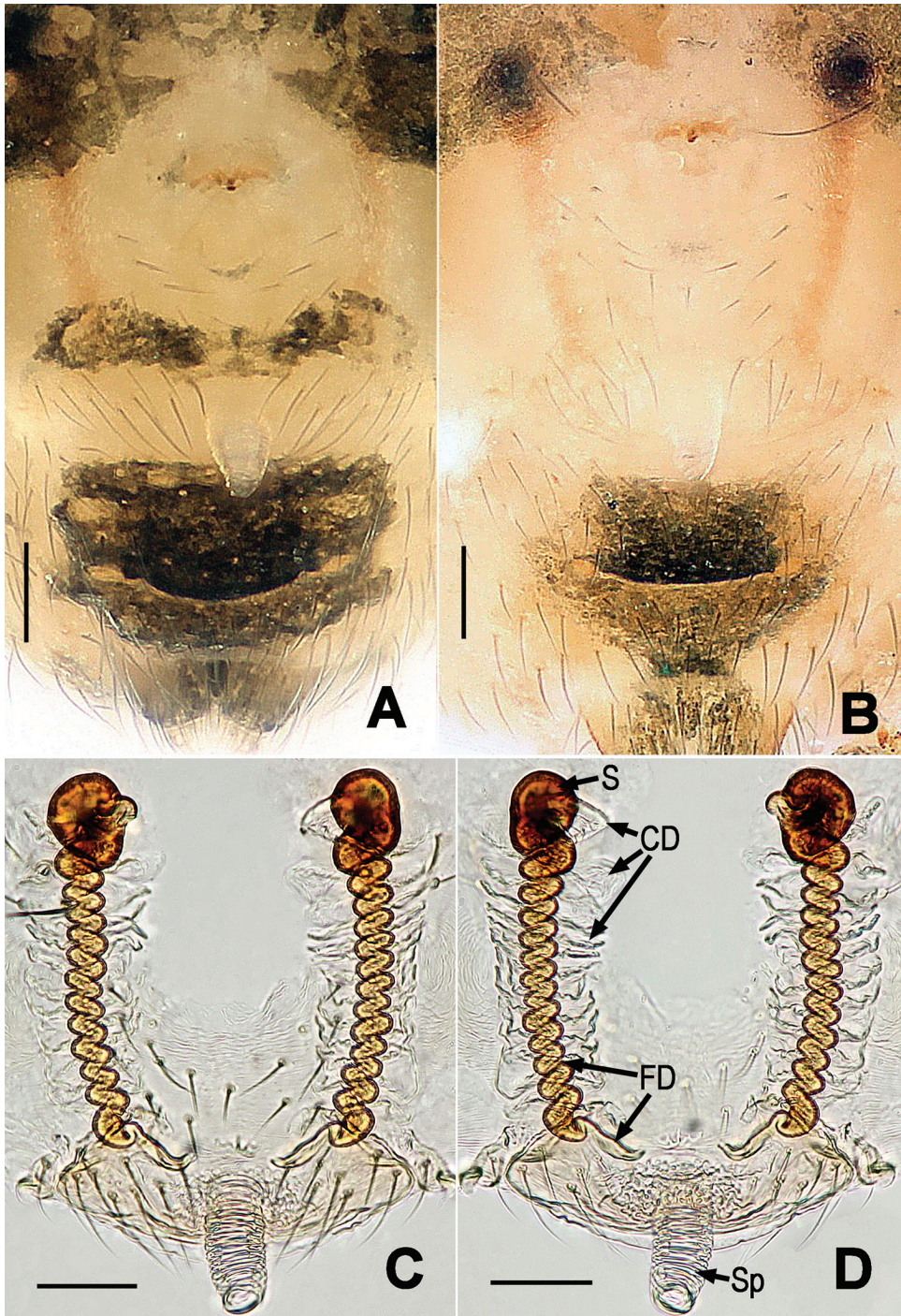
Figure 4. *Chanea voluta* sp. n., female paratype. **A** Epigynum, ventral **B** Epigynum (another paratype), ventral **C** Cleared vulva (lactic acid-treated), ventral **D** Epigynum, dorsal. Abbrs.: CD = copulatory duct; FD = fertilization duct; S = spermathecae; Sp = scape. Scale bars = 0.05 mm.

ture, 80 km of the road of Bomi to Medog (29°39.897'N, 95°29.963'E; Elevation: 2,140 m), 10 August 2013, X.Z. Cao leg., all types by manual sampling.

Etymology. The specific name derived from the Latin word "volutus" = coiled, refers to the coiled embolus in male palp and the spiral fertilization duct in female vulva; adjective.

Diagnosis. Male distinguished from *Chanea suukyii* Miller, Griswold & Yin, 2009 (see Miller et al. 2009: figs 49A–C, 50A–C, 51A–B, 52B–C) by the absence of paired macrosetea on the clypeus (Figs 1A, 1C), the longer paracymbium (Fig. 3C–D), the wider palpal bulb (Fig. 2A–C) and the variant embolic end (Fig. 3A–B), and female by the presence of a long scape (Fig. 4A–B), the larger spermatheca (Fig. 4C–D), the membranous fertilization ducts encircling around the coiled copulatory ducts (Fig. 4C–D).

Description. Male (holotype). Somatic characters see Fig. 1A–C. Coloration: Prosoma brown centrally, dark marginally. Chelicerae somber. Sternum yellow, with two pair of dark speckles on shoulder and posterior. Opisthosoma black dorsally, yellow ventrally and posteriorly. Legs pale yellow, each tibia and metatarsus yellow proximally, black distally.

Measurement: Total length 0.69. Prosoma 0.35 long, 0.36 wide, 0.38 high. Opisthosoma 0.45 long, 0.41 wide, 0.50 high. Clypeus 0.13 high. Sternum 0.25 long, 0.24 wide. Length of legs: I 1.27 (0.44, 0.16, 0.27, 0.19, 0.21); II 1.04 (0.33, 0.14, 0.21, 0.17, 0.19); III 0.80 (0.24, 0.11, 0.14, 0.13, 0.18); IV 0.93 (0.30, 0.12, 0.18, 0.15, 0.18).

Prosoma: Carapace near round. Cephalic pars elevated, slope forward and backward. Clypeal margin concave. Ocular area at apex. Eight eyes in two rows. AME black, others white. AME smallest, ALE largest. ALE>PME>PLE>AME. ALE and PLE contiguous. ARE precurved, PRE straight. Chelicerae small, shorter slightly than endites (Fig. 1C). Endites with tiny serrula. Labium semiround, fused to sternum. Sternum triangular, plump.

Legs: formula: I-II-IV-III. Leg I with a subdistal-ventral sclerotized femoral spot and a prolateral-submesial metatarsal clasping macroseta. Patellae I–IV with a dorsal seta distally. Tibiae I–IV with a dorsal seta proximally. Tibiae I and II with 3 trichobothria, but 4 on tibia III and IV. Metatarsi I–IV with only one trichobothrium.

Opisthosoma: globular dorsally, triangular laterally. Spinnerets grey, the anteriors larger than the posteriors. Colulus small, black, finger-shaped. Anal tubercle pale.

Palp (Figs 2A–C, 3A–D): Large, strongly sclerotized. Femur normal. Patella short, with a few setae. Tibia swollen, wider than long, askew cup-shaped, covered with marginal long setae dorsally and ventrally (Figs 2A–B, 3D). Cymbium large, membranous, envelopes dorsal, retrolateral and ventral face of palpal bulb (Figs 2A, 3C–D). Base of cymbium broad (Figs 2A, 3C). Cymbial groove distinct, and rugose (Fig. 3D). Paracymbium developed, finger-shaped, with long seta distally (Fig. 3C–D). Internal margin of cymbium with an even row of setae on cymbial fold and a small cymbial lobe (Figs 2C, 3C). Conductor (or tegulum) smooth, compressed, rounded (Fig. 2B–C). Embolus very long, coiling into ca. 6 loops, tightly encircles conductor and subtegu-

lum (Figs 2A–C, 3A–B). Embolar end slightly falcate, with tiny embolar apophysis (Fig. 3A–B), hidden behind distal cymbial conductor (Fig. 2A–B).

Female (one of paratypes). Somatic characters see Fig. 1D–F. Coloration: Same as in male.

Measurement: Total length 0.87. Prosoma 0.31 long, 0.38 wide, 0.36 high. Opisthosoma 0.48 long, 0.52 wide, 0.60 high. Clypeus 0.07 high, distinctly lower than in male. Sternum 0.27 long, 0.25 wide. Length of legs: I 1.40 (0.45, 0.19, 0.29, 0.22, 0.25); II 1.20 (0.39, 0.16, 0.24, 0.19, 0.22); III 0.87 (0.26, 0.12, 0.15, 0.15, 0.19); IV 1.10 (0.36, 0.13, 0.22, 0.18, 0.21).

Prosoma: Carapace near pear-shaped. Cephalic pars lower than in male. Eyes pattern, chelicerae, endites and sternum as in male.

Legs: Chaetotaxy and number of trichobothria same as in male, except for leg I without metatarsal clasping macroseta. Sclerotized femoral spot present at leg I and II. Leg formula: I-II-IV-III.

Opisthosoma: Globose dorsally. Genitalia black. Spinnerets grey, the anteriors larger than the posteriors. Colulus small, black, long finger-shaped.

Vulva (Fig. 4A–D): Epigynum weakly sclerotized, covered with short setae (Fig. 4A–B), with a membranous scape posterior-mesially (Fig. 4C). Scape blunt, rugose. Spermathecae small and egg-shaped, strongly sclerotized, set far anterior from epigastric furrow (Fig. 4B). Membranous copulatory ducts wrapped long, spiral fertilization ducts (Fig. 4C–D).

Distribution. Known only from the type locality (Fig. 10).

Genus *Mysmena* Simon, 1894

Mysmena Simon 1894: 558. Type species by original description *Theridion leucoplagiataum* Simon, 1879: 258 (= *M. leucoplagiata* (Simon, 1879)).

Composition. According to World Spider Catalog (2015), 27 described species, plus *M. lulanga* sp. n. described here from Nyingchi Prefecture, Tibet, China.

Distribution. Spain, Southern Europe to Azerbaijan, Saint Helena, Japan, Southwest China, Taiwan, Hainan Island, Vietnam, Oceania, islands of South Pacific, Guyana, Trinidad and Canada.

Comments. The genus *Mysmena* was erected by Simon in 1894 initially as a genus of Theridiiae with the type species *Theridion leycoplagiatum* Simon, 1879; later transferred to Symphytognathidae by Forster (1959), and then to Mysmenidae from Symphytognathidae by Forster and Platnick (1977). In recent years, research on species description reports of this genus mainly comes from China (Miller et al. 2009; Lin and Li 2008, 2013a, 2013b), Japan (Ono 2010), Queensland (Lopardo and Michalik 2013) and Canada (Lopardo et al. 2008). Lopardo and Hormiga (2015) suggested that *Calodipoena*, *Itapua*, *Calomyspoena*, *Tamasesia*, and *Kekenboschiella* are synonymized with *Mysmena* basing on the results of phylogeny

and evolutionary of the family Mysmenidae. Several optimized synapomrophies shared by most of this genus were proposed, include the spermatic duct switchback distally benting at a right angle, the presence of a long ventral scape, the weakly sclerotized fertilization ducts and the vulva with a distinguishable wall (Lopardo and Hormiga 2015).

Mysmena lulanga sp. n.
http://zoobank.org/D905C599-A81F-44E7-A7C8-7CD21C4F6277
Figs 5–10

Type material. *Holotype*: male (IZCAS), CHINA: Tibet Autonomous Region, Nyingchi County, the east of Lulang Town (29°41.984'N, 94°43.657'E; Elevation: 3480 m), 14 July 2013, L.H. Lin leg. *Paratypes*: 1 male and 7 females (IZCAS), same data as holotype; 1 male and 10 females (IZCAS), Nyingchi County, the east of Lulang Town (29°41.449'N, 94°43.605'E; Elevation: 3530 m), 14 July 2013, L.H. Lin leg., all types by manual sampling.

Etymology. The specific name derives from the type locality. The epithet is a noun in apposition.

Diagnosis. Male distinguished by the cymbial conductor with two distal macrometae (Figs 6A–B, 7C). Female distinguished from other congeners by the ovate spermatheca and the vulva without membranous copulatory duct or/and fertilization duct (Figs 8B, 9A–B). Compared with other Chinese *Mysmena* species, the new species and *M. baoxingensis* Lin & Li, 2013 have the most similar in configuration of palp and inner form of epigynum (see Lin and Li 2013a: figs 14A–E, 15A–D), but male differs from the latter by the shorter, wider embolus (Figs 6A–B, 7A–B), the two cymbial distal macrosetae (Figs 6B, 7A, 7C), and female by the near egg-shaped spermatheca (Figs 8B, 9A–B), the upswept fertilization ducts (Figs 8B, 9B) and the tapering, non-sclerotized scape (Figs 8A, 9A). Distinguished from the Vietnamese species *M. maculosa* and *M. tamdaoensis* (Lin & Li, 2014) by the lack of cymbial spur and the female abdomen without posterior projection, or by a simple embolus and the epigynum with a long scape. Further distinguished from other *Mysmena* species in Sulawesi (Baert 1988), New Guinea (Baert 1982, 1984; Forster 1959), Samoa (Marples 1955), North America (Lopardo and Dupérré 2008) and Latin America (e.g. Baert and Maelfait 1983; Gertsch 1960; Gertsch and Davis 1936; Levi 1956) by the shorter embolus and the lack of membranous copulatory duct (Figs 6A–B, 9B).

Description. Male (holotype). Somatic characters see Fig. 5A–C. Coloration: Prosoma darkish, ocular area black. Sternum black, with a pale longitudinal stripe centrally. Opisthosoma black dorsally, with three pair of white speckles, one large centrally and two small marginally, white pigment stripe at the lateral and posterior, black ventrally. Femora of legs pale yellow, other segments pale proximally, darkish distally.
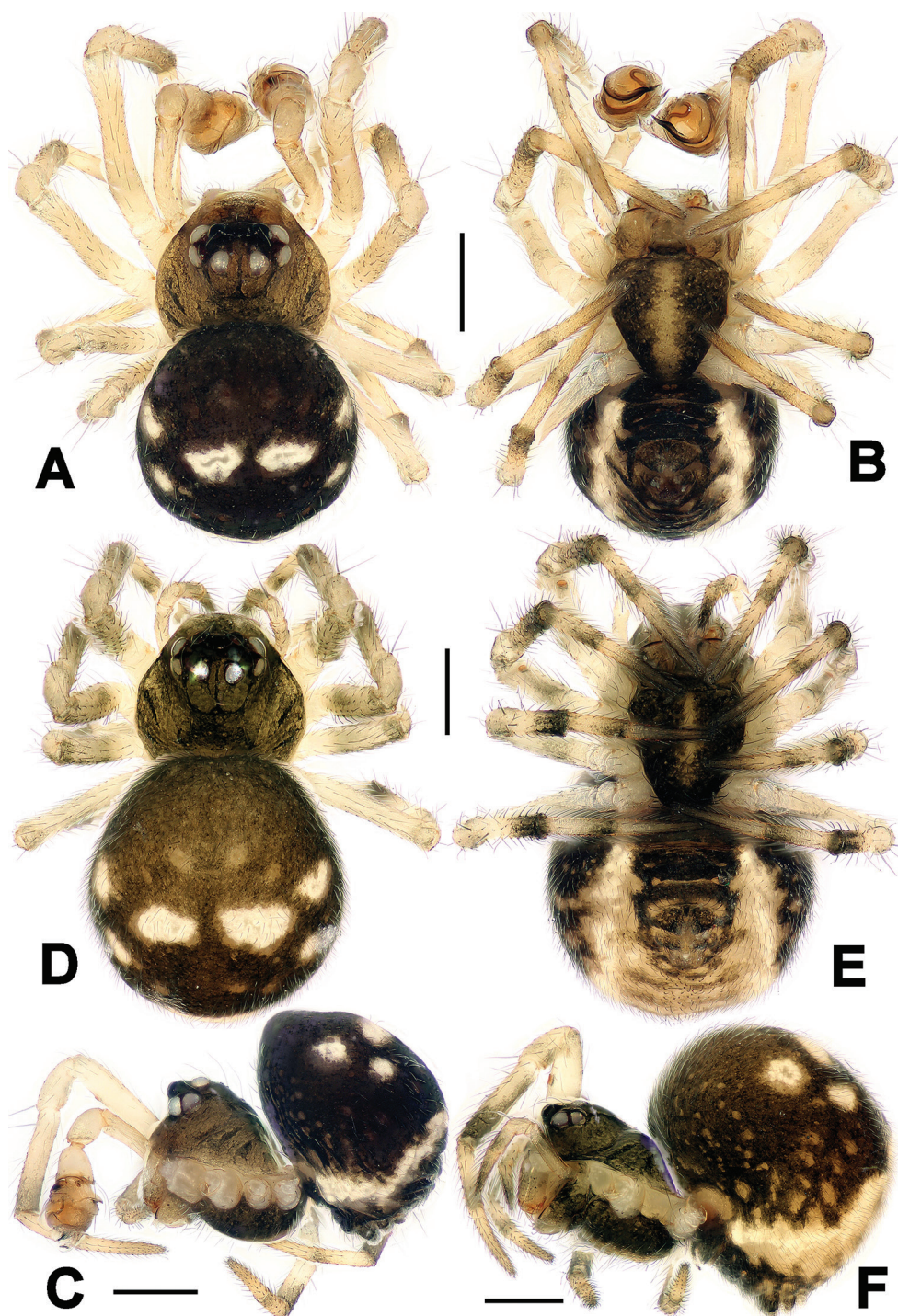
Figure 5. *Mysmena lulanga* sp. n., male holotype (**A–C**) and female paratype (**D–F**). **A, D** Habitus, dorsal **B, E** Habitus, ventral **C, F** Habitus, lateral. Scale bars = 0.20 mm.
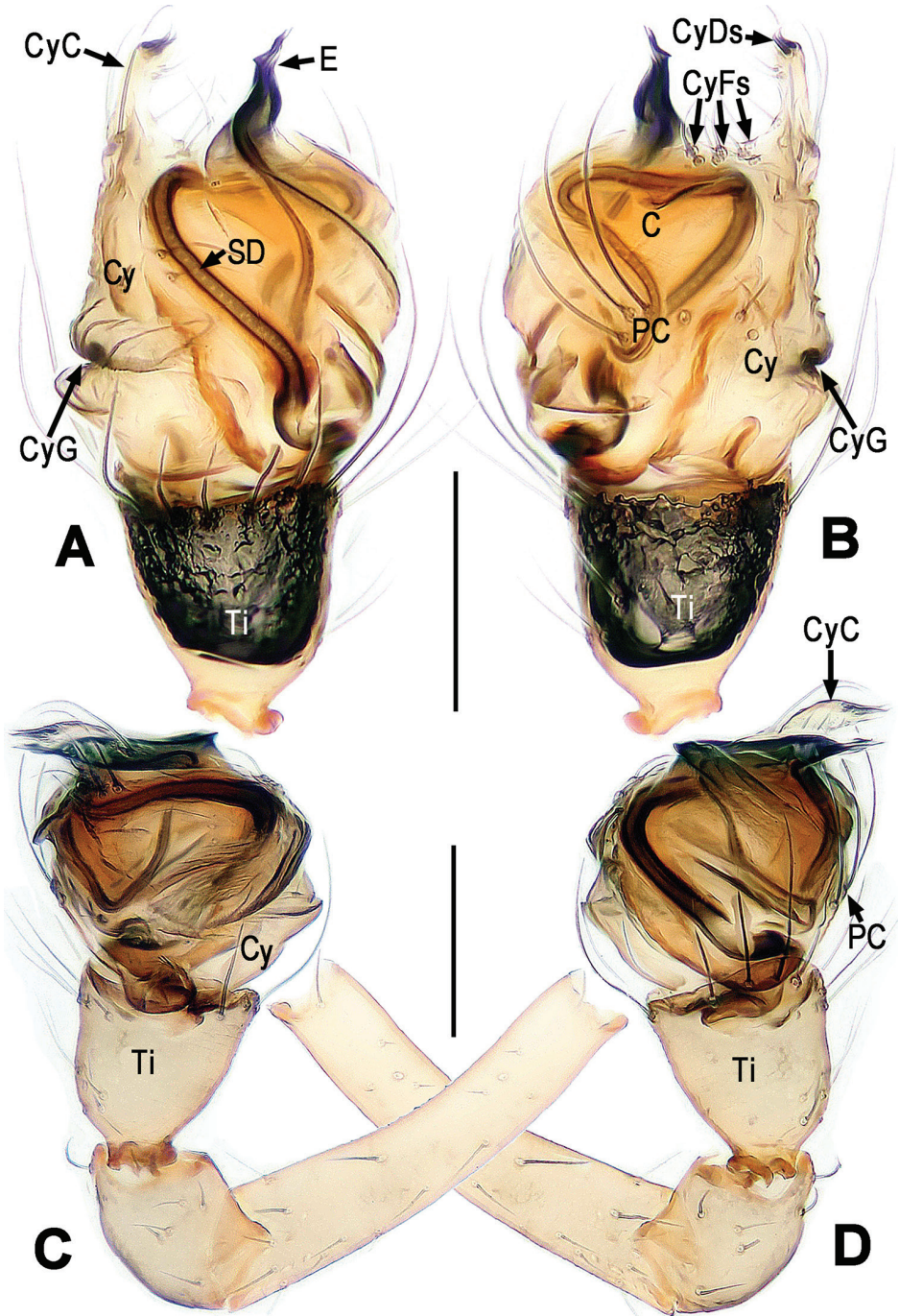
Figure 6. *Mysmena lulanga* sp. n., male holotype. **A** Left palp, ventral **B** Left palp, dorsal **C** Left palp, prolateral **D** Left palp, retrolateral. Abbrs.: C = conductor; Cy = cymbium; CyC = cymbial conductor; CyDs = cymbial distal macroseta; CyFs = setae on cymbial fold; CyG = cymbial groove; E = embolus; PC = paracymbium; SD = spermatic duct; Ti = tibia. Scale bars = 0.10 mm.
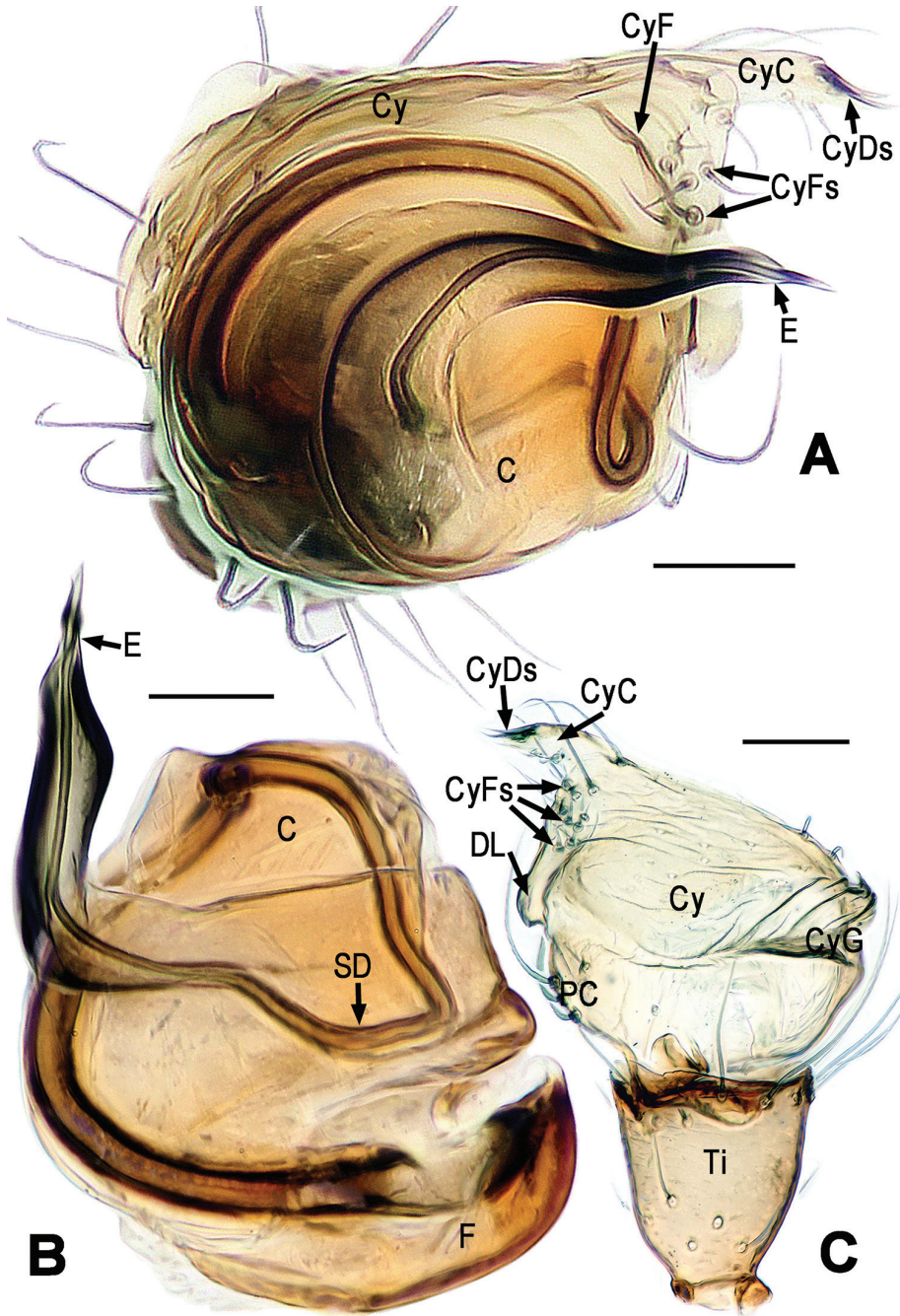
Figure 7. *Mysmena lulanga* sp. n., male holotype. **A** Left palp, apical **B** Palpal bulb, ventral-apical **C** Cymbium and palpal tibia, prolateral. **A–C** lactic acid-treated. Abbrs.: C = conductor; Cy = cymbium; CyC = cymbial conductor; CyDs = cymbial distal macroseta; CyF = cymbial fold; CyFs = setae on cymbial fold; CyG = cymbial groove; DL = distal lobe of cymbium; E = embolus; PC = paracymbium; SD = spermatic duct; Ti = tibia. Scale bars = 0.05 mm.
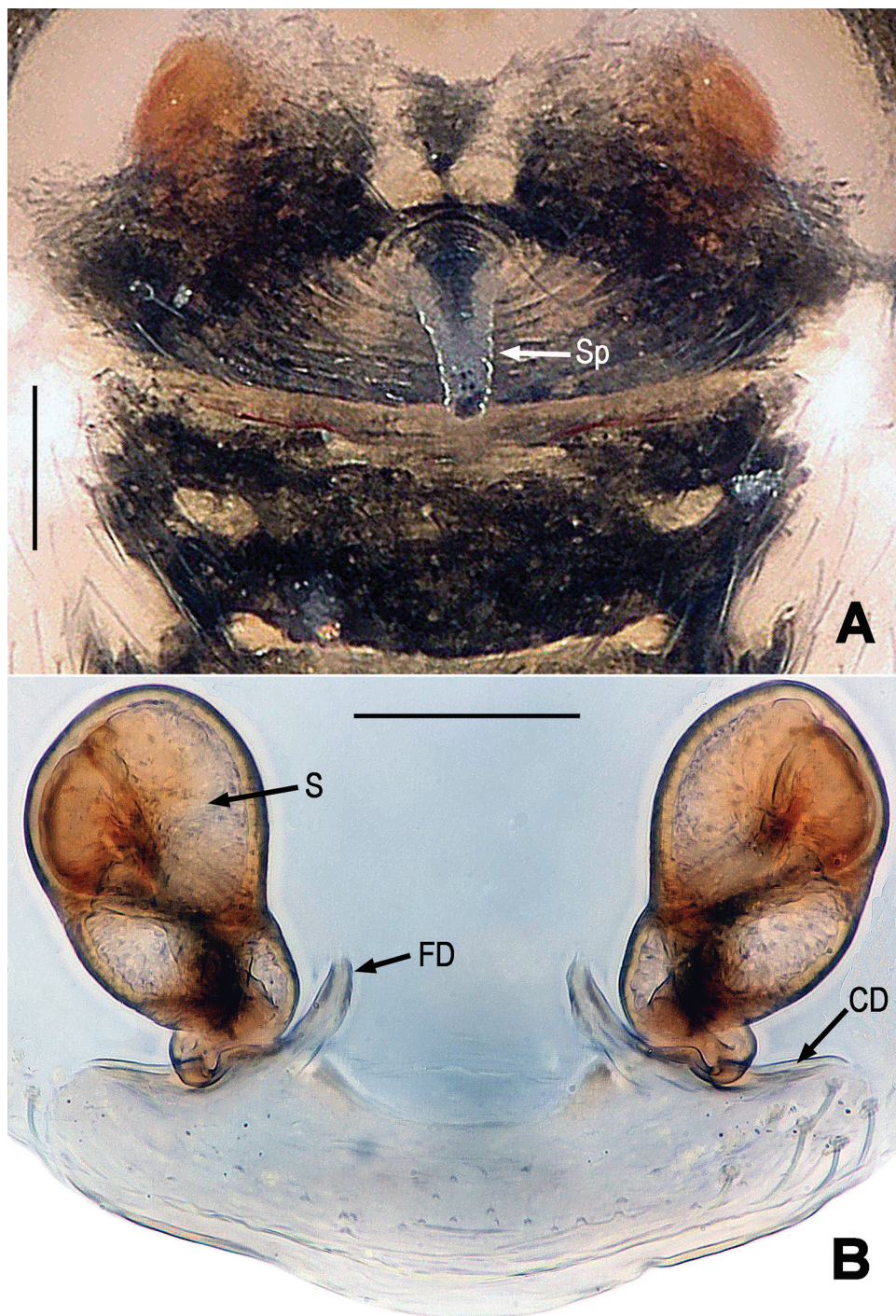
Figure 8. *Mysmena lulanga* sp. n., female paratype. **A** Epigynum, ventral **B** Cleared vulva (lactic acid-treated, omitted scape), dorsal. Abbrs.: CD = copulatory duct; FD = fertilization duct; S = spermathecae; Sp = scape. Scale bars = 0.05 mm.
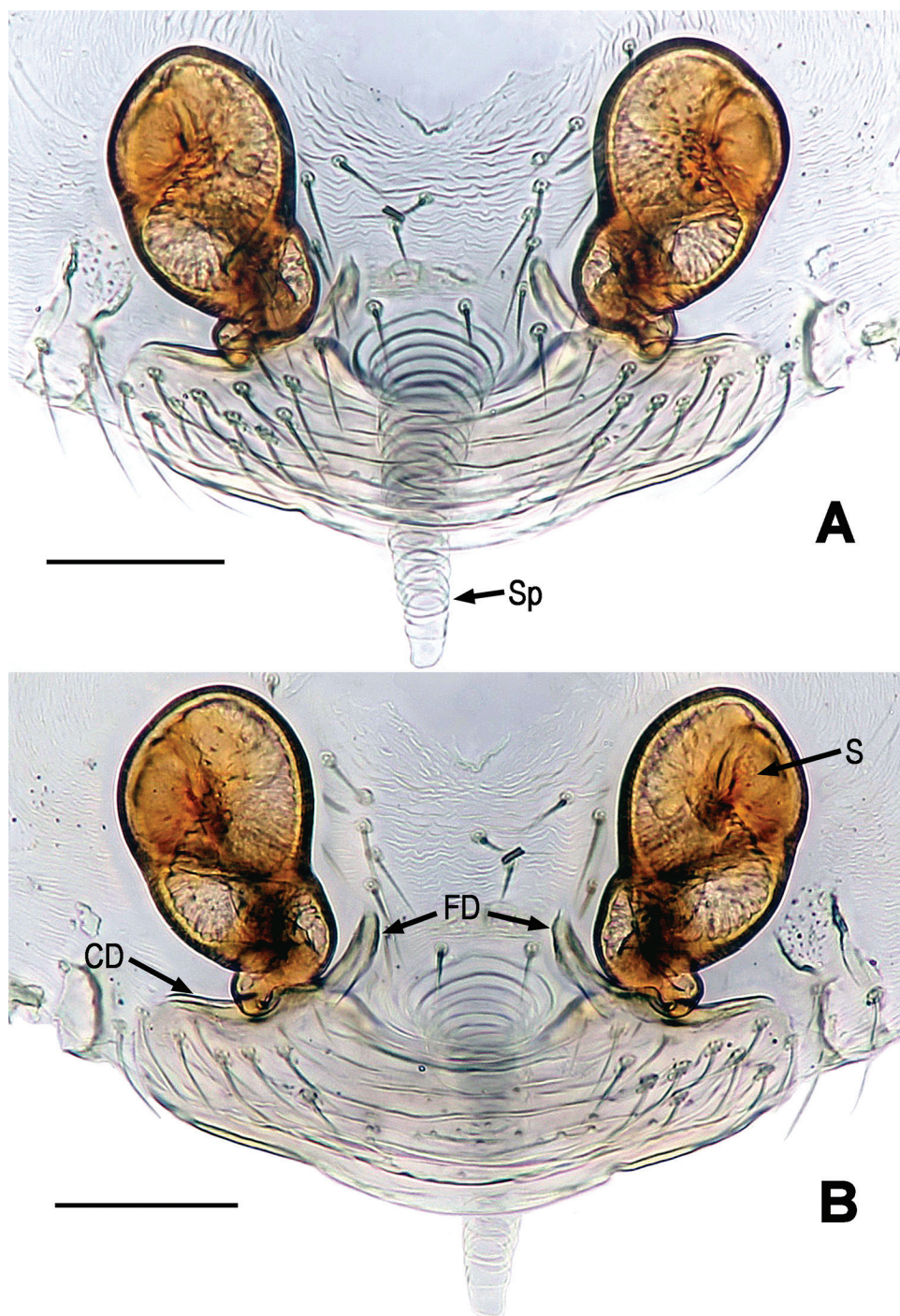
Figure 9. *Mysmena lulanga* sp. n., female paratype. **A** Epigynum (lactic acid-treated), ventral **B** Cleared vulva (lactic acid-treated), dorsal. Abbrs.: CD = copulatory duct; FD = fertilization duct; S = spermathecae; Sp = scape. Scale bars = 0.05 mm.

Measurement: Total length 0.71. Prosoma 0.33 long, 0.35 wide, 0.31 high. Opisthosoma 0.45 long, 0.43 wide, 0.50 high. Clypeus 0.09 high. Sternum 0.24 long, 0.25 wide. Length of legs: I 1.18 (0.38, 0.16, 0.24, 0.18, 0.22); II 1.04 (0.32, 0.14, 0.22, 0.16, 0.20); III 0.79 (0.23, 0.12, 0.14, 0.13, 0.17); IV 0.94 (0.29, 0.13, 0.18, 0.15, 0.19).

Prosoma: Carapace near round. Cephalic pars elevated, sharply vertical forward and slope backward. Clypeal margin concave. Ocular area at apex. Eight eyes in two rows. AME black, others white. ALE and PLE contiguous. AME smallest, ALE equal to PME in size. ALE=PME>PLE>AME. ARE slightly precurved, PRE slightly recurved. Chelicerae pale, small, shorter than endites (Fig. 5C). Endites with tiny serrula. Labium rectangular, wider than long, fused to sternum. Sternum cordiform, plump.

Legs: formula: I-II-IV-III. Leg I with a prolateral-mesial metatarsal clasping macroseta. Sclerotized femoral spot present at leg I and II. Patellae I–IV with a dorsal seta distally. Tibiae I–IV with a dorsal seta proximally. Tibiae I and II with 3 trichobothria, but 4 on tibia III and IV. Metatarsi I–IV with only one trichobothrium.

Opisthosoma: Globular dorsally. Spinnerets dark, the anteriors larger than the posteriors. Colulus tiny, black. Anal tubercle darkish.

Palp (Figs 6A–D, 7A–C): Femur long, ca. 3 times as long patella. Patella short, with a few setae. Tibia swollen, cup-shaped, covered with long setae on distal margin ventrally and dorsally (Fig. 6A–D). Cymbium membranous, wide, arisen from tibial margin prolaterally (Figs 6C, 7D). Cymbial groove distinct, rugose (Figs 6A–B, 7C). Paracymbium small semiround, undevolped (Fig. 7C). Distal lobe of cymbium auriform (Fig. 7C). Setae on cymbial fold irregular arrange (Figs 6B, 7A, 7C). Cymbial conductor horn-shaped, with two strong cymbial distal marocsetae at apex (Figs 6B, 7A). Conductor (or tegulum) smooth, globular (Figs 6B, 7A–B). Spermatic duct visible through subtegulum (Figs 6A–B, 7A–B). Embolus wide, strongly sclerotized. Embolar end sharp (Fig. 7A–B).

Female (one of paratypes). Somatic characters see Fig. 5D–F. Coloration: Same as in male.

Measurement: Total length 0.95. Prosoma 0.38 long, 0.40 wide, 0.35 high. Opisthosoma 0.66 long, 0.60 wide, 0.67 high. Clypeus 0.08 high, slightly lower than in male. Sternum 0.26 long, 0.27 wide. Length of legs: I 1.25 (0.41, 0.17, 0.26, 0.19, 0.22); II 1.10 (0.35, 0.16, 0.22, 0.17, 0.20); III 0.87 (0.26, 0.14, 0.15, 0.14, 0.18); IV 1.04 (0.33, 0.15, 0.21, 0.16, 0.19).

Prosoma: Carapace near pear-shaped. Cephalic pars lower than in male. Eyes pattern, chelicerae, endites and sternum as in male.

Legs: Chaetotaxy and number of trichobothria same as in male, except for leg I without metatarsal clasping macroseta. Sclerotized femoral spot present at leg I and II. Leg formula: I-II-IV-III.

Opisthosoma: Globose dorsally. Spinnerets grey, the anteriors larger than the posteriors. Colulus small, black, tongue-shaped.

Vulva (Figs 8A–B, 9A–B): Epigynum large, weakly sclerotized. Epigynal area covered with short setae (Fig. 8A). A long, tapering scape arising from the middle posi-
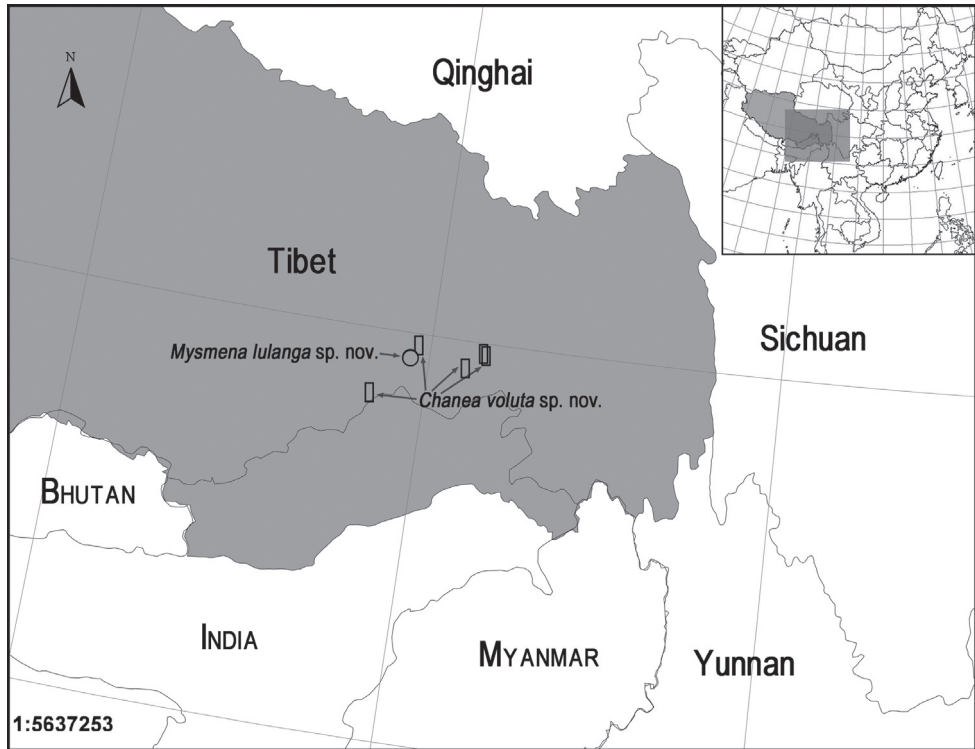
Figure 10. Records of two new species of Mysmenidae from Tibet, China.

tion between spermathecae, not from epigynal posteromargin mesially (Figs 8A, 9A). Spermathecae large, strongly sclerotized, near egg-shaped (Figs 8B, 9B). A translucent, broad anterior genital plate lain beneath spermathecae (Figs 8B, 9B). Copulatory ducts short, derives from ventral-posterior position of spermathecae ventrally, and connected with anterior corner of genital plate (Figs 8B, 9A–B). Fertilization ducts short, upswept, connected with dorsal-posterior position of spermathecae (Fig. 8B).

Distribution. Known only from the type locality (Fig. 10).

Discussion

Finding the species *Chanea voluta* sp. n. allowed us to clearly place the genus *Chanea* within the Mysmenidae, by the presence of the most important characters of the genus that the type species *C. suukyii* and *C. voluta* sp. n. both share: an extra-long (at least five loops) coiled embolus, and the very long (at least ten loops) spiral copulatory duct or/and fertilization duct. In addition, another significant common feature between them is the relatively small spermatheca located far from the epigastric groove. These common features indicate that these species belong to the same genus. As for the

clypeal setae in male, although quite typical for *Chanea suukyii*, we think this may be only a species specific character. Like the front cheliceral setae found in the males of some *Mysmena* species, some species have them (e.g. *M. arcilonga*, *M. rostella*, *M. vangoethemi*, *M. taiwanica*), but others do not. This same situation also appears in the genus *Gaoligonga*. The scape may be present or absent; the same is true in other mysmenid species. However, these characters are still in doubt.

In conclusion, the monophyly and circumscription of the genus *Chanea* and its relationships within Mysmenidae needs more study (Lopardo and Hormiga 2015).

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RESEARCH ARTICLE

Thysanoptera-Terebrantia of the Hawaiian Islands: an identification manual

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Abstract

An illustrated identification system is presented to 99 species and 49 genera in three families recorded from the Hawaiian Islands in the Thysanoptera suborder Terebrantia. Only seven (possibly eight) of these species are considered endemic, the remainder being adventive to these islands. The only previous study of Hawaiian Thysanoptera, by Zimmerman in 1948, included 47 Terebrantia species in 21 genera.

Keywords

Preamble

This paper derives from a 200 page un-illustrated typescript prepared by Steve Naka-hara some years prior to his retirement in 1998 from work on thrips. His co-author, Dick Tsuda, sent that typescript to Laurence Mound in June 2015, and in the absence of funding to complete such an extensive work, this annotated identification manual was prepared in Canberra, Australia. Records of taxa from particular Hawaiian Islands are copied from the original typescript.

Introduction

This account of the Thysanoptera-Terebrantia known from the Hawaiian Islands includes 99 species, of which only seven (or possibly eight) are considered endemic and over 90 species are considered adventive from other parts of the world. The obvious conclusion from these numbers is, *either* the native thrips fauna of Hawaii is particularly small, *or* collecting activity for thrips associated with the native flora is inadequate. The data provided here thus contribute little to our understanding of island biogeography, but emphasise two matters of considerable importance to plant quarantine and plant protection: 1, that thrips are particularly prone to dispersal through commercial activities, especially the horticultural trade in live plants which harbor undetected thrips contaminants, and 2, that Hawaii is particularly susceptible to such invaders because almost half of the 1800 established flowering plant species are non-native (Wagner et al. 1990). The only previous account of Hawaiian thrips was provided by Zimmerman (1948). He reviewed earlier studies, but used a classification that is now seriously outdated. Amongst the suborder Terebrantia from Hawaii Zimmerman listed only 47 species in 21 genera and two families. Of those 47 species, 30 have since undergone some sort of nomenclatural change, and subsequent workers, particularly Nakahara, Sakimura and Tsuda, have recorded many additional taxa (see Appendix). As a result, Nishida et al. (1992) listed 83 species in 44 genera of Terebrantia, although Bernarr Kumashiro kindly provided (August 2015) an unpublished manuscript listing a further seven species identified by Sueo Nakahara. The Bishop Museum Hawaiian Arthropod Checklist (2015) includes 92 Terebrantia names. However, that list is both incomplete and includes several unsubstantiated records, and moreover nomenclature of some taxa is out of date.

General information about Thysanoptera including identification systems are available on several web-sites, including Hoddle et al. (2012) and Mound et al. (2012), and full nomenclatural information about these insects is available in ThripsWiki (2015). General information about thrips in the form of hard-copy is available in Mound and Marullo (1996), and also Stannard (1968), although the nomenclature in the latter is seriously out-of-date. The Appendix given below, following Literature Cited, lists many published reports by authors in Hawaii on the thrips fauna of these islands.

Biology of Thysanoptera

About 50% of Thysanoptera species feed only on fungi that develop on dead leaves, twigs and branches of woody higher plants (Morse and Hoddle 2006). These fungivorous thrips are all members of the single family in the suborder Tubulifera, and as such are not considered here. The species discussed in this presentation, the Terebrantia, feed on the tissues of living plants, on leaves, flowers and fruit surfaces, with a few species predatory on other small arthropods. It is members of this suborder that so often cause feeding damage to agricultural and horticultural crops, with several species transmitting damaging tospoviruses.

An important aspect of the biology of thrips is the identity of the plants on which individual species can maintain populations, although this relationship can be difficult to establish (Mound 2013). Adults of many species are highly dispersive, and land on plants on which they cannot breed or even feed. However, in published literature the names of plants from which adult thrips have been collected are commonly quoted as "hosts", depite the lack of evidence of feeding let alone breeding on such plants. Thrips species of some genera exhibit considerable levels of host specificity. Many genera are associated only with Poaceae, the grasses and bamboos (Mound 2011b). *Dichromothrips* species are specific to Orchidaceae, and *Projectothrips* specific to *Pandanus* flowers. But the larger genera such as *Frankliniella*, *Scirtothrips* and *Thrips* include many species that appear to be generalists, but with other species that are host specific. One important aspect of the generalist species is that 13 of them are currently recognized as the vectors of various Tospovirus species that cause damage to many crops (Riley et al. 2011).

Thysanoptera as migrants

Given that the only recorded endemic Hawaiian Terebrantia are seven described species of *Neurisothrips*, and possibly one species of *Projectothrips*, the origin of the remaining 90 species is of considerable plant protection interest. At least 50 of these species are found widely around the world. For these, the country in which they originally evolved is probably of limited importance when considering invasion pathways. Such species could have reached Hawaii from any part of their disrupted distribution, although Yamanaka et al. (2015) appeared to assume that each invasive species had entered Hawaii from the area in which it had evolved. Despite this, an invasion pathway from the Americas is indicated by the 15 species that are found otherwise only in North America, and a second pathway is indicated by the five species shared only with the Neotropics. Similarly 15 species are known only from Southeast Asia or Australia, and a trans-Pacific pathway is presumably responsible for their introduction into Hawaii.

Taxonomy of Thysanoptera

The members of this Order of insects are known as thrips. This word is a plural noun, such that whether "two thrips" or just "one thrips", the word thrips remains unchanged in the same way that the word sheep is both singular and plural. The word thrips is a Greek word for woodworm, because many of the early records of these insects referred to fungus-feeding species that live on dead branches. Thrips are slender, elongate insects, usually flattened dorso-ventrally, and the adults range from 0.5 to 15.0 mm in length. Adults and larvae are unusual amongst insects in having only a single mandible, the left one, because the right mandible is resorbed early in development. The other character state of thrips that is almost unique amongst adult insects is the absence of tarsal claws and the presence of a tarsal arolium. In contrast, the characteristic fringed

wings from which the ordinal name is derived occur in many other small insects, including beetles, wasps, moths and caddisflies. However, adults of many thrips species are apterous or micropterous – that is, wingless or with very short wings.

Two suborders are recognised, the Terebrantia and the Tubulifera. Only one family is recognised in the Tubulifera, but eight families are recognised in the Terebrantia (plus a further five families for fossil taxa) (ThripsWiki 2015).

Technical terms

The following technical terms are used in the keys provided here. In association with the three ocelli on the head there are commonly three pairs of setae: ocellar setal pair I in front of the first ocellus, pair II arise laterally close to the compound eyes, pair III vary in position from inside to just outside the ocellar triangle. Ocellar setal pair I are absent in species of *Taeniothrips* and *Thrips* (Figs 107, 111), but present in species of *Frankliniella* (Figs 65–67). When referring to setae on the tergites and sternites, it is usual to consider the pair nearest the body mid-line as setal pair S1, the other setae then being numbered sequentially away from the mid-line. The abdominal tergites of species in *Frankliniella* and *Thrips* and related genera bear laterally a pair of organized microtrichial rows referred to as ctenidia (Figs 14, 15). The tergites, and/or the sternites, sometimes bear a posteromarginal flange or craspedum, and this may be entire or lobed in various ways (Figs 38, 47). Campaniform sensilla are pore-like structures (Figs 14, 27) that are presumably stretch receptors on the chitinous surface of various parts of the thorax and abdomen.

Key to suborders

1   Abdominal segment X tubular; ovipositor inflatable and extruded at base of tube; fore wings when present, with no surface microtrichia nor visible longitudinal veins .... **Tubulifera**
–   Abdominal segment X longitudinally divided ventrally, ovipositor of 4 sawedged valves; fore wings, when present, with surface microtrichia and two longitudinal veins ....**Terebrantia**

Sub-order TUBULIFERA

Worldwide in this suborder only one family (Phlaeothripidae) and two subfamilies (Idolothripinae and Phlaeothripinae) are recognised, although ThripsWiki (2015) provides a list of 14 more family-group names that have been proposed for particular groups of species. Both of the recognised subfamilies of Phlaeothripidae are represented in the Hawaiian fauna. Nishida et al. (1992) list 10 species of Idolothripinae and 46 species of Phlaeothripinae, whereas the Bishop Museum Hawaiian Arthropod

Checklist (2015) lists 10 species of Idolothripinae and 50 species of Phlaeothripinae. Recent changes to the list of Phlaeothripinae (Mound and Okajima 2015) include one newly described species, *Dolichothrips franae* Mound & Okajima, and one name change with *Dolichothrips nesius* now a synonym of *Dolichothrips indicus*. Two genera dominate both lists of Phlaeothripinae: *Haplothrips* with nine species and *Hoplothrips* with 18 species. Some of the *Haplothrips* species cannot be recognised without a modern revision, and the situation with the species of *Hoplothrips* is even more unsatisfactory. Bagnall (1910) described 11 Hawaiian species that are now in *Hoplothrips*, and Mound (1968) studied the original specimens and concluded that it was not possible to determine how many separate species were represented. These specimens were re-examined in 2015, and there is little doubt that the number of real biological species is considerably less than eleven. However, formal synonymies cannot be proposed without field studies to establish the range of body size within at least one population, including the differences between large and small individuals, between sexes, and between winged and wingless morphs. The Phlaeothripidae of Hawaii are not considered further in this study.

Sub-order TEREBRANTIA

Of the eight families worldwide that are recognised in this suborder (ThripsWiki 2015), only three have been found in the Hawaiian Islands. However, these include the two largest families that comprise the most common species of thrips around the world.

Key to Terebrantia families in Hawaiian Islands

1　　Antennal segments III and IV with emergent, simple or forked sense cones (Figs 1, 2) ....**Thripidae**
–　　Antennal segments III and IV with sensoria not protruding, elongate or oval (Figs 3, 6) **2**
2　　Antenna 9-segmented, III–IV elongate, parallel sided, with sensoria elongate along these segments (Figs 3, 4); fore wing broad, apex rounded (Figs 11–13) ... .**Aeolothripidae**
–　　Antenna 8-segmented, III–IV with convex sides, sensoria transverse or sub-circular at apex of segments (Figs 6, 7); fore wing slender and pointed ....**Merothripidae**

AEOLOTHRIPIDAE

Over 200 species in 23 genera are listed in this family (ThripsWiki 2015). More than 50% of these species are placed in the Holarctic genus *Aeolothrips*, and these are mostly
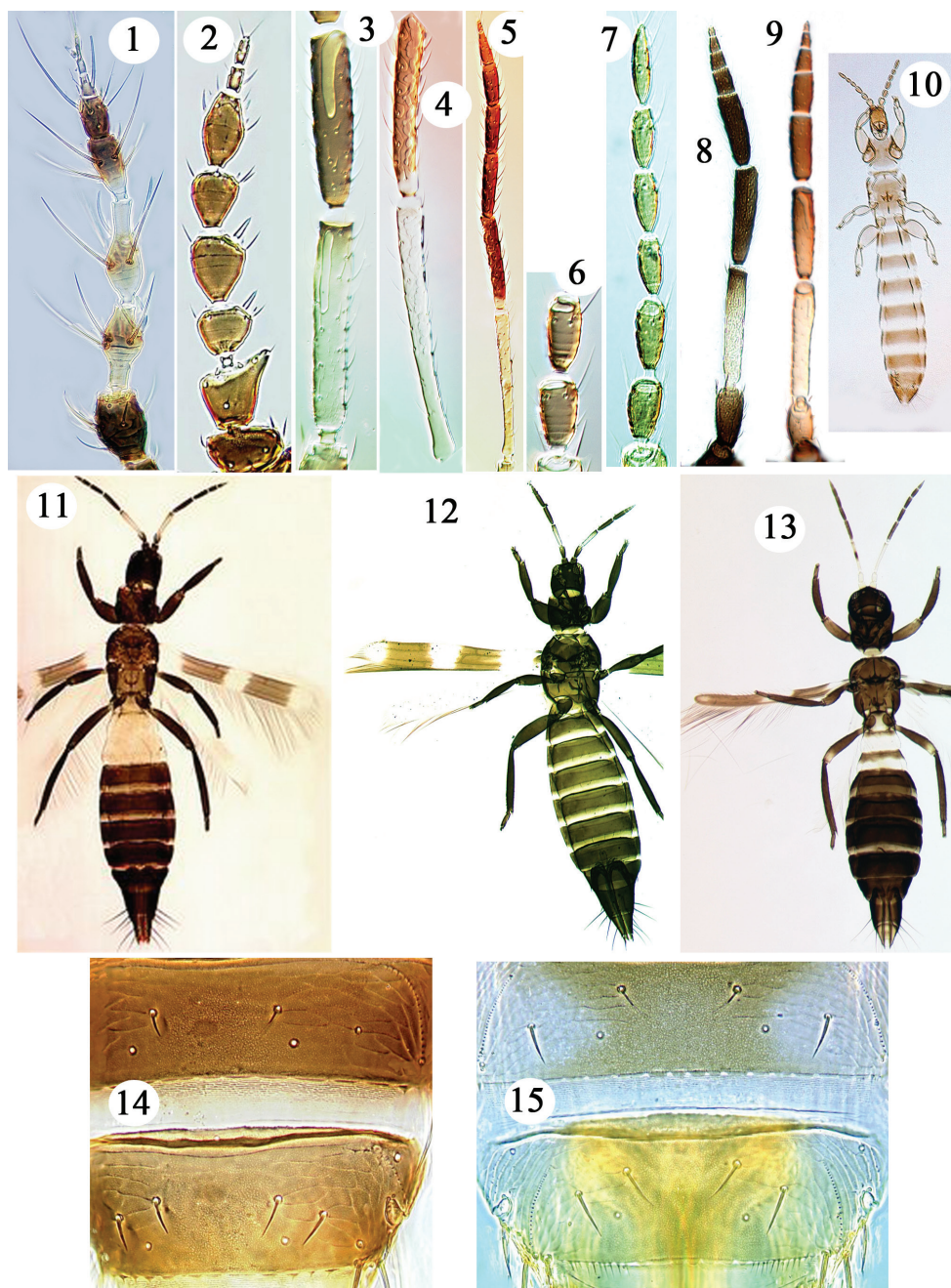
Figures 1–15. Terebrantia from Hawaii. Antennae **1–9**: **1** *Selenothrips rubrocinctus* **2** *Chirothrips manicatus* **3** *Aeolothrips fasciatus* segments III–IV **4** *Franklinothrips vespiformis* segments III–IV **5** *Franklinothrips vespiformis* **6** *Merothrips floridensis* segments III–IV **7** *Merothrips floridensis* **8** *Aeolothrips fasciatus* **9** *Aeolothrips nasturtii*. Females **10–13**: **10** *Merothrips morgani* **11** *Aeolothrips bicolor* **12** *Aeolothrips fasciatus* **13** *Franklinothrips vespiformis*. Tergites VII & VIII 14–15: **14** *Frankliniella schultzei* **15** *Thrips australis*.

flower-living but are possibly facultative predators. In contrast, a large proportion of Aeolothripidae genera are from the tropics, with many of the species obligate predators on other small arthropods in trees or at ground level.

Key to genera from Hawaiian Islands

1   Antennal segment III less than 6 times as long as wide; sensoria on III–IV linear, no more than 0.5 as long as segment (Fig. 3) ....***Aeolothrips***
–   Antennal segment III about 10 times longer than wide; sensoria on III–IV sinuous and almost as long as segment (Fig. 5) ....***Franklinothrips***

***AEOLOTHRIPS* Haliday:** The 105 species listed in this genus are almost entirely from the Holarctic, with no more than five species known from India or South Africa (ThripsWiki 2015). Bailey (1951) provided an introduction to the American species of the genus. One species of *Aeolothrips* is described from South America, but this cannot at present be distinguished from the widespread *fasciatus* that is also known from Hawaii.

Key to species from Hawaiian Islands

1   Abdominal segments II and III pale (Fig. 11) in contrast to rest of blackish brown abdomen..***bicolor***
–   Abdomen completely blackish brown **2**
2   Antennal segment VI less than one-half as long as V (Fig. 8) ....***fasciatus***
–   Antennal segment VI about two-thirds as long as V (Fig. 9) ....***nasturtii***

***Aeolothrips bicolor* Hinds:** This is considered to be a predator of scale insects and mites. Widespread in eastern USA southward through Texas and Mexico to Costa Rica, it has been found on Kauai, Maui, Molokai, and Oahu. The abdomen is bicoloured, the fore wing bears two dark cross bands, and tergite IX of the male bears a pair of claspers. It is ant-like in appearance and behavior, and is usually found living at ground level amongst grasses (Mound and Marullo 1996).

***Aeolothrips fasciatus* (Linnaeus):** Described from Europe, this species appears to be a facultative predator of small arthropods in various flowers. It is recorded from Hawaii, Maui and Oahu, is widespread in USA, and is known from New Zealand and southern Australia. However, there are several species that are similar in colour and structure, and the precise identity of *fasciatus* cannot be established without males (Mound et al. 2012).

Aeolothrips nasturtii **Jones:** This species is closely similar to *fasciatus* in appearance, apparently differing only in the relative proportions of the antennal segments, but unfortunately the male of *nasturtii* remains unknown. The species is recorded from Maui, and is widespread in USA into Canada.

FRANKLINOTHRIPS **Back:** This genus includes 16 species, and these occur in various countries around the tropics (Mound and Reynaud 2005). Most of the species seem to live solitary in the canopy of trees, where they are remarkable ant-mimics and predatory on other small arthropods.

Franklinothrips vespiformis **Crawford:** Recorded widely around the world and often in vegetable crops, this species is reported from Hawaii and Oahu. It has sometimes been deployed as a biocontrol agent against pest thrips in European glasshouses (Loomans and Vierbergen 1999).

MEROTHRIPIDAE

This family comprises 16 species in three genera. A few species are found widely around the tropics, but most are Neotropical, with two species of one genus known from the Hawaiian Islands. Adult females bear a pair of lobes on the posterior margin of sternite VII, and these lobes have been considered to represent a reduced eighth sternite (Mound and O'Neill 1974).

MEROTHRIPS **Hood:** The species in this genus have 8-segmented antennae, with a circular or transverse sensorium at the apex of segments III and IV, and segment VIII elongate. They are minute insects that are fungus-feeders on dead twigs. The genus was treated by Zimmerman (1948) within the family Thripidae.

Key to species from Hawaiian Islands

1   Pronotum with faint longtitudinal striae medially as well as near posterior margin .... *morgani*
–   Pronotum with striae only on posterior area .... *floridensis*

Merothrips floridensis **Watson:** Widespread around the world, this species is recorded from Hawaii and Oahu. It is usually found on dead twigs and branches.

Merothrips morgani **Hood:** Although collected much less frequently than *floridensis*, this species has also been reported widely around the world in warm areas on all continents. The synonym *hawaiiensis* Moulton was described from Hawaii, and *morgani* is recorded from Maui, Molokai and Oahu.

THRIPIDAE

With rather more than 2000 species and 290 genera worldwide (ThripsWiki 2015), this is the second largest family of Thysanoptera. The species are almost entirely phytophagous on higher plants, both on leaves and in flowers, with a few predatory on mites, and a very few feeding on mosses or rarely on fungal pathogens of plants (Mound et al. 2012). Generally rather small in size, the members of this family are the organisms most commonly recognised as "thrips" by entomologists, and the family includes most of the species in this Order of insects that are considered pests.

Key to subfamilies of Thripidae

1   Body surface strongly reticulate (Figs 16–18), particularly head, thorax and fore femora; usually dark brown in colour; fore wing with first longitudinal vein fused to costal vein; meso- and metathoracic furca with no spinula ....**Panchaetothripinae**

–   Body surface either not reticulate, or with relatively weak sculpture, and colour varying from brown to almost white; fore wing first vein distinct from costa; meso- and/or metathoracic furca usually with median spinula...........**2**

2   Metathoracic furca lyre-shaped, greatly prolonged anteriorly (Fig. 28).......... ....**Dendrothripinae**

–   Metathoracic furca transverse or produced as simple median spinula (Figs 59–60)..**3**

3   Femora and tibiae with rows of microtrichia (Fig. 32); fore wing first vein with complete row of setae (Fig. 36), second vein with no setae or with only one or two near wing apex; sense cone on antennal segment VI with base greatly elongate and narrow; abdominal tergite IX without campaniform sensilla, with at least 4 pairs of posteromarginal setae................**Sericothripinae**

–   Femora and tibiae without closely spaced rows of microtrichia; fore wing chaetotaxy different; sense cone on antennal segment VI with base circular to elongate-oval; abdominal tergite IX usually with one or two pairs of campaniform sensilla (Fig. 80), with 2 or 3 pairs of posteromarginal setae...........**Thripinae**

PANCHAETOTHRIPINAE

A taxonomic account of this group was provided by Wilson (1975), and it now comprises 135 species and 38 genera (ThripsWiki 2015). The species feed on green leaves where they usually pupate. Many are considered pests on various plants, but often as much from their habit of soiling leaves as of causing serious tissue damage. Most panchaetothripines live in tropical countries, but several are important pests in greenhouses in temperate regions.
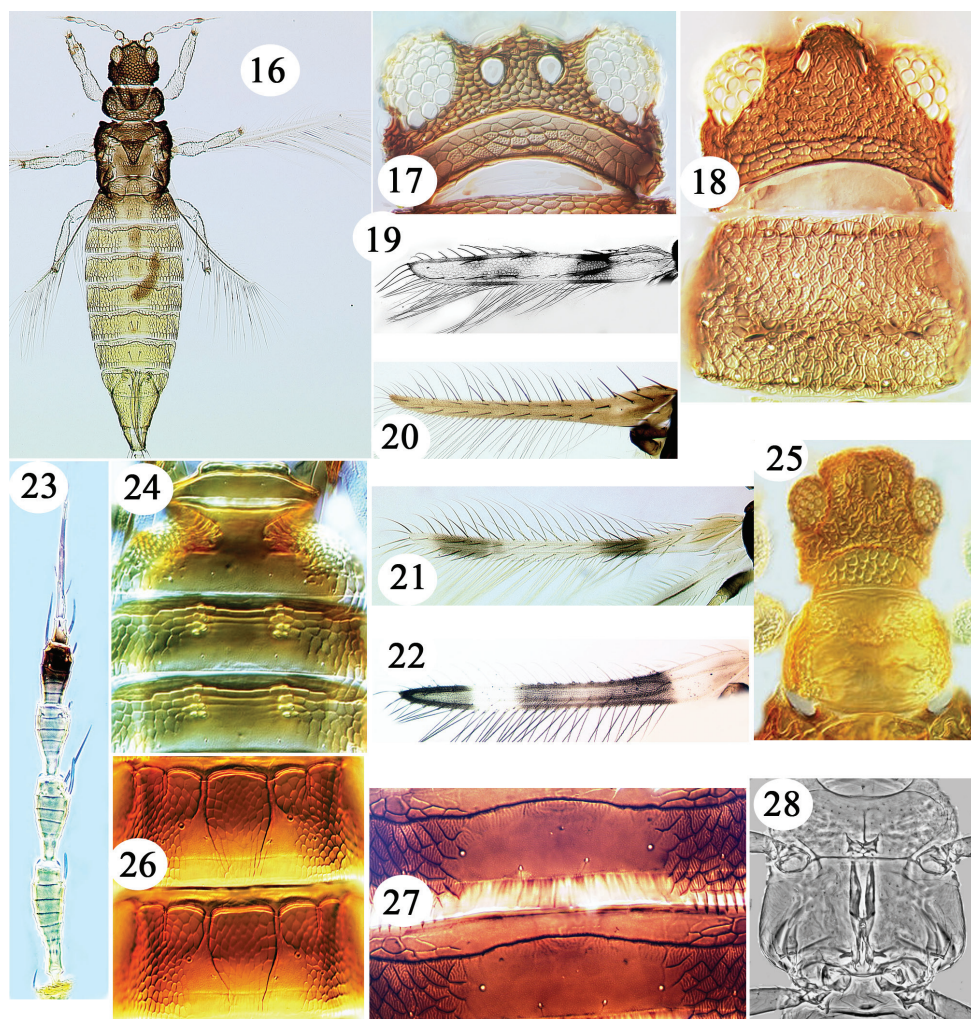
Figures 16–28. Thripidae from Hawaii. **16** *Heliothrips haemorroidalis*. **17** *Helionothrips errans*, head **18** *Caliothrips fasciatus*, head & pronotum. Fore wing **19–22**: **19** *Parthenothrips dracaenae* **20** *Selenothrips rubrocinctus* **21** *Hercinothrips bicinctus* **22** *Caliothrips fasciatus*. **23** *Heliothrips haemorroidalis* antenna **24** *Anisopilothrips venustulus*, tergites I–III. Tergites III–IV **26–27**: **26** *Helionothrips errans* **27** *Caliothrips fasciatus*. **28** *Asprothrips seminigricornis* metathoracic furca.

Key to genera from Hawaiian Islands

1 Fore wing with polygonal reticulation (Fig. 19); antenna 7-segmented .... ***Parthenothrips***
– Forewing not reticulate; antenna 8-segmented **2**
2 Antennal segments III–IV with simple sense cones (Fig. 23)......................**3**
– Antennal segments III–IV with sense cones forked (Fig. 1)..........................**6**

3   Abdominal segment II anterolaterally with dense cluster of recurved, stout, microtrichia (Fig. 24); mesonotum with complete longitudinal median division...**4**

–   Abdominal segment II without paired anterolateral clusters of stout microtrichia; mesonotum without complete longitudinal median division **5**

4   Tergite X with apices of terminal setae acute; metanotum with longest pair of setae on anterior half of sclerite; tergites III–VII with paired clusters of reticles (Fig. 24)...***Anisopilothrips***

–   Tergite X with apices of terminal setal pair capitate; metanotum with longest pair of setae on posterior half of sclerite; tergites without clusters of reticles.. ....***Elixothrips***

5   Fore wing anterior margin with cilia, posterior margin with cilia straight, wing apex rounded; head with polygonal reticulation, not projecting in front of eyes (Fig. 16) ....***Heliothrips***

–   Fore wing anterior margin without cilia, posterior margin with cilia wavy, wing apex pointed; head projecting in front of eyes, with rugose sculpture (Fig. 25)..***Rhipiphorothrips***

6   Fore wing uniformly deeply shaded (Fig. 20); head with a basal neck; abdominal tergite X without dorsal split......................................***Selenothrips***

–   Fore wing not uniformly dark; head without distinct neck; abdominal tergite X with dorsal longitudinal split...**7**

7   Tarsi 2-segmented; fore wing with 2 complete rows of setae (Fig. 21)........... ....***Hercinothrips***

–   Tarsi one-segmented; fore wing first vein with few setae (Fig. 22)...............**8**

8   Head without markings within sculptured reticles, except posterior to strong occipital ridge (Fig. 17); abdominal tergites with scalloped antecostal ridge (Fig. 26)..***Helionothrips***

–   Head with markings within sculptured reticles, without occipital ridge (Fig. 18); abdominal tergites with antecostal ridge not scalloped (Fig. 27) ....***Caliothrips***

ANISOPILOTHRIPS **Stannard & Mitri:** Only one species is recognized in this tropical genus. It is closely related to *Elixothrips* and also to *Astrothrips* in having a dense cluster of recurved microtrichia on the second abdominal tergite.

Anisopilothrips venustulus **(Priesner):** Described from, and widespread around, the Caribbean, this species is also recorded from Florida, as well as Taiwan, Japan, Australia and Fiji. Abdominal tergites III–VII each have a conspicuous pair of reticulate areas arranged like a flower or bunch of grapes (Fig. 24). The species is listed from Hawaii without further data in an unpublished, updated list of Hawaiian insects provided by Bernarr Kumashiro, and has been intercepted from Hawaii by quarantine officials in California.

***CALIOTHRIPS* Daniel:** This genus of 22 species is widespread around the tropics, and Nakahara (1991) provided a key to 10 species from the Nearctic region. Leaf-feeding at all stages, but pupating at ground level, a few species are considered crop pests, including of cotton seedlings in parts of Africa (Wilson 1975). The hind coxae of adults have a coiled apodeme internally, and membership of the genus is usually obvious because of the presence of many markings within the sculptured reticles on the head and pronotum. Both species recorded from Hawaii have the lateral areas of the tergites with polygonal reticulation.

Key to species from Hawaiian Islands

1	Fore wing brown with 2 white crossbands (Fig. 22); antennal segments III–IV yellow with brown median area, V brown with base yellow ....***fasciatus***
–	Fore wing white except for brown apex and occasional pale brown area in basal quarter; antennal segments III–V predominantly yellow, with apex pale brown ....***punctipennis***

***Caliothrips fasciatus* (Pergande):** The North American Bean Thrips, this species used to be considered a pest of agricultural crops in western USA (Bailey 1957), but is now considered of limited importance (Hoddle et al. 2006). It has been reported from Hawaii, Lanai, Molokai, and Oahu, as well as Canada, Mexico, Puerto Rico, Argentina, and Brazil, but an old record from China is possibly an error (Mound et al. 2011).

***Caliothrips punctipennis* (Hood):** Little is known about this American grass-living species. It has curiously pale fore wings, and is recorded from Florida, Texas and Mexico, as well as Maui and Oahu.

***ELIXOTHRIPS* Stannard & Mitri:** The only species in this genus bears an array of recurved stout microtrichia anterolaterally on the second abdominal tergite. In this it resembles species of the tropical genera *Astrothrips* and *Anisopilothrips*, but is distinguished by the presence of a pair of capitate setae at the abdominal apex.

***Elixothrips brevisetis* (Bagnall):** Described from the Seychelles, this species has been reported widely from countries bordering the Pacific Ocean, as well as from Hawaii and Oahu. It is a pest of banana fruits in Martinique as well as Hawaii (Muruvanda 1986), but the male of the species remains unknown.

***HELIONOTHRIPS* Bagnall:** A total of 27 species from various tropical countries are currently listed under this genus (ThripsWiki 2015), and a few of these are sometimes reported as minor pests (Wilson 1975). They are characterized by the sculpture of the antecostal ridge on the abdominal tergites that forms a series of prominent scallop-like ridges (Fig. 26).

Helionothrips errans (**Williams**): Described from a greenhouse in Europe, this species is widespread in tropical countries, and is commonly considered a pest of cultivated orchids, including *Cymbidium* species. It has been reported from the Hawaiian Islands only once, from a greenhouse in the Volcano area of Hawaii.

HELIOTHRIPS **Haliday:** Three species are now considered valid in this genus, all from South America (Nakahara et al. 2015). Two of the species have restricted distributions in southern Brazil, but the third is found worldwide.

Heliothrips haemorrhoidalis (**Bouché**): The Greenhouse thrips is a common minor pest, but can be particularly damaging on plants that are growing suboptimally or where fruit hanging in clusters touch each other and provide protected areas for larvae, pupae, and adults to conceal themselves. Mature adults are dark brown with yellow legs, but adults freshly emerged from pupae commonly have the abdomen golden yellow. Attacked plants usually bear distinctive "bleached" areas that result from feeding and small black faecal spots that larvae and adults deposit on leaves. The host-plant range is extensive, but commonly involves plants with hard leaves that lack glandular trichomes (Scott-Brown and Simmonds 2006). Originally from Southwestern Brazil but now cosmopolitan, this thrips is recorded from Hawaii, Kauai, Maui, Midway, Molokai, and Oahu.

HERCINOTHRIPS **Bagnall:** The nine species included in this African genus are unique amongst Panchaetothripinae in having the tarsi two segmented, and the fore wings with both longitudinal veins bearing a complete row of setae. Two of the species are widespread around the world, but a third has recently been recorded as introduced to Portugal, damaging the leaves of succulent plants of the genus *Aloe* (Mateus et al. 2015).

Key to species from Hawaiian Islands

1   Fore wing median pale band longer than the brown cross bands on either side (Fig. 21)..***bicinctus***
–   Fore wing median pale band indistinct or shorter than dark areas on either side ....***femoralis***

Hercinothrips bicinctus **Bagnall:** Widespread throughout subtropical countries, and sometimes common in greenhouses in temperate countries, this species was first collected on the Hawaiian Islands at Pauoa, Oahu, 16.vi.1998, from *Coccinea grandis*. Highly polyphagous, it is often a pest on banana fruits.

Hercinothrips femoralis (**Reuter**): Similarly polyphagous and as widespread around the world as *bicinctus*, this species is reported from Hawaii, Kauai, Maui, and Oahu.

***PARTHENOTHRIPS* Uzel:** Only one species is placed in this genus, and this is easily recognised from the highly distinctive broad reticulate fore wings (Fig. 19). The country of origin of the genus remains in doubt, although amongst Panchaetothripinae only *Arachisothrips* from the Neotropics has such a broad fore wing.

***Parthenothrips dracaenae* (Heeger):** Commonly known as the Parlour Palm thrips, from its worldwide association with the leaves of cultivated *Howea* palms, this species is not commonly taken out of doors. On the Hawaiian Islands it has been taken on the leaves of *Cordyline terminalis* and *Polyscias* sp., and is recorded from Hawaii, Kauai, Maui, and Oahu.

***RHIPIPHOROTHRIPS* Morgan:** This genus comprises three Asian and two African species (Wilson 1975). The head bears rugose, irregular reticulate sculpture, with a distinctive transverse ridge, and a prolongation in front of the eyes (Fig. 25). The fore wings have minute veinal setae, and lack cilia on the costal margin.

***Rhipiphorothrips pulchellus* Morgan:** Distinctively coloured, with the head and sides of the pterothorax brown, but the pronotum, abdomen, antennae and legs yellow, this species was decribed originally from Sri Lanka. It is widely recorded across Asia, from a range of different plant species. In contrast to a very similar Asian species, *cruentatus*, the males do not have a tooth-like tubercle laterally on the fourth abdominal tergite. It has been found on Oahu, in association with *Acalypha wilkesiana*, *Carissa grandiflora*, *Eugenia malaccensis*, *Leucaena leucocephala*, and *Mangifera indica*.

***SELENOTHRIPS* Karny:** Only one species is placed in this genus. It is readily recognised from the reticulate head sharply constricted to a basal neck that lacks reticulation, and the unusually dark fore wings that have two rows of widely spaced black setae (Fig. 20).

***Selenothrips rubrocinctus* (Giard):** Known as the red-banded cacao thrips, because of its brightly coloured larvae and frequent association with cocoa tree foliage, this species is polyphagous. Probably Neotropical in origin, this species is now pantropical, and has been recorded from Hawaii, Kauai, Lanai, Maui, Molokai, and Oahu, on the leaves of a wide range of unrelated plant species.

DENDROTHRIPINAE

Worldwide, there are almost 95 species listed in 12 genera in this subfamily (ThripsWiki 2015). Mostly from the Old World with few listed from the Americas, they seem to be mainly associated with the leaves of trees. Only two genera are recorded from the Hawaiian Islands. All species in this subfamily have a greatly enlarged lyre-shaped metafurca (Fig. 28) that extends to the mesothorax, and is associated with large muscles that facilitate the remarkable jumping ability of these thrips.

Key to genera from Hawaiian Islands

1   Abdominal tergites III–VI with median pair of setae small and wide apart (Fig. 30); pronotum with no long setae; ocellar setae pair III between posterior ocelli ....***Asprothrips***

–   Abdominal tergites III–VI with median pair of setae longer than distance between their bases (Fig. 31); pronotum with 2 pairs of long posteroangular setae; ocellar setae pair III arising anterior to ocellar triangle ......***Leucothrips***

***ASPROTHRIPS* Crawford:** Five species are recognised in this genus, and these are probably all East Asian in origin. In contrast to the single species recorded from Hawaii, the others all have the body dark brown at least in part.

***Asprothrips seminigricornis* (Girault):** This is a minute, white thrips with the terminal antennal segments dark brown. It has been described under three different names, from Australia, New York and Hawaii, the latter name being *Scirtothrips antennatus*. It is highly polyphagous, and in Australia has been found breeding on the young leaves of peach (*Prunus persica*), Tung Tree (*Vernicia fordii*), granadilla (*Passiflora ligularis*), mulberry (*Morus alba*), and also *Citrus* (Mound and Wells 2015). It is also recorded from California, Florida, and Bermuda, as well as Hawaii, Kauai, and Oahu.

***LEUCOTHRIPS* Reuter:** Four of the five known species in this genus are from the New World, one from Guadeloupe, two from South America and one from North and South America. The fifth species, *nigripennis*, is widespread around the world in association with cultivated ferns, and is readily recognized by its uniformly dark fore wings. The genus seems to be the ecological equivalent of the Eurasian genus *Dendrothrips*, living on the leaves of a range of trees and herbs. The species of these two genera share a curious instability in antennal segmentation and form of sense cones. *Leucothrips* species have the fore wing costal cilia arising at the margin, although *Dendrothrips* species have these cilia arise submarginally and ventrally.

Key to species from Hawaiian Islands

1   Antennal segments III and IV with sense cone simple in both sexes; head pale..***piercei***

–   Antennal segments III and IV with sense cone forked in female, simple in male; head with small red spot on anterior margin at base of antennae ....***theobromae***

***Leucothrips piercei* (Morgan):** Described originally from Texas, this species is recorded from Arizona and California, as well as Mexico, Surinam, Brazil and Peru. It is known from Kauai and Oahu, where it is common on leaves of *Xanthium*, and also on beets, bean, carrot, eggplant, lettuce, mustard, parsley, *Hibiscus*, and radish (Zimmerman 1948).

***Leucothrips theobromae* (Priesner):** Described from Surinam, this species seems to be widespread in at least the northern parts of South America, including Panama, Colombia, Ecuador and Peru. On Oahu it has been taken from the leaves of *Ricinus communis*.

SERICOTHRIPINAE

Currently three genera are recognised in this subfamily of 152 species. However, a further 12 generic names are available that have been proposed for individual species with one or more exceptional characteristics (ThripsWiki 2015). The phylogenetic significance of the three genera remains doubtful. One of them, *Hydatothrips*, occurs only in warmer parts of the world, whereas the other two are more widespread.

Key to genera from Hawaiian Islands

1   Metanotal sculpture longitudinal, with no microtrichia (Fig. 34) ....
        ....***Neohydatothrips***
–   Metanotal sculpture transverse, posterior third with rows of microtrichia
        (Fig. 35)...***Sericothrips***

***NEOHYDATOTHRIPS* John:** Worldwide, a total of 103 species is recognised in this genus, and these species occur in both temperate and tropical zones of both hemispheres. Members of this genus are fully winged, and the metasternal anterior margin is transverse with only a small indentation. Many of the species are brightly coloured with various patterns of dark and light on the body and fore wings. There are many microtrichia on the lateral thirds of the tergites, and the fore wing has a complete row of setae on the first vein (Fig. 36) but no setae on the second vein except sometimes near the wing apex. Only two species are known from the Hawaiian Islands, and both are widespread around the world.

Key to species from Hawaiian Islands

1   Fore wing almost uniformly pale or lightly shaded, clavus darker (Fig. 37);
        body mainly yellow; on *Sida* spp...***gracilipes***
–   Fore wing with two dark bands; body mainly dark brown (Fig. 33); on *Tagetes* spp. ....***samayunkur***

***Neohydatothrips gracilipes* (Hood):** Although adults are recorded from various plants, this species seems to breed particularly on small weeds in the genus *Sida*, but

possibly also on other Malvaceae. The legs and body are mainly yellow, but there are small brown markings on the head and thorax, and the tergal antecostal ridges are dark. The male bears a single small pore plate on the seventh sternite. Described from Mexico, this thrips is recorded from Maui and Oahu, and is known from many other areas including Texas, Trinidad, Costa Rica, India and Australia.

***Neohydatothrips samayunkur* (Kudo):** Apparently specific to species of *Tagetes*, this thrips has probably been dispersed by the horticultural trade in marigold plants. Recorded from Hawaii and Oahu, it has been seen from Florida, Mexico, Costa Rica, El Salvador, Brazil, Japan, Australia, Kenya, and Sri Lanka.

***SERICOTHRIPS* Haliday:** Eight species are included in this genus, one of which is from South Africa and the others from the Northern Hemisphere. Unlike the members of the other two genera in this subfamily, the species of *Sericothrips* have a tendency to produce apterous adults.

***Sericothrips staphylinus* Haliday:** This European thrips was introduced to Hawaii as a biological control agent against the knoxious shrubby weed *Ulex europaeus* (Markin et al. 1996), on which it has become established. Adults of both sexes are usually wingless, with macropterous females relatively uncommon.

THRIPINAE

This is the largest of the Terebrantia subfamilies, with nearly 1700 species in 235 genera. The group is represented throughout the world, wherever green plants can grow, and many species are considered to be crop pests. A particularly large number of taxa are specific to Poaceae (Mound 2011b), with smaller numbers associated with Fabaceae and Orchidaceae, but host-plant exploitation by these insects seems to have been largely opportunistic (Mound 2004), with many species in the largest genera (*Thrips* and *Frankliniella*) being polyphagous.

Key to genera from Hawaiian Islands

1	Antennal segments III–IV each with a simple sense cone (Figs 2, 53)	**2**
–	Antennal segments III–IV each with a forked sense cone (Figs 1, 70)	**11**
2	Female tergite X with prominent pair of thorn-like setae (Fig. 80)	***Limothrips***
–	Female tergite X without such stout setae	**3**
3	Antennal segment II strongly asymmetric, external margin produced into a point (Figs 2, 37); pronotum trapezoidal, posterior margin wider than anterior (Fig. 37)	**4**
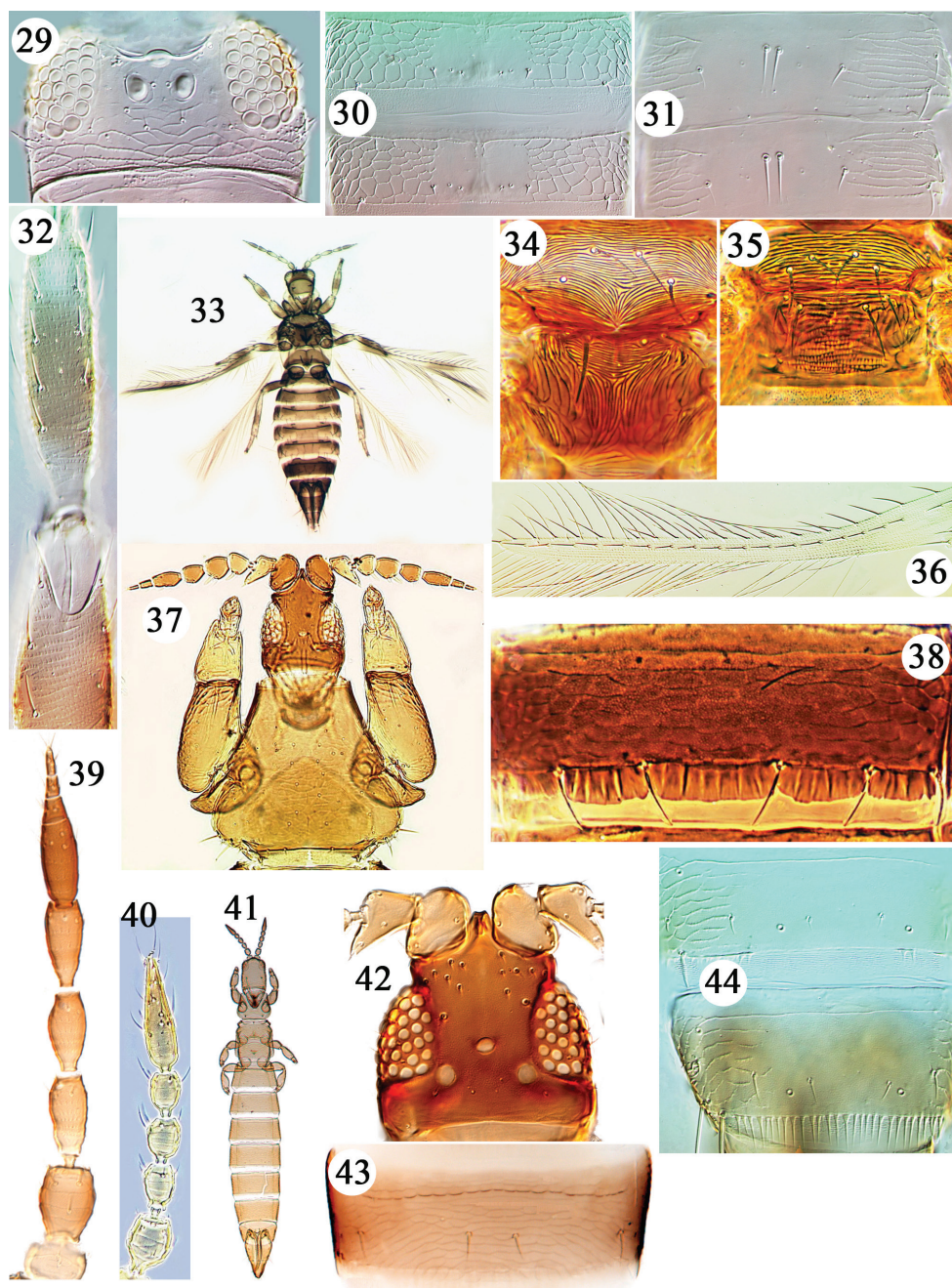
Figures 29–44. Thripidae from Hawaii. *Asprothrips seminigricornis* **29–30**: **29** head **30** tergites III & IV **31** *Leucothrips theobromae*, tergites III & IV. *Neohydatothrips samayunkur* **32–34**: **32** fore tibia **33** female **34** meso & metanotum. **35** *Sericothrips staphylinus* meso & metanotum. **36** *Neohydatothrips gracilipes* fore wing **37** *Arorathrips mexicanus*, head & pronotum **38** *Apterothrips apteris* sternite IV **39** *Anaphothrips obscurus* antenna. *Aptinothrips rufus* **40–41**: **40** antenna **41** female **42** *Arorathrips spiniceps*, head **43** *Arorathrips mexicanus* tergite IV **44** *Anaphothrips swezeyi* tergites VII–VIII.

– Antennal segment II more or less symmetrical, not produced laterally; pronotum transverse (if rarely trapezoidal then with prominent flattened pair of setae at posterior angles: Fig. 78) **5**

4 Mesothoracic sternal furca strongly developed with paired lateral flanges and invaginated medially (Fig. 54); antennal segment I less than 2.5 times as wide as base of segment II .... ***Chirothrips***

– Mesothoracic sternal furca weakly developd, without paired lateral flanges, invaginations widely separated (Fig. 55); antennal segment I more than 2.5 times as wide as base of segment II (Fig. 37) ....***Arorathrips***

5 Head clearly longer than wide but not projecting in front of eyes (Fig. 41); body yellow; antennae 6-segmented (Fig. 40) ....***Aptinothrips***

– Head different; body usually brown; antennae 8- or 9-segmented...............**6**

6 Abdominal tergites VI–VIII with paired ctenidia laterally (Fig. 46)..***Bolacothrips***

– Abdominal tergites without paired ctenidia...**7**

7 Fore wing costa and first vein each with row of long capitate setae (Fig. 63), pronotum with two pairs of similar capitate posteroangular setae; fore wing second vein without setae.. ***Echinothrips***

– Fore wing without such long capitate setae, or wing absent **8**

8 Head prolonged in front of eyes (Fig. 92); fore tibia with fringed spur at inner apex (Fig. 93)... ***Organothrips***

– Head and fore tibia different..**9**

9 Pronotum with no long setae; sternites with deeply lobed craspedum (Fig. 38); dark brown apterous species ....***Apterothrips***

– Pronotal posteroangular setae prominent; sternites without lobed craspeda.....**10**

10 Pronotum with two pairs of long pointed posteroangular setae; tergal median setae small and far apart, craspedum with rounded lobes (Fig. 47) .....***Bregmatothrips***

– Pronotum with one pair of long, flattened posteroangular setae (Fig. 78); tergal median setae long and close together, craspedum with pointed teeth (Fig. 79)..***Kurtomathrips***

11 Lateral thirds of tergites with many irregularly arranged, broadly based, stout microtrichia (Fig. 56); head with prominent postocular ridge............ .... ***Dendrothripoides***

– Tergites and head different **12**

12 Lateral thirds of tergites with closely spaced rows of small microtrichia (Fig. 103)..***Scirtothrips***

– Lateral thirds of tergites without or with few irregular microtrichia **13**

13 Female sternite VII with posteromarginal setae pairs I and II close together medially and distant from lateral pair S III (Fig. 104) ....***Rhamphothrips***

– Female sternite VII with all three pairs of posteromarginal setae equidistant from each other **14**

14 Female with ovipositor weak and lacking serrations or with weak serrations (Fig. 97); male antenna with segment III very small but IV–VI greatly enlarged ....***Plesiothrips***

–   Female with ovipositor bearing conspicuous serrations, extending to apex of
           segment X...**15**
15   Pronotum without prominent posteroangular setae (Fig. 57)....................**16**
–   Pronotum with one or two pairs of prominent posteroangular setae (Figs 65,
           99)..**18**
16   Tergites II–IV with median setal pair long and close together (Fig. 45); tergal
           posterior margin with craspedum; sternites with discal setae and 4–5 pairs of
           posteromarginal setae; male sternite III with glandular opening on antecostal
           region .... *Baileyothrips*
–   Tergal median setae arising further apart from each other than their length;
           tergites without any craspeda; sternites without discal setae, with 3 pairs of
           marginal setae; male with sternal pore plates...**17**
17   Ocellar setae pair I present; antennal segment VI with partial division giving
           apparent 9-segmented condition (Fig. 39), III and IV not prolonged into an
           apical neck..*Anaphothrips*
–   Ocellar setae pair I absent; antennae 8-segmented, III and IV with elongate
           apex and sense cones extending more than one third across succeeding seg-
           ment (Fig. 58) .... *Dichromothrips* [in part]
18   Tergite VIII with paired ctenidia anterolateral to spiracle (Figs 71, 76).....**19**
–   Tergite VIII *either* without ctenidia *or* with paired ctenidia posteromesad of
           spiracle (Fig. 15) **20**
19   Pronotum posterior margin with one pair of small setae between the major
           median posteromarginal setae (Fig. 65); tergites V–VI with well-developed
           pairs of ctenidia laterally; ocellar setae pair III arising between or in front of
           posterior ocelli .... *Frankliniella*
–   Pronotum posterior margin without pair of small setae between major me-
           dian pair of posteromarginal setae (Fig. 99); tergites V–VI without well-de-
           veloped ctenidia laterally; ocellar setae pair III arising on tangent between
           posterior margins of posterior ocelli ....*Pseudanaphothrips*
20   Tergites V–VII with paired ctenidia (Fig. 15); head without pair of setae in
           front of first ocellus (Fig. 111) **21**
–   Tergites V–VII without any ctenidia; head usually with pair of setae in front
           of first ocellus (Fig. 85) **23**
21   Prosternum with several pairs of setae (Fig. 81); tergites with toothed craspe-
           dum (Fig. 82) ....*Microcephalothrips*
–   Prosternum without setae; tergites without prominent craspedal teeth......**22**
22   Ocellar setae pair II longer than pair III (Fig. 131) ....*Stenchaetothrips*
–   Ocellar setae pair II shorter than or equal to pair III (Fig. 111)...........*Thrips*
23   Pronotum with 6 pairs of very long setae (Fig. 105)...................*Scolothrips*
–   Pronotum with no more than three pairs of long setae..............................**24**
24   Antennal segment VIII spindle-shaped, almost 4 times as long as VII (Fig.
           110); pronotum with 3 pairs of long posteroangular setae......*Projectothrips*

–   Antennal segment VIII shorter (Figs 88-91); no more than 2 pairs of pronotal posteroangular setae..**25**

25   Fore wing first and second longitudinal veins both with complete row of setae...***Neurisothrips***

–   Fore wing veins with incomplete setal rows...**26**

26   Tergite VIII with area of specialised sculpture extending anteromesad from spiracles (Fig. 48)..***Chaetanaphothrips***

–   Tergite VIII without such specialised sculpture around spiracles..............**27**

27   Head with ocellar setae pair I present..**28**

–   Head lacking ocellar setae pair I in front of first ocellus (Figs 106–107)....**30**

28   Antenna with 9 segments (Fig. 109) .... ***Psydrothrips***

–   Antenna with 8 segments (Fig. 98) **29**

29   Mesonotum with median setal pair arising in front of posterior margin (Fig. 108); ocellar setae pair III arise anterolateral to ocellar triangle; antennal III largely yellow .... ***Tenothrips***

–   Mesonotal median setal pair arising at posterior margin (Fig. 94); ocellar setae pair III arise within ocellar triangle; antennal segment III brown with constricted apical third white (Fig. 95) ....***Pezothrips***

30   Tergite VIII with no posteromarginal comb **31**

–   Tergite VIII with complete posteromarginal comb of microtrichia (Fig. 61)...**32**

31   Fore wing second vein with few, widely spaced setae; tergite IX of female with campaniform sensilla; male without sternal pore plates, and tergite IX without drepanae.. ***Danothrips***

–   Fore wing second vein with complete setal row; tergite IX of female without campaniform sensilla; male with sternal pore plates and tergite IX with pair of drepanae .... ***Trichromothrips***

32   Metathoracic furcal spinula present but weak in *corbetti* (Figs 59–60); on Orchidaceae.. ***Dichromothrips***

–   Metathoracic furca with no spinula...**33**

33   Head prolonged in front of compound eyes (Fig. 106); fore wing second vein with 4 or 5 widely spaced setae ....***Sciothrips***

–   Head not prolonged in front of eyes (Fig. 107); fore wing second vein setal row continuous... ***Taeniothrips***

***ANAPHOTHRIPS* Uzel:** More than 80 species are listed in this genus. In the northern hemisphere many of the species are associated with Poaceae (Nakahara 1995), but in Australia members of this genus are known to breed on plants in a wide range of other families (Mound and Masumoto 2009). Adults have no long setae on the pronotum, and males in many species have C-shaped sternal pore plates. Both of the species recorded from the Hawaiian Islands have a partial suture across antennal segment VI (Fig. 39), thus producing a 9-segmented condition that is unusual amongst Thripinae.

Key to species from Hawaiian Islands

1   Abdominal tergites with many sculpture lines across median area; tergite IX major setal pairs S1 and S2 not extending beyond apex of segment X. ..... ***obscurus***
–   Abdominal tergites with no lines of sculpture on median area; tergite IX major setal pairs S1 and S2 extending beyond apex of segment X .... ***swezeyi***

Anaphothrips obscurus **(Müller):** Widely distributed throughout the temperate areas of the world on various Poaceae, this yellow thrips is sometimes a minor pest of cereal crops, and has been taken on Maui and Oahu. The male is known only from Iran (Mirab-Balou and Chen 2010), the worldwide populations comprising only females.

Anaphothrips swezeyi **Moulton:** Although this small yellow species was described originally from sugar cane in the Hawaiian Islands, there is no evidence that this is where it originated. It has been recorded from Hawaii, Kauai, Lanai, Molokai and Oahu, but was taken commonly on New Caledonia, and also along the coastal region of eastern Australia from where the male was first described (Mound and Masumoto 2009).

APTEROTHRIPS **Bagnall:** Only two species are placed in this genus, and Nakahara (1988) provided details of how to distinguish them. They are both dark brown, wingless species, with the antennae 9-segmented due to an incomplete suture across segment VI, and the sternites bear a lobed craspedum on the posterior margin (Fig. 38).

Apterothrips apteris **(Daniel):** Described from California, this species is found southwards along the west of South America, being recorded from Mexico, Panama, Ecuador, Chile, Peru and southern Argentina, and then across the Southern Ocean to New Zealand and Australia. In Hawaii it was originally misidentified and recorded as *secticornis*, a species that occurs northwards from California and in northern Europe. In coastal California, *apteris* breeds on *Erigeron*, but in Western Australia and New Zealand it has caused damage to alfalfa, and in Tasmania it has been found on garlic plants (Mound and Wells 2015).

APTINOTHRIPS **Haliday:** Four species are recognised in this genus, all wingless (Fig. 41) and living on grass leaves, and all were originally native to northern Europe. Two species are now widely distributed around the world, and *rufus* is probably one of the most common insects worldwide.

Aptinothrips rufus **(Haliday):** The form of the 6-segmented antennae, with the large terminal segment, is distinctive in this species (Fig. 40). Living on the leaves of various Poaceae, it is recorded from Hawaii, Maui and Oahu, and occurs in temperate climate zones around the world, including highland areas in tropical countries such as Kenya and Costa Rica.

ARORATHRIPS **Bhatti:** This genus comprises 16 species and was erected for a series of species originally placed in the genus *Chirothrips*. As with the members of that genus, all of the species breed in the flowers of Poaceae. Nakahara and Foottit (2012) provided an account of *Arorathrips* species, all of which are from the Americas, although *mexicanus* is widespread around the tropics.

Key to species from Hawaiian Islands

1   Outer margin of fore tibia prolonged around base of second tarsal segment (Fig. 37); abdominal tergites and sternites with tuberculate scallops on anterior margin (Fig. 43)...*mexicanus*
–   Outer margin of fore tibia not prolonged; tergites and sternites without tuberculate scallops. **2**
2   Head with at least 30 small setae; prosternal basantra with setae; abdominal sternites with median 2 pairs of posteromarginal setae arising on posterior margin ....*fulvus*
–   Head with 10–22 small setae (Fig. 42); basantra without setae; abdominal sternites with median 2 pairs of setae arising in front of posterior margin .....
        ....*spiniceps*

Arorathrips fulvus **(Moulton):** Described originally from Oahu, with one synonym from Brazil, this species is recorded from Texas, Tennessee, Argentina, and Uruguay, as well as Hawaii and Kauai. Yellowish-brown, it sometimes has the abdomen paler than the thorax, and is unusual in having many small setae on the prosternal basantra. It is possibly associated with species of *Paspalum*.

Arorathrips mexicanus **(Crawford):** In addition to the original description based on specimens from Mexico, this species has been described under three other names, from Florida, Louisiana and Argentina. It is widespread in the Americas, and known from South Africa, Thailand, Philippines, Australia and New Caledonia, as well as Hawaii, Kauai, Lanai, Maui, Midway and Oahu. It is one of the most common thrips on grasses in many tropical areas, and is reported from various species of tropical Poaceae, including sugar cane.

Arorathrips spiniceps **(Hood):** Described from Arizona, with one synonym from Hawaii, this species is widespread across the USA, and is recorded from Mexico, Guatemala, Cuba, Costa Rica, Dominica, Bermuda, Argentina, Papua, Solomon Islands and Australia, as well as Kauai and Oahu. It is recorded from various species of Poaceae, including sugar cane.

BAILEYOTHRIPS **Kono & O'Neill:** Only two species are recognized in this genus, although doubt has been expressed that these are distinct species (Mound and Marullo

1996). These thrips originated, presumably, from southern USA or the Carribean region. Originally described as species of *Anaphothrips*, due to the lack of long pronotal posteroangular setae, they differ from that genus in having tergites with a posteromarginal craspedum that is toothed laterally, and the sternites with discal setae.

Key to species from Hawaiian Islands

1   Abdominal tergites laterally with many discal microtrichia (Fig. 45); pronotum without brown spots; antennal segments IV–V grayish brown with bases pale, VI brown..***arizonensis***
–   Abdominal tergites with few discal microtrichia except on anterior tergites; pronotum with light brown spots in submarginal row on each side, antennal segments IV–V pale in basal half, base of VI occasionally pale ....***limbatus***

***Baileyothrips arizonensis* (Morgan):** Described from Arizona with one synonym from California, this species is recorded from Texas and Florida as well as Oahu. Reported from various plants, it appears to be associated species of *Euphorbia*, although Bailey (1940) indicated that it was a minor pest of cotton.

***Baileyothrips limbatus* (Hood):** As indicated above, this species is very similar to *arizonensis*, and is also associated with *Euphorbia* species. Described from Panama, it is recorded from Costa Rica, Guatemala, Jamaica, Trinidad and Florida, as well as Maui.

***BOLACOTHRIPS* Uzel:** Twelve species are listed in this genus, and with one exception, all of them are from tropical and subtropical countries living on Poaceae. It is closely related to the genus *Thrips*, in lacking ocellar setae pair I and in having tergal ctenidia with those on VIII posteromesad of the spiracles (Fig. 46). However, the sense cones on antennal segments III and IV are simple, not forked (Mound 2011b).

***Bolacothrips striatopennatus* (Schmutz):** Described from Sri Lanka, and known on grasses from India to Japan and Taiwan, also Guam, northern Australia, Florida, Georgia and Kauai.

***BREGMATOTHRIPS* Hood:** The nine species currently recognized in this genus are from various warm temperate to subtropical parts of the world, all living on Poaceae, with *venustus* widely distributed. The females have a narrow pale, weakly scalloped, craspedum on the posterior margin of the tergites (Fig. 47) and they all have two dorso-apical setae on the first antennal segment, except *venustus* that has a single such seta An identification key to the species was provided by Mound (2011b).

***Bregmatothrips venustus* Hood:** This species was recorded from Oahu under the synonymic name *sonorensis* Stannard (see Bhatti 1984). It is recorded from various grasses,
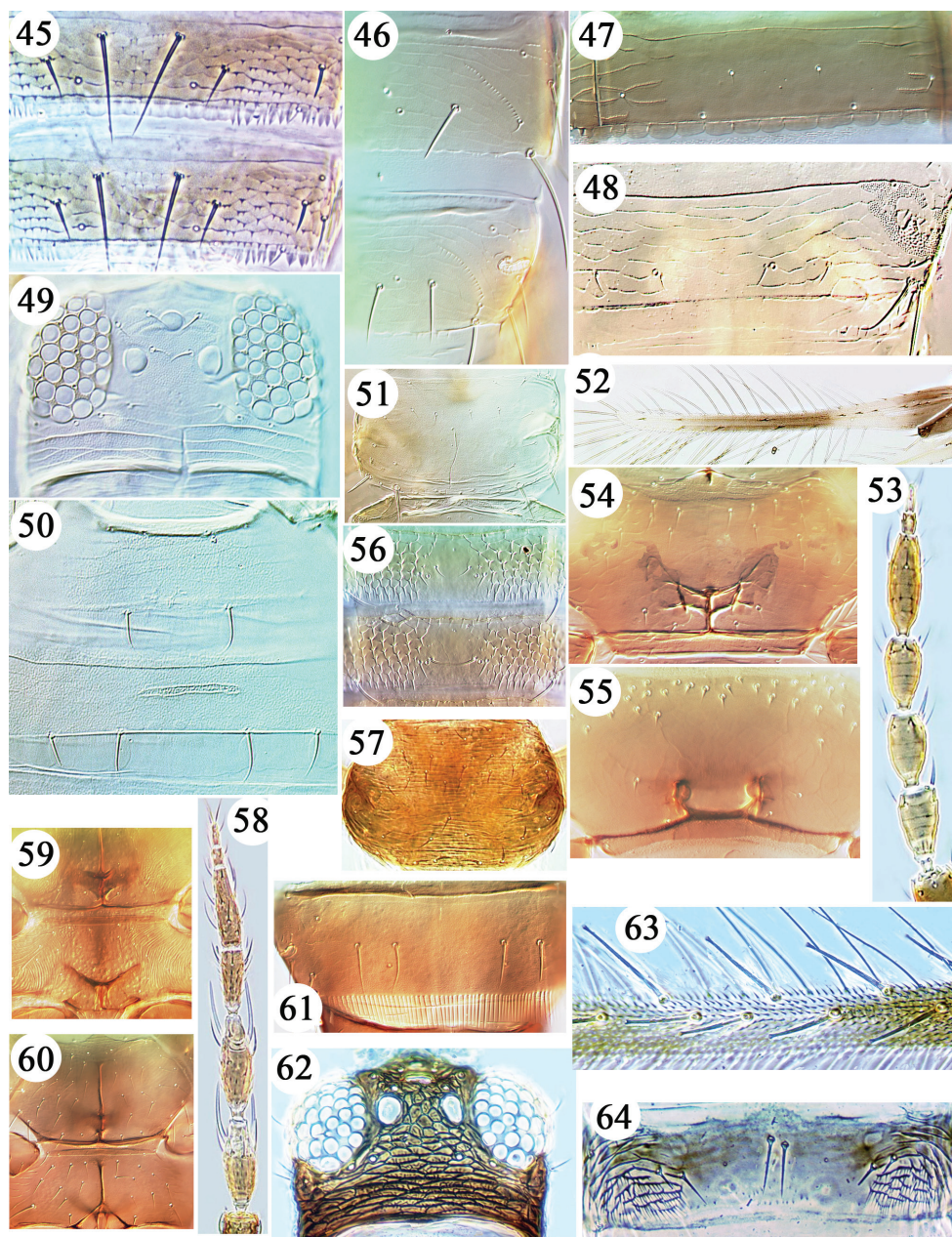
Figures 45–64. Thripinae from Hawaii. **45** *Baileyothrips arizonensis* tergites IV & V. **46** *Bolacothrips striatopterus* tergites VII & VIII. **47** *Bregmatothrips venustus* tergite IV. **48** *Chaetanaphothrips leeuweni* tergite VIII. *Ch. signipennis* **49–50**: **49** head **50** sternites II & III. *Ch.orchidii* **51–52**: **51** pronotum **52** fore wing **53** *Limothrips cerealium* antenna. Metathoracic furca **54–55**: **54** *Chirothrips manicatus* **55** *Arorathrips mexicanus* **56** *Dendrothripoides innoxius* tergites. *Dichromothrips corbetti* **57–59**: **57** pronotum **58** antenna **59** meso & metathoracic furcae. *D. smithi* **60–61**: **60** meso & metathoracic furcae **61** tergite VIII. *Echinothrips americanus* **62–64**: **62** head **63** fore wing setae **64** tergite IV.

including *Echinochloa crus-galli*, and is widespread across southern USA to Mexico and Panama. Winged females are brown in colour, but the short-winged females and males are bicoloured with most of the thorax yellow.

CHAETANAPHOTHRIPS **Priesner:** This is a Southeast Asian genus of 20 species, of which three species are widespread around the world, mainly in the tropics but sometimes in greenhouses in temperate areas. All the species are yellow, with a characteristic area of stippled cuticle extending anteromesad from the two spiracles on tergite VIII (Fig. 48), and the males, where known, have a pair of large, stout setae on tergite IX that arise from a common tubercle.

Key to species from Hawaiian Islands

1　　　Head with 3 pairs of ocellar setae, ocellar setae pair I present anterolateral to first ocellus (Fig. 49); female with sternite II lacking discal setae, and sternite III with a small pore plate (Fig. 50) ....***signipennis***
–　　　Head with 2 pairs of ocellar setae, ocellar setae pair I absent; sternite II of female with 1–3 discal setae, sternite III without a pore plate **2**
2　　　Pronotum with 2 pairs of posteroangular setae, outer pair shorter than inner pair; fore wing with median brown band long, occupying at least half of wing length (Fig. 52).. ***orchidii***
–　　　Pronotum with 1 pair of short posteroangular setae; fore wing with median brown band short, 1–3 times as long as width of wing....................***leeuweni***

Chaetanaphothrips leeuweni **(Karny):** This appears to be the least common of the three widespread pest species. It is recorded widely in the Caribbean islands, also Florida, and on several Pacific islands including Oahu.

Chaetanaphothrips orchidii **(Moulton):** This species is a polyphagous leaf feeder in moist environments and is an occasional pest of *Anthurium*, orchids, and *Asystasia* in Hawaii. It induces and feeds within rolled leaves (Mound and Wells 2015), young terminals, flower buds and under basal leaf sheaths of petioles, causing scarring and malformation of leaves and flowers, and feeding may also retard plant growth (Sakimura 1975). Sometimes reported as a pest of banana fruits, orchid flowers, and ornamental plants in greenhouses, this is one of three thrips species causing ringspots on oranges and grapefruits in Florida (Childers and Frantz 1994). Reported from Hawaii, Kauai, Maui, and Oahu, it is widespread around the world.

Chaetanaphothrips signipennis **(Bagnall):** Known as the banana rust thrips, this species is known as a pest of bananas in Oriental, Australian, and Central American regions, and causes white streaks in Hawaii on Ti leaves, *Cordyline terminalis* (Sakimura 1975). Recorded from Hawaii and Oahu, it is known from many tropical and sub-

tropical countries, including Florida. It is unusual within this genus in the presence of ocellar setae pair I, and also the presence of a pore plate on the third sternite in females.

***CHIROTHRIPS* Haliday:** There are 42 species currently listed in this genus, mostly from temperate parts of the world. As with the species of *Arorathrips*, these thrips breed within the florets of Poaceae, usually with only one larva in each floret (Nakahara and Foottit 2012). Moreover, they pupate within the glumes, and many species are thus distributed in commercial grass seed. They have a characteristic body form, with the pronotum trapezoidal, the head rather small, the fore legs rather stout, and the antennae short with the second segment asymmetric.

Key to species from Hawaiian Islands

[* doubtful record]

1   Antennal segment II strongly produced laterally with margin concave (Fig. 2); sternites with craspedum bearing rounded teeth ....***manicatus*** *
–   Antennal segment II asymmetric, angulate laterally with margin almost straight; sternites with craspedum bearing conical teeth ....***patruelis***

***Chirothrips manicatus* (Haliday):** No specimens of this species have been seen from the Hawaiian Islands, despite the record in Nishida et al. (1992). It is included here primarily because it is one of the most common Thysanoptera species in the northern temperate zone, and is likely to occur in Hawaii. A European insect, it is also known from southern Australia and New Zealand. The species breeds in the flowers of grasses, the larvae having reduced legs and unable to move from one floret to another. It is recorded as a pest of cereal crops (Lewis 1973) but breeds in many Poaceae.

***Chirothrips patruelis* Hood:** Described originally from New York, this species is widespread from Canada to New Mexico and Arizona, but is also recorded from Peru and Hawaii. It is similar in structure to *manicatus*, and presumably has similar relationships to grass flowers.

***DANOTHRIPS* Bhatti:** Nine species are listed in this Southeast Asian genus. It is presumably related to *Chaetanaphothrips*, the male having a pair of spine-like setae medially on tergite IX, but the tergites and sternites lack craspeda, and there is no comb on tergite VIII.

***Danothrips trifasciatus* Sakmura:** Adults of this small yellow species with banded fore wings have been collected from a wide range of unrelated plants. It has been reported as causing leaf damage to *Anthurium*, also ringspot damage on grapefruits and oranges (Sakimura 1975). Described originally from Hawaii but presumably South-

east Asian in origin, it is known from Hawaii, Kauai, Maui and Oahu, is widely distributed among Caribbean islands and into Florida, but also known from Sumatra and Northeastern Australia.

***DENDROTHRIPOIDES* Bagnall:** Of the five species in this genus, one is known from Zambia, two from the Philippines and the other two from Southeast Asia. The genus is highly recognizable, because of the large, broadly based microtrichia on the tergites (Fig. 56), and the transverse ridge across the head.

***Dendrothripoides innoxius* (Karny):** One of the synonyms of this species is *ipomoeae*, a name that recognises that this thrips is often a pest on the leaves of *Ipomoea batatas*, the sweet potato. However, it has been found on several other plants, and possibly in association with leaf damage to lettuce (Zimmerman 1948). Recorded from Hawaii, Kauai, and Oahu, this species is widespread in Southeast Asia and across the Pacific from Australia to Panama, but is also recorded from Florida and Brazil.

***DICHROMOTHRIPS* Priesner:** This genus includes 18 species from the Old World between Africa, Asia and Australia, and two of these are known from the Hawaiian Islands. Two further species, *semicognitus* and *phalaenopsidis*, were described by Sakimura (1955) from specimens taken in quarantine at Honolulu imported from the Philippines, and listed from Oahu in Nishida et al. (1992). But there is no record of either species living on the Hawaiian Islands. The members of this genus presumably all breed only on Orchidaceae, on which they sometimes cause economic damage, including *smithi* that is a pest on commercial Vanilla crops in India. As in *Taeniothrips* species, the 8-segmented antennae tend to have segments III and IV with the apex slender (Fig. 58), tergite VIII has a well developed regular comb of long microtrichia (Fig. 61), the tergites lack ctenidia, and there are no sternal discal setae. Males of species in *Dichromothrips* have prominent, paired pore plates on some sternites.

Key to species from Hawaiian Islands

1	Fore wing banded, subapical area pale in contrast to dark apex and median area ....***dendrobii***
–	Fore wing uniformly brown with base pale **2**
2	Pronotum with no long posteroangular setae (Fig. 57).....................***corbetti***
–	Pronotum with 1 pair of posteroangular setae more than twice as long as other posteromarginal setae..***smithi***

***Dichromothrips corbetti* (Priesner):** Described from Malaysia, but widely reported around the world, particularly as damaging cultivated *Vanda* orchids, this species has characteristic transverse sculpture lines on the metanotum, and unlike other species

in the genus lacks any long pronotal setae (Fig. 57). Common in Southeast Asia, and reported in greenhouses from Australia, it is known from Hawaii, Kauai, Maui and Oahu, as well as in orchid houses across the northern hemisphere.

***Dichromothrips dendrobii* Sakimura:** Despite the presence of long pronotal posteroangular setae, this species is similar in structure to *corbetti*, and is distinguished particularly by the banded fore wings. Presumably from the Philippines, it is reported from Oahu as damaging the leaves and flower buds of *Dendrobium superbum*.

***Dichromothrips smithi* (Zimmermann):** This species has been taken several times by quarantine in California on orchids imported from Hawaii. It is also listed in an unpublished, updated list of Hawaiian insects prepared by Bernarr Kumashiro. Presumably established on the Hawaiian Islands, this thrips is known as a pest of Vanilla crops in India, and is recorded from Malaysia, Solomon Islands, Taiwan, and Japan.

***ECHINOTHRIPS* Moulton:** A genus of seven species from various parts of North and South America, these thrips are dark brown, with the head and pronotum reticulate (Fig. 62), a row of long capitate setae on the fore wing first vein (Fig. 63) but with no setae on the second vein, tergal median setae close together (Fig. 64), tergite VIII with a complete comb, and the males with multiple small sternal pore plates (Mound and Marullo 1996). One species has become widespread around the world.

***Echinothrips americanus* Morgan:** Originally from the Eastern United States, this species is recorded from Hawaii and Oahu, and is now widespread as a greenhouse pest across the northern hemisphere (Vierbergen et al. 2006). It has also been found in Indonesia and Northern Australia (Mound et al. 2013). Originally associated with *Impatiens* species, in greenhouses it has been regarded as a pest of *Capsicum* as well as of ornamental plants.

***FRANKLINIELLA* Karny:** This is one of the largest genera of Thysanoptera, with over 230 species, mostly from the Americas, but with a particularly large number of species from the Neotropics (Mound and Marullo 1996; Cavalleri and Mound 2012). Most of these species are flower-living, but a few live only on Poaceae, and several species are pests and tospovirus vectors. All of the species bear paired ctenidia on the posterior abdominal tergites, and on tergite VIII the ctenidia are anterolateral to the spiracles (Figs 71, 76). Ocellar setae pair I are present on the head in front of the first ocellus (Fig. 67), and the fore wings bear two continuous rows of setae. The pronotum usually bears four pairs of long setae, and there is a small pair of median setae between the major pair of median posteromarginal setae (Fig. 65). Males have pore plates on the sternites, and females of a very few species have pore plates on the second abdominal sternite.
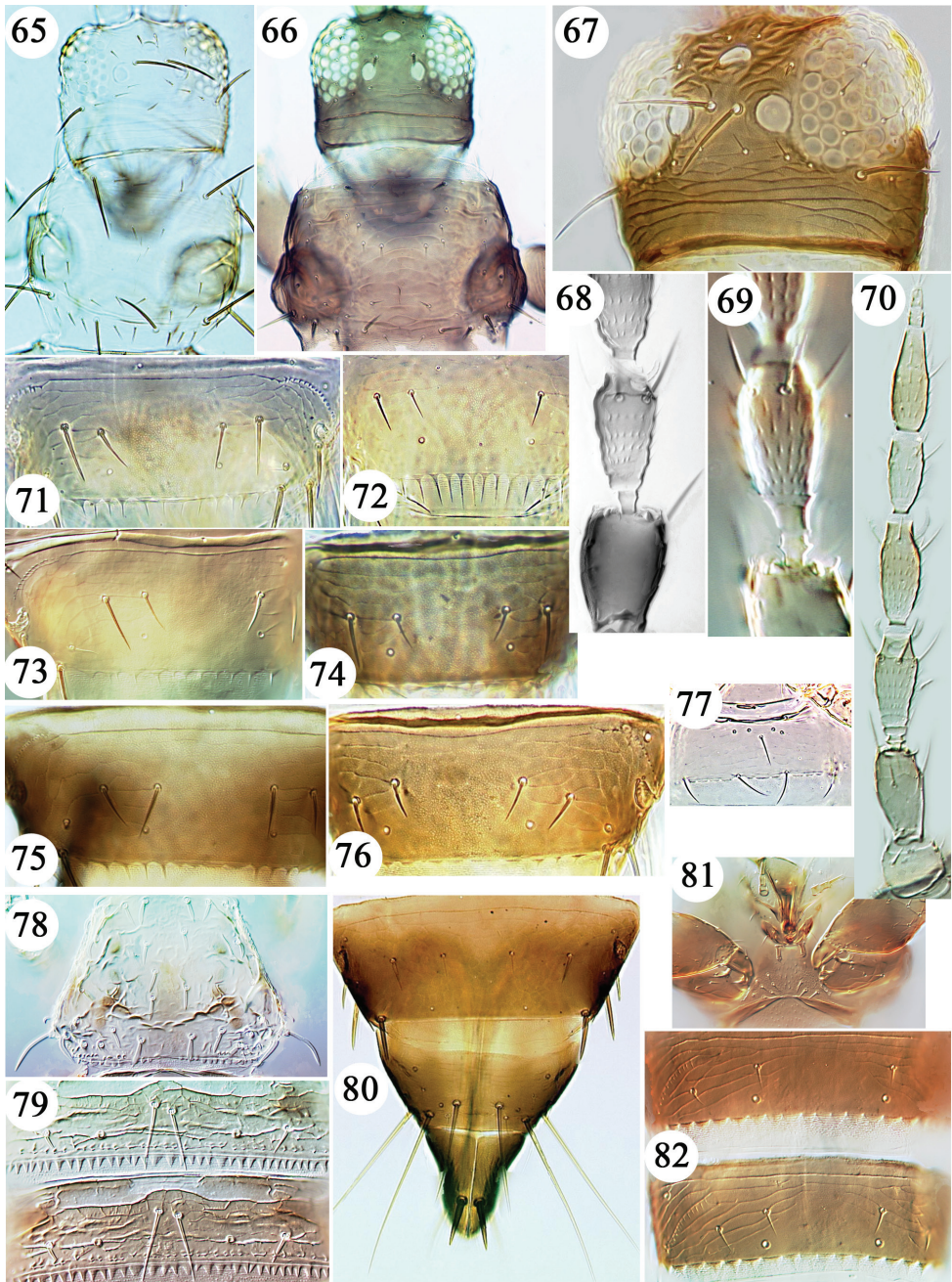
Figures 65–82. Thripinae from Hawaii. **65** *Frankliniella occidentalis* head & pronotum. **66** *Fr. minuta* head & pronotum **67** *Fr. schultzei* head. Antennal segment III *Frankliniella* species **68–69**: **68** *fusca* **69** *cephalica* **70** *Fr. invasor* antenna. Tergite VIII *Frankliniella* species **71–76**: **71** *occidentalis* **72** *williamsi* **73** *crotalariae* **74** *hemerocallis* **75** *insularis* **76** *schultzei* **77** *Fr. williamsi* sternite II. *Kurtomathrips morrilli* **78–79**: **78** pronotum **79** tergites IV–V **80** *Limothrips cerealium* tergites VIII–X. *Microcephalothrips abdominalis* **81–82**: **81** prosternum **82** tergites IV & V.

Key to species from Hawaiian Islands

1   Tergite VIII posterior margin with no comb, or comb represented only by 2–3 teeth laterally (Fig. 76)..**2**

–   Tergite VIII posterior margin with comb of long microtrichia, or of short microtrichia with broad triangular bases (Figs 72, 73), complete across entire margin or with small median gap equivalent to 2 or 3 missing microtrichia (Fig. 75)..**5**

2   Ocellar setae pair III arising within ocellar triangle (Fig. 67)......................**3**

–   Ocellar setae pair III arising outside or on anterior margins of ocellar triangle (Figs 65, 66) **4**

3   Head not produced in front of eyes; ocellar setae pair III arising between posterior ocelli, or on tangent between anterior margins of posterior ocelli (Fig. 67); tergite VIII posterior margin usually with no microtrichia (Fig. 76)..***schultzei***

–   Head slightly produced in front of eyes; ocellar setae pair III arising in front of tangent between anterior margins of posterior ocelli; tergite VIII posterior margin with a few microtrichia laterally ....***bondari***

4   Pedicel of antennal segment III with sharp-edged ring, distal to which is a chalice-like collar (Fig. 69); tergite VIII posterior margin with a few small microtrichia laterally ....***cephalica***

–   Pedicel of antennal segment III with margins parallel to softly rounded (Fig. 68); tergite VIII posterior margin with several broadly based scallops; sometimes micropterous ....***fusca***

5   Ocellar setae pair III no longer than diameter of an ocellus, arising on outer margin of ocellar triangle (Fig. 66); pronotal anteromarginal setae short, no longer than width of antennal segment II; tergite VIII with posteromarginal comb teeth as long as S1 setae on tergite VI.....................................***minuta***

–   Ocellar setae pair III more than 2.0 times as long as diameter of an ocellus; pronotal anteromarginal setae longer than width of antennal segment II; comb on VIII with teeth variable, but never as long as S1 setae on tergite VI **6**

6   Pedicel of antennal segment III with sharp-edged ring (Fig. 70); comb on tergite VIII with widely spaced teeth..***invasor***

–   Pedicel of antennal segment III with margins parallel to softly rounded; comb on tergite VIII variously constructed..**7**

7   Fore wing brown with base sharply paler **8**

–   Fore wing uniformly pale or weakly shaded **9**

8   Metanotum with pair of campaniform sensilla present; tergite VIII comb teeth longer than their basal width, commonly with one or two absent medially (Fig. 75) ....***insularis***

–   Metanotum with no campaniform sensilla; tergite VIII comb teeth shorter than their basal width, often irregular or bifurcate, and present across entire margin (Fig. 74) ....***hemerocallis***

9   Body yellow with brown markings medially on tergites, or body brown ....
         ....*occidentalis*
–   Body yellow, with no obvious darker markings...**10**
10   Sternite II usually with 1–3 discal setae medially (Fig. 77); tergite VIII
         comb with long regular teeth (Fig. 72); living on Poaceae leaves, particularly
         Zea mays ....*williamsi*
–   Sternite II with no discal setae medially; tergite VIII comb with short irregu-
         lar teeth (Fig. 73); living in flowers of *Crotalaria* species ....*crotalariae*

***Frankliniella bondari* Hood:** Described from Brazil, and recorded from Cuba, Mex-
ico, Florida and Georgia, this small yellow species was first taken on Molokai in 1990.
It is now known from Hawaii, Molokai and Oahu, but although adults have been
taken from *Polyanthus* flowers there is no information available on the range of plants
on which it might breed.

***Frankliniella cephalica* (Crawford):** This is one of the most common thrips in a
wide range of flowers, particularly white flowers, in countries around the Caribbean,
including Florida and Texas. It has been taken on Maui and Oahu, and is one of only
two species from Hawaiian Islands with a sharp-edged disc on the pedicel of the third
antennal segment. In contrast to *invasor*, tergite VIII posterior margin has only a few
microtrichia and these are placed near the lateral margins.

***Frankliniella crotalariae* Mound & Marullo:** Previously known only from Costa Rica,
this species is easily misidentified with *occidentalis*, but the abdomen is clear yellow, and
the comb on tergite VIII is shorter and more irregular (Fig. 73). It has been taken in the
flowers of *Crotalaria* species on Hawaii, and one sample collected by R.G. Hollingsworth
at Pahala in August 2015 included both sexes and large numbers of larvae.

***Frankliniella fusca* (Hinds):** Widespread from Canada to the Caribbean, including
Mexico, Puerto Rico and Martinique and also introduced to The Netherlands, the
tobacco thrips is a major pest in Georgia and Florida. It is polyphagous, and is a major
vector of tospoviruses, causing problems on peanut and cotton crops. It is reported
from Hawaii, but with no indication of being a pest locally. Adults of both sexes can
be either fully winged (macropterous) or have wings shorter than the thorax width
(micropterous).

***Frankliniella hemerocallis* Crawford:** The day-lily thrips appears to be monophagous
on *Hemerocallis* leaves and flowers. Described originally from Wisconsin, it is wide-
spread on its host in North America. It is also recorded from Bermuda, Costa Rica,
Japan, and Hungary, as well as Oahu, but the country of origin is not clear. It is a large
dark brown species with bicoloured fore wings.

***Frankliniella insularis* (Franklin):** One of the most common thrips species of Central and South America, but also found in southern areas of USA, this species has been taken on Hawaii. Another large dark species, with bicoloured fore wings, it is commonly found between the petals of *Malvaviscus* flowers. However, it appears to breed particularly in the flowers of various cultivated Fabaceae, including *Cajanus* and *Pachyrhizus*, on which it can be a minor pest.

***Frankliniella invasor* Sakimura:** Although common in Hawaii, from where it was described originally, this species was presumably introduced from the Caribbean region. It is recorded from Hawaii, Kauai, Lanai, Maui, Molokai and Oahu, but is also known from Trinidad, St Vincent and Puerto Rico as well as Panama, Costa Rica, Guatemala and Mexico. It has been collected in the flowers of various plants, including *Gardenia*, *Leucaena*, and *Mangifera*. There are other closely similar yellow species with an angulate pedicel on the third antennal segment in flowers in the Caribbean region (Mound and Marullo 1996).

***Frankliniella minuta* (Moulton):** Described from California originally, this species is widespread in the Western USA southwards through Central America to Peru, and also recorded from Lanai, Oahu and Midway Island. A polyphagous species, it is one of a group of *Frankliniella* species in which the setae on the head and pronotum are particularly short (Fig. 66), and in which species are usually found in the flowers of Asteraceae (Sakimura and O'Neill 1979).

***Frankliniella occidentalis* (Pergande):** Western flower thrips is one of the most important pest insects around the world, and has been found on Hawaii, Kauai, Lanai, Maui and Oahu. Originally from the western USA, it is now found worldwide, and is the most important vector of the thrips-borne Tospovirus diseases (Riley et al. 2011). It is highly polyphagous, but at times it is a useful beneficial when it feeds on populations of leaf mites (Agrawal et al. 1999). The body colour is variable, being dark brown in cooler areas, but more commonly yellowish with brown markings on the tergites. Molecular data now indicates that this species may be a complex of non-interbreeding, genetically distinct, races that cannot be distinguished morphologically (Rugman-Jones et al. 2010)

***Frankliniella schultzei* (Trybom):** The country of origin of this species, the tomato thrips, is not clear. It occurs as both a yellow and a brown form, and both forms are found worldwide. The extent of genetic variation and its significance among populations of *schultzei* remains to be studied effectively, and the colour forms possibly represent two or more different species. It has been claimed that only the brown form is a tospovirus vector, but populations of yellow individuals are important as virus vectors on vegetable crops in Northeastern Australia. The species is found particularly in the tropics and subtropics, and has been recorded from Hawaii, Kauai, Lanai, Niihau and Oahu. It is usually easily recognised because of the position of ocellar setae pair III, and the absence of a comb on tergite VIII.

Frankliniella williamsi **Hood:** This species lives on various Poaceae, and is particularly associated with the leaves of *Zea mays*. Seedlings of field corn can be stunted or killed by this thrips, and seed production reduced by 20–40% (Mau and Gusukuma-Minoto 1999). It is also implicated in the mechanical transmission of maize chlorotic mottle virus of corn in Kauai and some states in mainland USA (Jiang et al. 1992). It is a large, clear yellow species, and is most easily recognised by the presence of discal setae on the second abdominal sternite.

KURTOMATHRIPS **Moulton:** Four species are listed in this genus (Borbon 2005), all from the Americas. Adults are usually wingless, with the body strongly sculptured, the head smaller than the trapezoidal pronotum, the antennae 8-segmented with no sense cone on segment III and one simple one on IV, and males with a transverse pore plate on sternites III–VII.

Kurtomathrips morrilli **Moulton:** Body mainly yellow, with small brown markings, the pronotal posteroangular setae of this species are long and flattened (Fig. 78). It is widespread in Southwestern USA, but also found in Mexico and Jamaica, as well as Kauai, Maui and Oahu. Bailey (1957) reported it as damaging cotton and chrysanthemums in Arizona and California.

LIMOTHRIPS **Haliday:** Although eight species are listed in this European genus, three of these are known only from old descriptions from which they cannot be recognised (zur Strassen 2003). These thrips breed on the leaves and in the flowers of species of Poaceae, sometimes producing enormous populations, and some species have been widely distributed around the world. The terminal abdominal segments bear one or more distinctive pairs of very stout setae (Fig. 80).

Limothrips cerealium **(Haliday):** This is one of the most widespread species of thrips, found all across the temperate zone of the northern hemisphere, and also in Australia as well as Hawaii, Kauai and Oahu. Swarms of this thrips rising from cereal crops are common in Europe in warm stormy weather, giving the common name of "Thunder Flies" (Kirk 2004).

MICROCEPHALOTHRIPS **Bagnall:** Although similar to members of the genus *Thrips* in many characters, such as the presence and position of tergal ctenidia and the absence of pair I of the ocellar setae, the single species in this genus is remarkable for the presence of a group of setae on the prosternum (Fig. 81).

Microcephalothrips abdominalis **(Crawford):** As indicated by the name, the head of this species is unusually small, and the tergites and sternites bear a posteromarginal craspedum of pointed lobes (Fig. 82). It is widespread around the world, particularly in subtropical areas, and is common on various Pacific islands, including Hawaii, Kauai, Maui and Oahu. It breeds in the flowers of many different Asteraceae, including sunflowers.

NEURISOTHRIPS **Sakimura:** This is an endemic Hawaiian genus of which seven species have been described. These species share the following character states with *Frankliniella* species: antennae 8-segmented, ocellar setal pair I present, both fore wing veins with complete row of setae, metanotal median setae usually at anterior margin, sternites and pleurotergites without discal setae, male sternites III–VII with transverse pore plates. However, the two genera differ in that species of *Neurisothrips* lack tergal ctenidia, and their tergites and sternites bear a posteromarginal craspedum that varies in size among the species but is lobed between the posteromarginal setae. The following key is based on the holotypes of the species described by Moulton together with one of the original specimens of *multispinus*. These type specimens are all uncleared slide-mounts and unsuitable for the production of clear images. Also studied were over 50 slide-mounts prepared by the late Kanjyo Sakimura. From these slides it is possible to deduce that this endemic genus is far more species-rich than published information indicates. However, the available specimens are uncleared with many character states difficult to observe. To examine this unique endemic radiation, field studies are needed in the Hawaiian Islands to establish host associations and distributions for each species. Fresh material is needed for slide mounting and critical study of morphology, as well as DNA analyses.

Key to species

1	Ocellar setae pair III shorter than distance between posterior ocelli; postocular setae pair IV scarcely longer than length of one ocellus (Fig. 84)............**2**
–	Ocellar setae pair III and postocular setae pair IV much longer (Figs 84, 85)....**3**
2	Fore wing with dark median band and dark apex; body, legs and all antennal segments brown; tergites laterally with group of less than 5 setae ....*fasciatus*
–	Fore wing pale without dark areas; body, legs and antennal segments I–IV also base of V and VI yellow (Fig. 91); tergites laterally with group of about 7 setae.. *dubautiae*
3	Body largely yellow...**4**
–	Body brown to dark brown...**5**
4	Tergites with transverse row of 3 or 4 dark setae laterally (Fig. 86); antennal segments I–II yellow, III–VII dark brown; metanotal median setae arise almost medially, well behind anterior margin .... *carteri*
–	Tergites laterally with irregular group of about 7 setae; antennal segment I white, II light brown, and III yellow in basal quarter; metanotal median setae arise at anterior margin ....*williamsi*
5	Antennal segment III 75 microns long (60 microns in male), slender with constricted apex (Fig. 89)..*antennatus*
–	Antennal segment III no more than 50 microns long, apex usually less constricted (Fig. 90) **6**
6	Postocular setae pair IV 75 microns long ....*fullawayi*
–	Postocular setae pair IV 50 microns long ....*multispinus*
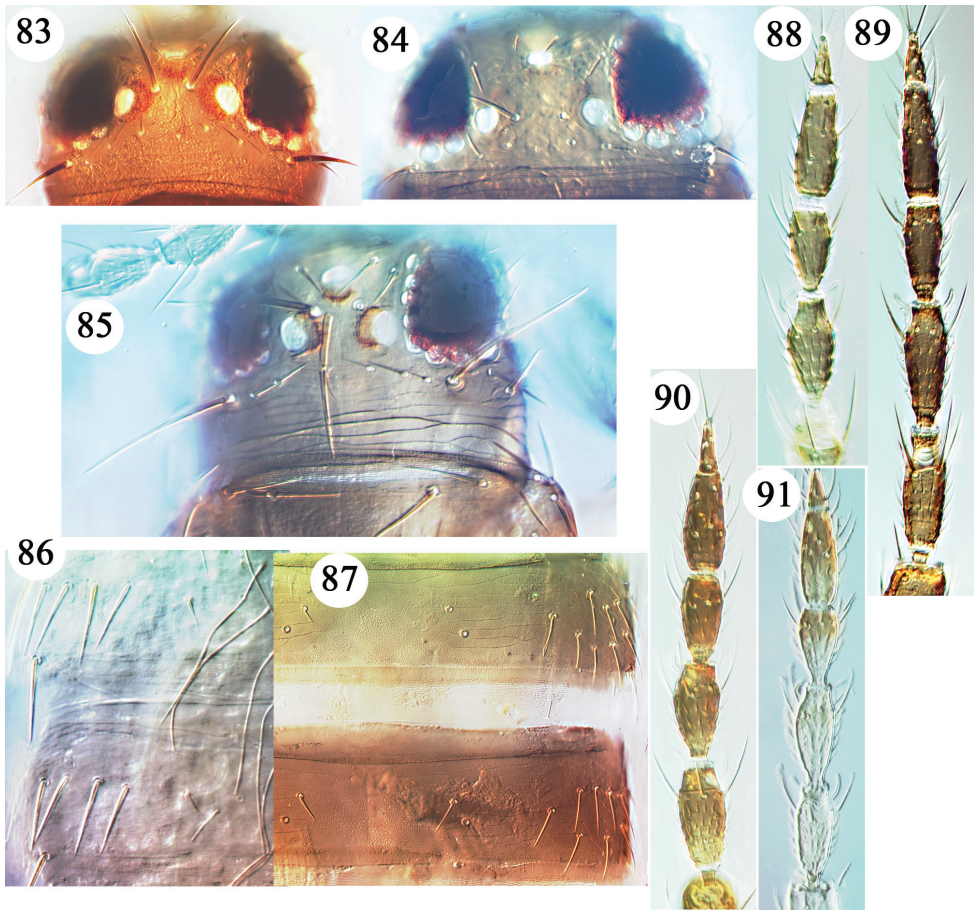
Figures 83–91. *Neurisothrips* species. Heads **83–85**: **83** *antennatus* holotype **84** *fasciatus* holotype **85** *fullawayi* holotype. Tergites IV–V **86–87**: **86** *carteri* holotype **87** *multispinus*. Antennae **88–91**: **88** *williamsi* holotype **89** *antennatus* holotype **90** *multispinus* **91** *dubauti*.

***Neurisothrips antennatus* (Moulton):** Although described originally from a single male taken on Oahu, this species has been recorded subsequently from Hawaii, Kauai, Lanai, Maui, and Molokai. It has been collected from various plants, including *Astelia*, *Menziesiana*, *Broussaisia*, and *Metrosideros*.

***Neurisothrips carteri* (Moulton):** Described from a single female taken in a wind trap on Oahu, the arrangement of the setae on the lateral areas of the abdominal tergites seems to be unique (Fig. 86). Moreover, the metanotal median setae arise well behind the anterior margin of that sclerite. The species has been recorded from Hawaii, Molokai, and Oahu.

***Neurisothrips dubautiae* (Moulton):** The type series of this yellow species comprised seven females and 10 males taken on Oahu from *Dubautia*, one of the native Aster-

aceae. Ocellar setae pair III are only 25 microns long, and postocular setae pair IV are about the same length.

***Neurisothrips fasciatus* (Moulton):** Described from a single female taken in a wind trap on Oahu, this species is unique in the genus in having banded fore wings. However it is similar to *dubautiae* in having unusually short setae on the head, with ocellar setae pair III 25 microns long, and postocular setae pair IV scarcely 15 microns. The abdomen of the holotype is shrunken, thus obscuring details, but there seem to be fewer setae laterally on the tergites than in the other members of this genus.

***Neurisothrips fullawayi* (Moulton):** This brown species appears to be closely similar to *multispinus*, and longer series of specimens are needed to provide a clearer distinction between them. Described from four females and one male, it has been recorded from Hawaii, Kauai, Molokai, and Oahu from various plants including *Broussaisia*, *Broussonetia* and *Pipturus*.

***Neurisothrips multispinus* (Bagnall):** Recorded from Hawaii, Kauai, Maui, and Oahu, this is possibly the most common species in this genus, and has been taken from the flowers of various plants including *Ipomoea* sp. and *Styphelia tameiameiae*. A dark brown species, it is not currently distinguished satisfactorily from *fullawayi*.

***Neurisothrips williamsi* (Moulton):** A yellow species with the tergal antecostal ridges and the major setae dark, this species was described from three females. Antennal segments III and IV have their apices narrowed, and there is a group of well-developed setae laterally on the tergites as in *multispinus* (Fig. 87). It has been recorded from Hawaii, Kauai and Oahu, from the flowers of various plants including *Acacia koa*, *Metrosideros*, and *Myoporum sandwicense*.

***ORGANOTHRIPS* Hood:** Three species are recognised in this genus, although the distinction between *O. bianchi* from the Pacific and *O. indicus* from Asia is not entirely clear (Mound 2000). The genus is recognised from the curious fringed spur at the inner apex of the fore tibia (Fig. 93), and the prolongation of the head in front of the eyes (Fig. 92). These thrips all live on aquatic plants, apparently breeding within mucous on the plant stems below water-level.

***Organothrips bianchii* Hood:** Described from Oahu on *Colocasia esculenta*, this species is also known from Kauai, Lanai, Maui, Molokai and Oahu, as well as the Palau Islands and Samoa. The fore wing is unusual in shape, curving forwards with the apex slightly rounded.

***PEZOTHRIPS* Karny:** This genus is possibly polyphyletic. Nine of the 10 included species are from the Palaearctic region, between Europe and Tibet. In contrast, *kellyanus* is considered Australian in origin but has been introduced to southern Europe. At
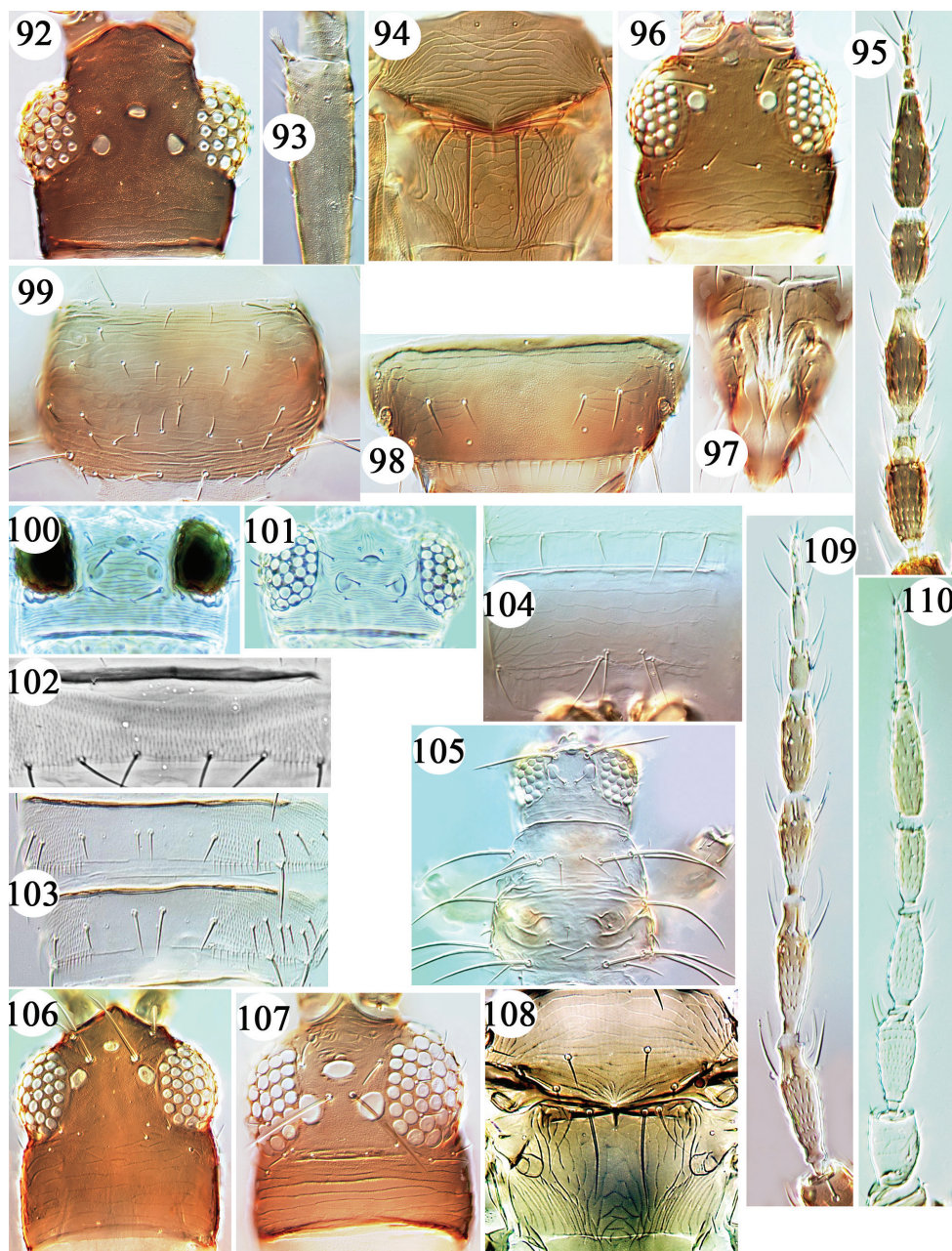
Figures 92–110. Thripinae from Hawaii. *Organothrips indicus* **92–93**: **92** head **93** fore tibia. *Pezothrips kellyanus* **94–95**: **94** meso & metanota **95** antenna. *Plesiothrips perplexus* **96–97**: **96** head **97** ovipositor. *Pseudanaphothrips araucariae* **98–99**: **98** tergite VIII **99** pronotum. *Scirtothrips* species **100–103**: **100** *citri* head **101** *dorsalis* head **102** *dorsalis* sternite IV **103** *inermis* tergites IV & V **104** *Rhamphothrips pandens* sternite VII **105** *Scolothrips sexmaculatus* head & pronotum. **106** *Sciothrips cardamomi* head **107** *Taeniothrips euchariae* head **108** *Tenothrips frici* meso & metanota. Antennae **109–110**: **109** *Psydrothrips kewi* **110** *Projectothrips bhattii*.

one time this genus was confused with *Megalurothrips*, but all the species in that genus breed in the flowers of Fabaceae.

Pezothrips kellyanus (Bagnall): Kelly's citrus thrips is considered to be originally from eastern Australia, where it is common in various scented, white flowers. However, this citrus pest has been introduced to southern Europe, and is common in New Zealand and New Caledonia. It was intercepted by quarantine in California from Hawaii in 1998, recorded in a pre-departure agricultural inspection at Kona in 2000, and in 2014 was collected from flowers on Hawaii where it is clearly established. The adults have antennal segment III sharply bicoloured, with the constricted apex white in contrast to the dark brown of the rest of this segment (Fig. 98). Males have longer antennae, and there is a series of 20 or more small pore plates on each sternite.

PLESIOTHRIPS Hood: This is a New World genus with 19 species listed from various parts of North and South America. Females of these species all have the ovipositor exceptionally weak and lacking strong serrations. Moreover, the males have antennae very different from those of females, with antennal segment III very short but segments IV to VI elongate. All of these species live on Poaceae, but there are no studies on their biology.

Plesiothrips perplexus (Beach): This is the most widespread member of the genus. It is known widely across the Americas, and is common among the Caribbean and Pacific islands, as well as the warmer parts of Australia and New Zealand. It is recorded from Hawaii, Kauai, Lanai, Molokai and Oahu, where it has been taken from many different grass species, including sugar cane. Like many common thrips species, adults vary in colour, with the abdomen commonly paler than the brown head and thorax.

PROJECTOTHRIPS Moulton: The nine species listed in this genus apparently all live in the flowers of *Pandanus* species, the screw pines, between India, northern and eastern Australia, and the Pacific islands. The antennae are characteristic, with segment VIII long and spindle-shaped (Fig. 110).

Projectothrips trespinus (Moulton): Described from Oahu, but also recorded from Hawaii, Kauai and Maui, this species is possibly endemic to the Hawaiian Islands. Adults have been collected from various plants, but the species presumably breeds only in the flowers of *Pandanus*.

PSEUDANAPHOTHRIPS Karny: Eight of the nine species listed in this genus are from Australia, with one described from Taiwan. However, one of the Australian species is introduced to the Hawaiian Islands along with its host plant. The species of *Pseudanaphothrips* are similar to *Frankliniella* species in the following characters: both fore wing veins with complete setal rows, antennae 8-segmented, ocellar setae pair I present in front of the first ocellus. However, *Pseudanaphothrips* species lack the pair of small setae medially on the pronotal posterior margin, and tergal ctenidia are absent or very weak.

***Pseudanaphothrips araucariae* Mound & Palmer:** This thrips lives in the male cones of *Araucaria bidwilli* in Australia, but has been found in large numbers on Oahu and Hawaii in the male cones of *Araucaria heterophylla*, the Norfolk Island pine. It has also been seen from Tahiti. There is a pair of well-developed ctenidia on tergite VIII, but the preceeding tergites bear a scattering of microtrichia on various sculpture lines.

***PSYDROTHRIPS* Palmer & Mound:** Two species are listed in this Neotropical genus. The first was described from a greenhouse in England but subsequently recorded from Mexico, and the second was described from Oahu. It is one of the few Thripidae with 9-segmented antennae (Fig. 109), the sternites bear discal setae, and tergite VIII has a long posteromarginal comb.

***Psydrothrips luteolus* Nakahara & Tsuda:** Described from Oahu, this species is also known from Florida. It causes damage and malformation to the terminals of Araceae plants, and Edwards (1995) recorded considerable feeding damage to unfurled leaves of commercial *Spathiphyllum*, leading to longitudinal scars on open leaves.

***RHAMPHOTHRIPS* Karny:** There are 17 species listed in this genus, all from the Old World tropics. The genus is characterised by the close proximity of posteromarginal setal pairs I and II medially on sternite VII of females (Fig. 104). Moreover, the head is small in comparison to the pronotum, and the mouth cone unusually long. The tergites and sternites have a posteromarginal craspedum.

***Rhamphothrips pandens* Sakimura:** Although described from Hawaii, the country of origin of this small yellow species remains unclear. It has been recorded widely across the Pacific, from Northern Australia and New Caledonia, through Polynesia and Kiribati to Florida, Jamaica and other Caribbean territories (Mound and Tree 2011). The species appears to feed on the leaves of a wide range of plants in various families.

***SCIOTHRIPS* Bhatti:** A single species is placed in this Asian genus. It has the head prolonged in front of the eyes (Fig. 106), and tergite VIII bears a long posteromarginal comb of microtrichia. Structurally similar to *Taeniothrips*, the genus is distinguished in having fewer setae on the fore wing second vein.

***Sciothrips cardamomi* (Ramakrishna):** Apparently specific to the flowers of certain Zingiberaceae, including cardamom, of which it is considered a pest in India. It has also been recorded from such plants in Hawaii and Costa Rica (Mound and Marullo 1996).

***SCIRTOTHRIPS* Shull:** This genus includes about 110 species from various warmer parts of the world. Both sexes have closely spaced rows of fine microtrichia on the lateral thirds of the abdominal tergites (Fig. 103), the pronotum bears many closely spaced transverse striae, and antennal segment II has the inner major seta larger than the outer seta. Females lack campaniform sensilla on tergite IX, and males of some

species have paired lateral drepanae on tergite IX. These are leaf-feeding thrips, usually associated with young leaves and developing fruits rather than flowers, and several species are important pests.

Key to species from Hawaiian Islands

1   Head with ocellar setae pair III arising between the posterior ocelli (Fig. 101); fore wings with posterior fringe cilia straight..**2**

–   Head with ocellar setae pair III arising within ocellar triangle, between anterior and posterior ocelli (Fig. 100); fore wings with posterior fringe cilia wavy **3**

2   Abdominal sternites with rows of microtrichia extending across median area (Fig. 102); tergites with brown area on median third .... ***dorsalis***

–   Abdominal sternites with microtrichia restricted to lateral areas; tergites pale medially but antecostal ridges shaded...***inermis***

3   Pronotum with longest posteroangular setae about 3 times as long as pronotal discal setae; tergites with no dark transverse marking; many closely spaced transverse lines between posterior ocelli ....***citri***

–   Pronotum with longest posteroangular setae less than 2 times as long as discal setae; tergites with dark transverse antecostal ridge; few widely spaced lines between posterior ocelli ....***perseae***

Scirtothrips citri **(Moulton):** The Californian citrus thrips is widespread in Arizona, California, New Mexico, Texas and Mexico. Moreover, populations that may represent this species can be found across the southern states to Florida. A further complication is that some other *Scirtothrips* species described from California are very similar to *citri* and may not be biologically distinct (Hoddle et al. 2012). The major native host plant in California is considered to be a species of *Rhus*, but *citri* is a polyphagous insect, and on Maui has been found on *Citrus* and *Mangifera*.

Scirtothrips dorsalis **Bagnall:** This Asian species is widespread from India to Japan and Australia, and has been introduced to Florida and Israel. Highly polyphagous, it is a serious pest on a range of crops across these countries. However, there are problems concerning the identity of some populations, both from morphological data (Mound and Stiller 2011), and from molecular data (Hoddle et al. 2008b). It has been taken on Maui and Oahu from various plants, but the pest status of these populations remains unclear. It is one of a small number of species in the genus *Scirtothrips* in which rows of microtrichia extend medially fully across the abdominal sternites.

Scirtothrips inermis **Priesner:** Described from the Canary Islands, this species has been reported from various parts of the world, including Europe, Australia, California and Maui. However, it has usually been collected in low numbers, with no evidence of

economic damage to any plants. On Norfolk Island it was found to be quite common on the young leaves of several fruit tree crops, but again without evidence of any damage (Mound and Wells 2015).

Scirtothrips perseae **Nakahara:** Described from California as a pest on avocado leaves and young fruits, five further synonyms of this species are known from Mexico (Hoddle et al. 2008a). There is a record of this species from Maui without further data in an unpublished, updated list of Hawaiian insects provided by Bernarr Kumashiro during 2015.

SCOLOTHRIPS **Hinds:** The 14 species included in this genus are well-known as predators of spider mites on a wide range of plants, and are sometimes marketed as biocontrol agents. The genus was erected for *sexmaculatus* Pergande, a species described from California but known widely across the USA. The name *sexmaculatus* has also been used for populations in other parts of the world, but these generally are misidentifications of different species that are restricted to the Old World (Mound 2011a). Members of the genus are easily recognized from the presence of six pairs of unusually long setae on the pronotum (Fig. 105), and they usually have the body largely pale, and the fore wings with small dark transverse markings.

Key to species from Hawaiian Islands

1   Pronotum with pair of posteromedian discal setae (Fig. 105); fore wing with subbasal brown area not reaching anterior margin, subapical brown area usually larger than subbasal area ....*pallidus*
–   Pronotum without paired posteromedian discal setae; fore wing with subbasal and subapical brown areas longer than wide ....*takahashii*

Scolothrips pallidus **(Beach):** Described from Iowa, and recorded from Oahu as well as from various localities between Canada and Mexico, this species is possibly no more than a pale form of *Scolothrips sexmaculatus*, the six-spotted thrips Mound (2011a).

Scolothrips takahasii **Priesner:** Under the name *priesneri* Sakimura, this species has been recorded from Hawaii, Kauai, Maui, Molokai and Oahu. However, it was first described from Taiwan, and the Hawaiian species was recognized as a synonym by Mound (2011a).

STENCHAETOTHRIPS **Bagnall:** This genus is closely related to the genus *Thrips*, and all 38 described species apparently breed only on species of Poaceae. These thrips share all the character states of genus *Thrips*, but the pair of setae lateral to the fore ocellus on the head (setal pair II) is longer than setal pair III that is associated with the ocellar triangle. Most of the species are from Southeast Asia, although the one first described was from Sudan.

Stenchaetothrips minutus (van Deventer): Described from Java originally, synonyms of this species were described from India, Brazil and Hawaii. It has been found living on various Poaceae, including sugar cane and maize, and is recorded from Hawaii, Kauai, Molokai and Oahu. Unlike many species in this genus, the fore wings are brown with only the basal quarter paler.

TAENIOTHRIPS Amyot & Serville: This genus includes 30 species from the Holarctic region and Southeast Asia (Mound et al. 2012), together with 20 species known only from fossils. These flower-living species are similar to members of the genus *Thrips* in lacking a pair of setae in front of the fore ocellus, but the two genera are unrelated in view of the absence of any tergal ctenidia on *Taeniothrips* species.

Taeniothrips eucharii (Whetzel): First described from Bermuda, with two synonyms from Taiwan and Japan, this thrips is widespread in association with various Amaryllidaceae, including *Hymenocallis*, *Eucharis*, *Lycoris*, *Narcissus* and *Zephyranthes*, and is common on *Liriope* (Liliaceae) in Japan (Mound and Tree 2009). It has presumably been moved around the world by the horticultural trade in bulbs, presumably originally from Southeast Asia, and is recorded from Hawaii, Molokai and Oahu. It is a typical member of the genus *Taeniothrips*, with long ocellar setae pair III arising within the triangle (Fig. 107), and a long regular comb of microtrichia on the eighth abdominal tergite.

TENOTHRIPS Bhatti: Nineteen species are listed in this genus, and these differ from *Taeniothrips* species in having a pair of setae in front of the first ocellus, that is, ocellar setal pair I is present. The genus appears to comprise two major groups. One group of species is from the Old World, mainly Europe, but the second group is known only from California and is referred to by Hoddle et al. (2012) under the generic name *Ewartithrips*.

Tenothrips frici (Uzel): Described from Europe, this small brown species is widespread around the temperate parts of the world in the yellow flowers of weedy Asteraceae, particularly *Hypochoeris* species. It is established in higher elevations of the Hawaiian Islands where the temperature is cooler, such as Kula area in Maui and the saddle road area in Hawaii. The sculpture of the posterior half of the metanotum is characteristic of this species (Fig. 108).

THRIPS Linnaeus: More than 290 species are listed in this genus from around the world, although none of these is native to the Neotropics. These species all lack pair I of the ocellar setae, and they all have paired ctenidia laterally on the abdominal tergites, the pair on tergite VIII arising posteromesad of the spiracles (Fig. 15). Other characters, such as the number of fore wing veinal setae, and discal setae on the sternites and pleurotergites are variable among species. Nakahara (1994) provided keys to the North American species of this genus, and Mound and Masumoto (2005) keys to the Australasian species.

In addition to the 13 species in this genus dealt with below, *Thrips trehernei* was recorded by Zimmerman (1948) collected from a pineapple at Honolulu in 1930. The original specimen is correctly identified, and is deposited in the California Academy of Sciences collection. However, in the absence of any further record from the Hawaiian Islands this European species is not considered further here. It breeds specifically in certain yellow-flowered Asteraceae, particularly *Taraxacum* species.

Key to species from Hawaiian Islands

|		
1	Abdominal sternites III–VI with no discal setae	**2**
–	Abdominal sternites III–VI with at least one pair of discal setae present (Figs 128–130)	**4**
2	Body clear yellow; metanotum with pair of campaniform sensilla present (Fig. 114); tergite II lateral margin with 4 setae	***palmi***
–	Body with at least some darker markings; metanotum without paired campaniform sensilla; tergite II with 3 lateral marginal setae	**3**
3	Ocellar pigment grey; abdominal pleurotergites, also lateral areas of tergites, with closely spaced rows of ciliate microtrichia (Fig. 125); fore wing first vein with 4 or more setae on distal half (rarely only 3); compound eyes without pigmented facets; tergites with median setal pair short	***tabaci***
–	Ocellar pigment red; pleurotergites and tergites without ciliate microtrichia; commonly micropterous, macropterae with 3 setae on first vein distal half; compound eyes with 5 pigmented facets; tergites with median setal pair 0.5 as long as the tergite (Fig. 126)	***nigropilosus***
4	Sternite VII with no discal setae (Fig. 129)	**5**
–	Sternite VII with several discal setae	**6**
5	Sternites III–VI with 5–15 discal setae (Fig. 129); fore wing brown with base pale; metanotum reticulate with few or no markings inside the reticles	***parvispinus***
–	Sternites III–VI with 0–6 discal setae (Fig. 128); fore wing uniformly grayish-brown; metanotum reticulate with many markings inside the reticles (Fig. 113)	***orientalis***
6	Metanotum with conspicuous reticulation (Figs 112, 116)	**7**
–	Metanotum with longitudinal sculpture lines at least on posterior half (Figs 115, 117)	**10**
7	Fore wing first vein with complete setal row; fore wing clavus with 6 marginal setae	***australis***
–	Fore wing first vein with long interruption in setal row; clavus with 5 marginal setae	**8**
8	Antennae 7-segmented; pleurotergites each with 2 or 3 discal setae; sternites IV–V with 15-25 discal setae	***imaginis***
–	Antennae 8-segmented; pleurotergites without discal setae; sternites IV–V with less than 15 discal setae	**9**

9   Metanotal median setae arising behind anterior margin (Fig. 116) ...***simplex***
–   Metanotal median setae arising at anterior margin ....***macullicollis***
10   Abdominal pleurotergites with discal setae present..........................***alliorum***
–   Abdominal pleurotergites with no discal setae..**11**
11   Tergite VIII posterior margin without microtrichial comb (Fig. 124) ....
         .... ***vitticornis***
–   Tergite VIII posterior margin with complete comb of microtrichia (Fig.
         127)..**12**
12   Fore wing clavus with terminal seta longer than subterminal seta (Fig. 123);
         mesonotum with sculpture lines around anterior campaniform sensilla (Fig.
         121); antenna 7 or 8 segmented..***hawaiiensis***
–   Fore wing clavus with terminal seta shorter than subterminal seta (Fig. 122);
         mesonotum with no sculpture lines around anterior campaniform sensilla
         (Fig. 120); antenna 7-segmented ....***florum***

Thrips alliorum **(Priesner):** Described from Taiwan, with one synonymous species described from Hawaii, *alliorum* is known from Japan, Korea and China living on the leaves of onion plants. It is also recorded from Hawaii, Kauai, Lanai, Maui, Molokai and Oahu. In contrast to the onion thrips, *Thrips tabaci*, it is a dark brown species with red ocellar pigments, the pleurotergites and sternites bear discal setae, and tergite VIII has a very weak posteromarginal comb.

Thrips australis **(Bagnall):** Originally from Australia, the gum tree flower thrips is now found in almost every country where *Eucalyptus* trees are planted, and it is reported from Hawaii, Kauai, Lanai, Maui, Molokai and Oahu. Adults may alight on many different plants, but this thrips is largely restricted for breeding to the flowers of *Eucalyptus* species and a few related Myrtaceae. Antennal segment VI is distinctively bullet-shaped (Fig. 119), the chaetotaxy of the fore wing and clavus is unusual, and the metanotum has equiangular reticulation with no internal markings and the median setae distant from the anterior margin (Fig. 112).

Thrips florum **Schmutz:** Recorded from Hawaii and Oahu, this common Asian species is now found widely from Sri Lanka to northern Australia and across the Pacific. It is also recorded from Florida, and in parts of the Caribbean including the Bahamas, Puerto Rico, Costa Rica, Dominican Republic and Guatemala. It is a polyphagous flower-living species, but seems to be of limited economic importance. It is further discussed below under *hawaiiensis*.

Thrips hawaiiensis **(Morgan):** Recorded from Hawaii, Kauai, Lanai, Maui, Molokai, Midway, Niihau and Oahu, this is the most common flower thrips in the Hawaiian Islands. In many tropical parts of the world it is found in association with *florum*, but although both species are variable they can be distinguished on the characters indicated in the key above. The variation in size and colour of adult females was studied
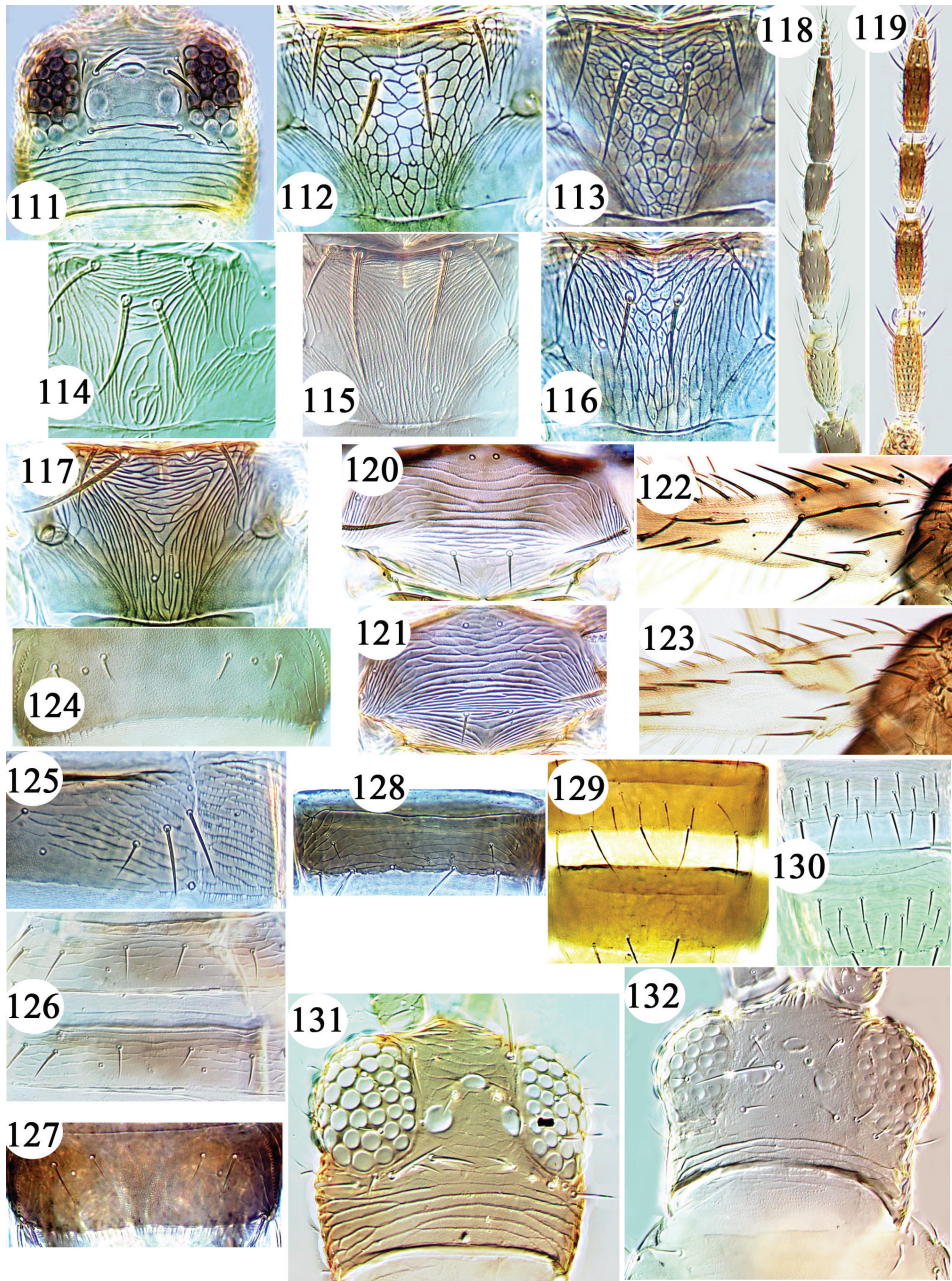
Figures 111–132. Thripinae from Hawaii. *Thrips* species **111–130**: **111** *hawaiiensis* head **112** *australis* metanotum **113** *orientalis* metanotum **114** *palmi* metanotum **115** *vittipennis* metanotum **116** *simplex* metanotum **117** *hawaiiensis* metanotum **118** *vittipennis* antenna **119** *australis* antenna **120** *florum* mesonotum **121** *hawaiiensis* mesonotum **122** *florum* clavus **123** *hawaiiensis* clavus **124** *vittipennis* tergite VIII **125** *tabaci* tergite & pleurotergite IV **126** *nigropilosus* tergites IV & V **127** *hawaiiensis* tergite VIII **128** *orientalis* sternite IV **129** *parvispinus* sternite VI & VII **130** *imaginis* sternites IV–V **131** *Stenchaetothrips minutus* head **132** *Trichromothrips cyperaceae* head.

by Palmer and Wetton (1987), but the most common form of *hawaiiensis* seen from Oahu in recent years is larger and darker than forms more commonly found across Asia. Both this species and *florum* have been described under many different names.

***Thrips imaginis* Bagnall:** The Australian plague thrips was recorded from *Styphelia tameiameiae* flowers at Haleakala National Park, Hawaii in July, 2003 (Annual Report Hawaii Dept. Agriculture, 2006). An internal report at the Systematic Entomology Laboratory, USDA, Beltsville, indicated that three females from this sample were studied, but in 2015 these could not be found. This thrips has not previously been recorded east of New Caledonia, has never been reported by quarantine in California, and the record from Hawaii requires further confirmation. It is a polyphagous and abundant species in southern Australia (Mound and Masumoto 2005).

***Thrips maculicollis* (Hood):** Described from northern Australia, and otherwise known only from New Caledonia (Mound and Masumoto 2005), this species has been intercepted several times by quarantine officials in California on leis originating in Hawaii and made from the flowers of *Fagraea berteriana*. According to Bernarr Kumashiro (in litt. 2015) this thrips has probably been established on Oahu and Hawaii for some considerable time.

***Thrips nigropilosus* Uzel:** This is a polyphagous, leaf-feeding, yellow species that is known to cause damage to various Asteraceae, including lettuce crops. Originally from Europe, it is widespread around the world, and reported from Hawaii, Kauai, Maui and Oahu. It is unusual within genus *Thrips* for being wing polymorphic, and even fully winged females have the median pair of setae on the tergites unusually long and almost half the length of their tergite (Fig. 126).

***Thrips orientalis* (Bagnall):** Commonly associated with the white, scented flowers of *Gardenia* and *Jasminum* species, this thrips is recorded from Hawaii and Oahu. It is widespread from India to northern Australia and across the Pacific, but has also been recorded from Tanzania, the Virgin Islands, and Florida. It is sometimes a confusing species to identify, because the number, even the presence, of discal setae on the sternites is so variable between individuals. It is necessary to examine each sternite in order to check this character when identifying a specimen with a reticulate metanotum (Fig. 128).

***Thrips palmi* Karny:** This is considered a major pest on the leaves of various vegetable crops across much of Asia, from India to Japan and northern Australia, and is known as a vector of tospoviruses (Murai 2002). It is recorded from Hawaii, Kauai, Maui, Molokai and Oahu, and has been introduced widely to warmer parts of the Americas and also to some African territories. It is a small yellow species that is similar in structure to the common Eurasian species *flavus*, but has ocellar setae pair III wider apart and arising just outside the ocellar triangle.

***Thrips parvispinus* (Karny):** Described from Thailand, and widespread in Southeast Asia to northern Australia, this species was found in 2006 damaging the young leaves of papaya at Puna and Hilo Hawaii. As indicated in the key above, it is similar in structure to *orientalis*, but seems to feed more frequently on leaves rather than flowers.

***Thrips simplex* (Morison):** The gladiolus thrips is probably found wherever these plants are cultivated. It feeds on the leaves and flowers, and the feeding damage is particularly obvious on red flowers as pale linear markings. A dark species, it is recorded from Hawaii, Kauai, Maui, and Oahu. It is unusual in having about seven setae on the distal half of the fore wing first vein, and in having markings within the reticles on the metanotum (Fig. 116).

***Thrips tabaci* Lindeman:** The onion thrips is a ubiquitous, polyphagous species, although it is not usually found in the wet tropics. It is well known as a pest of onion and garlic plants, and is also a tospovirus vector, and it is recorded from Hawaii, Kauai, Kure, Lanai, Maui, Midway, Niihau, and Oahu. Adults are unusual with the genus Thrips for having grey, instead of red or orange, ocellar pigment, and a useful diagnostic character is the presence of closely spaced the rows of microtrichia on the pleurotergites (Fig. 125). Males of *tabaci* are rarely found outside the eastern Mediterranean countries where the host genus *Allium* is native.

***Thrips vitticornis* (Karny):** Described from Thailand, with one synonymous species from Guam, this thrips is widespread from India to the South Pacific islands and northern Australia. A dark species, it is recorded from Hawaii, Kauai, Maui and Oahu, and is recognizable by the closely striate sculpture on the metanotum (Fig. 115). It appears to be associated with the flowers of certain Fabaceae, including *Canavallia* and *Calopogonium* species.

***TRICHROMOTHRIPS* Priesner:** Currently there are 34 species listed in this genus, and Bhatti (2000) provided a full account of the 27 species that were known at that time. Many of these species were treated originally as *Dorcadothrips* species, a genus now considered a synonym. Most of the species are from Southeast Asia. Adult females lack ocellar setae pair I in front of the fore ocellus (Fig. 132), tergite VIII lacks a posteromarginal comb, and tergite X has no longitudinal split. The males commonly have a pair of drepanae on tergite IX, and sternites with multiple small pore plates.

Key to species from Hawaiian Islands

1	Abdominal sternites with discal setae; tergal antecostal ridge pale brown ....***cyperaceae***
–	Abdominal sternites without discal setae; tergites uniformly pale yellow **2**

2   Head brown between eyes but pale yellow posterior to eyes; female sternites
         V–VI with submarginal brown area bearing callosity; male sternites III–VII
         with 5 pore plates, median one transverse ....***xanthius***
–   Head pale yellow between eyes with brown band posterior to eyes; female
         sternites without submarginal brown callosity; male sternites III–VII with 6
         pore plates, the 2 median ones oval.. ***oahuensis***

***Trichromothrips cyperaceae* (Bianchi):** Described originally from Hawaii, and also
reported from Maui and Oahu, this species has been found in southern California
and Bermuda. Apparently specific to *Cyperus rotundus*, it is probably introduced from
somewhere in Southeast Asia.

***Trichromothrips oahuensis* Nakahara:** Described from a few specimens collected
from *Ocimum basilicum* on Oahu, the only other published record of this species is
from Rurutu on the Austral Islands (Hoddle et al. 2008c). It is probably native to
southeast Asia.

***Trichromothrips xanthius* (Williams):** This species is sometimes a pest of orchids,
including *Cattleya* and *Cypripedium* species, but has also been reported from unrelated
greenhouse plants including *Asystasia* and *Chrysanthemum*. Described from Trinidad
but probably originally from Southeast Asia, it has been reported in greenhouses wide-
ly across North America, Europe, Japan, and Australia.

Acknowledgments

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Appendix – References to Thysanoptera from Hawaiian Islands

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RESEARCH ARTICLE

A new species of *Docosia* Winnertz from Central Europe, with DNA barcoding based on four gene markers (Diptera, Mycetophilidae)

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Abstract

A new species of *Docosia* Winnertz, *D. dentata* **sp. n.**, is described and illustrated, based on a single male specimen collected in Muránska planina National Park in Central Slovakia. DNA sequences (COI, COII, CytB, and ITS2) are included and compared for 13 species of *Docosia*. There was found only little congruence between the molecular results and previous scarce data about interspecific relationships based on morphology. The COI and CytB gene markers showed the highest interspecific gene distances while ITS2 showed the lowest ones. An updated key to the 23 Central European species of *Docosia* is also presented.

Keywords

Bibionomorpha, Sciaroidea, fungus gnats, Palaearctic Region, taxonomy, DNA sequences, identification key

Introduction

The species in the genus *Docosia* Winnertz, 1863 are rather uniform, medium sized fungus gnats (Diptera: Mycetophilidae) with dark body and unmarked hyaline wings. Their identification is mainly based on the characters on the male and female terminalia

(cf. Laštovka and Ševčík 2006). The genus was traditionally placed in the subfamily Leiinae (e.g. Søli 1997), though recent molecular studies challenge this and place *Docosia* among the Gnoristinae genera (Rindal et al. 2009, Ševčík et al. 2013).

Data on the biology of *Docosia* are scarce, with the exception of the common mycophagous species *Docosia gilvipes* (Walker, 1856), see the recent reviews by Chandler (2010), Jakovlev (2012) and Ševčík (2010a). One species (*Docosia fumosa* Edwards, 1925) has repeatedly been reared from bird's nests (cf. Rulik and Kallweit 2006).

Although *Docosia* is a principally Holarctic genus, several species have also been reported from the Neotropical, Afrotropical and Oriental regions (Bechev 2000, Ševčík 2010b, Oliveira and Amorim 2011, Kurina and Ševčík 2012). A total of 32 described species are currently known from Europe (Kurina and Ševčík 2011). Central European species may be identified according to the key and illustrations of the male and female terminalia provided by Laštovka and Ševčík (2006). Their key includes 16 species from the Czech and Slovak Republics. Additional species were described and figured by Ševčík (2006) from Slovakia, by Ševčík and Laštovka (2008) and Kurina (2008) from the Alps, and by Kurina and Ševčík (2011) from Slovakia and Greece.

A further new species of *Docosia* from Slovakia, tentatively announced by Ševčík (2012), is described in this contribution, together with DNA sequence data provided for this and related species, and the opportunity is taken to update the key to the 23 Central European species of the genus. Morphological terminology follows that of Søli (1997).

Material and methods

Material from the Czech and Slovak Republics

The holotype of the new species was collected by the senior author by sweeping in Muránska planina National Park in central Slovakia. This national park belongs to the most valuable protected areas in Slovakia with regard to biodiversity, with many rare and thermophilous species, often reaching there the northernmost limit of their distribution (cf. Ševčík and Kurina 2011a, b). The habitats include mainly karst valleys and limestone rocky slopes, covered mostly by beech and spruce forests.

The material used for DNA extraction was collected with Malaise traps or sweep net at different localities of the Czech and Slovak Republics in the years 2012–2015. The voucher specimens are deposited in the collection of Jan Ševčík (JSEVC) or in the Silesian Museum, Opava, Czech Republic (SMOC).

All the specimens were collected in 70% ethanol. The holotype is stored in the glycerine medium in a plastic pinned microvial. Before placing in glycerol the specimen was incubated in proteinase K to extract DNA.

Genomic DNA was extracted using NucleoSpin Tissue Kit (Macherey-Nagel, Düren, Germany) following the included protocol. The specimens were cleaned with PBS (Phosphate Buffered Saline) and left in lysis buffer with proteinase K overnight at 56 °C. The primers used for the PCR amplifications were as fol-

lows: LCO1490 (5'-GGTCAACAAATCATAAAGATATTGG-3') and HCO2198 (5'-TAAACTTCAGGGTGACCAAAAAATCA-3') (Folmer et al. 1994) for COI; CYTB-F (5'-TATGTTTTATGAGGACAAATATC-3') and CYTB-R (5'-AAATTC-TATCTTATGTTTCAAAAC-3') (Su et al. 2008) or mCYTB-R (5'-ATTACTC-CCCCTAATTTATTAGGAAT-3') (Ševčík lab) for cytochrome B; ITS2a (5'-TGT-GAACTGCAGGACACAT-3') and ITS2b (5'-TATGCTTAAATTCAGGGGGT-3') (Beebe & Saul, 1995) for ITS2; and mCOII-F (5'-CAAGATAGAGCTTCTCCTCT-TATAG-3') and mCOII-R (5'-GGCATAAATCTATGATTAGCCCCAC-3') (Ševčík lab) for COII. The amplification programme for the gene fragments was 94 °C for 3 min, followed by 35 cycles of 94 °C for 1 min, 49–50 °C for 1 min and 72 °C for 1:30 min and a final extension step at 72 °C for 7 min. The obtained PCR products were purified using Gel/PCR DNA Fragments Extraction Kit (Geneaid, New Taipei City, Taiwan) following manufacturer's protocol and sequenced by Macrogen Europe (Netherlands).

Material from Germany

German material discussed here was obtained within the German Barcode of Life Project (GBOL). Specimens used for DNA extraction were collected with Malaise traps at two different localities in Germany in the years 2013 and 2015. All the specimens were collected in pure 96% ethanol.

Genomic DNA was extracted from legs of the specimens using the BioSprint96 magnetic bead extractor by Qiagen (Hilden, Germany). Polymerase chain reaction (PCR) was carried out in total reaction mixes of 20 µl, including 2 µl of undiluted DNA template, 0,8 µl of each primer (10 pmol/µl), 2 µl of 'Q-Solution' and 10 µl of 'Multiplex PCR Master Mix', containing hot start Taq DNA polymerase and buffers. The latter components are available in the Multiplex PCR kit from Qiagen (Hilden, Germany). PCR reactions were run individually and not multiplexed.

Thermal cycling was performed on GeneAmp PCR System 2700 (Applied Biosystems, Foster City, CA, USA) as follows: hot start Taq activation: 15 min at 95 °C; first cycle set (15 repeats): 35-s denaturation at 94 °C, 90-s annealing at 55 °C (−1 °C/cycle) and 90-s extension at 72 °C. Second cycle set (25 repeats): 35-s denaturation at 94 °C, 90-s annealing at 40 °C and 90-s extension at 72 °C; final elongation 10 min at 72 °C using the primers LCO1490-JJ: 5´-CHACWAAYCATAAAGATATYGG- 3´ with HCO2198-JJ: 5´-AWACTTCVGGRTGVCCAAARAATCA- 3´ respectively (Astrin and Stüben 2008).

Sequencing of the unpurified PCR products in both directions was conducted at Beijing Genomics Institute (Hongkong, CN) by using the amplification primers. Barcode sequence analysis was done using the Geneious® software version 7.1.7 (http://www.geneious.com).

Vouchers were deposited in the collection of the Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany.

Sequence alignment and analyses

The sequences were aligned using MAFFT version 7 (Katoh and Standley 2013) on the MAFFT server (http://mafft.cbrc.jp/alignment/server/) with default settings and then manually edited. The protein-coding gene COI, COII and CytB sequences were checked based on amino-acid translations and yielded indel-free nucleotide alignments. All unreliably aligned regions of ITS2 fragment were removed in GBLOCKS 0.91b program (Castresana 2000) on the Gblocks server (http://molevol.cmima.csic.es/castresana/Gblocks_server.html). We created four alignments, one for each gene, and one concatenated alignment for all gene fragments with 15 taxa, including additional sequences from GenBank (KT316839, KC435639, KC435683 and KC435708). The final molecular dataset consists of 2039 characters: COI–658, COII–546, CytB–433, ITS2–402 bp. The datasets were analysed using maximum likelihood analyses conducted on the CIPRES computer cluster using RAxML-HPC BlackBox 7.6.3 (Stamatakis 2006) employing automatic bootstrapping on the partitioned dataset. All the sequences were deposited into GenBank and BOLD (http://dx.doi.org/10.5883/DS-DOCODENT), where detailed metadata is available (see Table 1). As outgroup taxa we selected two representatives of the subfamily Gnoristinae, in concordance with previous molecular studies (Rindal et al. 2009, Ševčík et al. 2013).

Genetic distances were calculated in MEGA6 (Tamura et al. 2013) using Kimura 2-parameter model (K2P) with pairwise deletion for the treatment and they are demonstrated in Table 2 and Fig. 5.

Species description

Docosia dentata sp. n.
http://zoobank.org/E75577BA-83A0-4596-BC12-61F22A505225
Figures 1–3

Type material. Holotype male, in a pinned microvial with glycerol. SLOVAKIA, Muránska planina National Park, Muráň env., Šiance National Nature Reserve, sweeping along forest edge, N48°46'12", E20°04'20", 1005 m a.s.l., 25. May 2012 (J. Ševčík leg.) [SMOC].

Description. Male (n = 1). Length of wing 4.2 mm.

Head blackish brown with numerous pale setae. Three ocelli, with lateral ones almost touching compound eyes, separated from the eye margins by their own diameter. Clypeus blackish, with setae pale. Mouthparts light brownish. Palpus brownish yellow, basally and apically darker. Scape, pedicel and all flagellomeres dark brown. Flagellomeres cylindrical, flagellomeres 1 to 7 about twice as long as broad, apical flagellomeres (8 to 14) slightly conical, three times as long as broad.

All parts of thorax blackish brown. All bristles and setae yellowish white. Scutellum with several marginal and submarginal pale bristles and with numerous setae.

Table 1. List of species, sampling locality and year, and accession numbers.

Species	Voucher code	Sampling locality and year	GenBank accession numbers				BOLD Process ID
			COI	COII	CYTB	ITS2	
Boletina nasuta (Haliday, 1839)	JSGS18	Slovakia, 2013	KT923571	KT923585	KT923598	KT923614	JSDO011-15
Gnoriste bilineata Zetterstedt, 1852	JSGS4	Czech Republic, 2009	KT316839	KT923584	KT923597	KT923613	JSDO014-15
Docosia dentata sp. n.	JSDO1	Slovakia, 2012	KT923562	KT923575	KT923600	KT923604	JSDO001-15
D. diutina Plassmann, 1996	ZFMK-TIS-2516913	Germany, 2013	KU146854	KU146860	KU146858	KU146856	SRDOC001-15
D. flavicoxa Strobl, 1900	JSDO9a	Slovakia, 2012	KT923570	KT923583	KT923596	KT923612	JSDO009-15
D. fumosa Edwards, 1925	ZFMK-TIS-2556735	Germany, 2015	KU146855	KU146861	KU146859	KU146857	SRDOC002-15
D. fuscipes (Roser, 1840)	JSDO2	Slovakia, 2015	KT923563	KT923576	KT923590	KT923605	JSDO002-15
D. gilvipes (Walker, 1856)	JSGS29	Slovakia, 2013	KT923572	KT923586	KT923599	KT923615	JSDO012-15
D. landrocki Laštovka & Ševčík, 2006	JSDO7	Slovakia, 2014	KT923568	KT923581	KT923594	KT923610	JSDO007-15
D. lastovkai Chandler, 1994	JSDO4	Slovakia, 2013	KT923565	KT923578	KT923591	KT923607	JSDO004-15
D. montana Laštovka & Ševčík, 2006	JSDO5	Slovakia, 2013	KT923566	KT923579	KT923592	KT923608	JSDO005-15
D. moravica Landrock, 1916	JSDO6	Slovakia, 2013	KT923567	KT923580	KT923593	KT923609	JSDO006-15
D. muranica Kurina & Ševčík, 2011	JSM10	Slovakia, 2013	KC435639	KT923587	KC435683	KC435708	JSDO013-15
D. sciarina (Meigen, 1830)	JSDO8	Czech Republic, 2014	KT923569	KT923582	KT923595	KT923611	JSDO008-15
D. setosa Landrock, 1916	JSDO3	Slovakia, 2015	KT923564	KT923577	KT923601	KT923606	JSDO003-15

Table 2. Kimura 2-parametr genetic distances for COI, COII, CytB and ITS2. The lowest and highest values among *Docosia* species are highlighted in bold.

COI	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 *D. dentata* sp. n.														
2 *D. diutina*	8,6%													
3 *D. flavicoxa*	9,8%	12,4%												
4 *D. fumosa*	13,3%	13,1%	13,5%											
5 *D. fuscipes*	8,2%	9,4%	11,1%	12,8%										
6 *D. gilvipes*	13,9%	14,6%	14,1%	12,8%	13,5%									
7 *D. landrocki*	9,3%	9,9%	12,3%	13,3%	10,6%	15,9%								
8 *D. lastovkai*	12,6%	13,5%	15,2%	13,9%	11,9%	14,8%	14,0%							
9 *D. montana*	7,5%	10,6%	11,4%	15,3%	10,4%	14,8%	11,7%	14,4%						
10 *D. moravica*	13,2%	15,1%	15,4%	19,1%	14,7%	**19,6%**	15,1%	17,0%	16,4%					
11 *D. muranica*	10,2%	13,0%	14,6%	16,6%	11,3%	16,2%	13,3%	15,5%	12,0%	17,8%				
12 *D. sciarina*	9,4%	11,5%	11,8%	14,6%	11,2%	14,3%	12,0%	13,1%	9,0%	15,7%	14,4%			
13 *D. setosa*	**6,0%**	10,0%	10,3%	14,1%	10,3%	14,7%	10,6%	13,9%	7,1%	14,7%	12,3%	9,0%		
14 *Boletina nasuta*	15,9%	17,8%	16,2%	18,6%	16,3%	16,1%	17,4%	16,4%	18,0%	20,1%	16,2%	15,7%	16,1%	
15 *Gnoriste bilineata*	16,1%	17,9%	18,4%	15,4%	17,0%	15,6%	18,2%	17,5%	18,6%	19,8%	20,3%	17,5%	17,2%	14,9%

COII	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 *D. dentata* sp. n.														
2 *D. diutina*	6,6%													
3 *D. flavicoxa*	7,5%	8,2%												
4 *D. fumosa*	14,4%	17,2%	14,9%											
5 *D. fuscipes*	7,5%	8,9%	11,0%	17,4%										
6 *D. gilvipes*	7,2%	10,2%	11,9%	16,8%	8,6%									
7 *D. landrocki*	6,8%	5,6%	7,8%	15,2%	8,4%	10,7%								
8 *D. lastovkai*	11,7%	12,9%	14,2%	**19,3%**	11,7%	9,7%	14,8%							
9 *D. montana*	6,2%	7,3%	9,4%	15,8%	9,3%	10,3%	8,4%	13,5%						

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
10 *D. moravica*	6,2%	8,8%	7,3%	16,6%	9,1%	9,3%	9,1%	12,2%	7,3%					
11 *D. muranica*	8,6%	11,0%	12,9%	16,0%	9,1%	**4,3%**	11,5%	12,2%	11,1%	11,0%				
12 *D. sciarina*	6,7%	8,7%	8,4%	17,4%	10,1%	8,9%	8,9%	13,0%	6,9%	7,3%	11,6%			
13 *D. setosa*	5,1%	6,4%	7,7%	15,2%	8,2%	10,0%	6,4%	13,5%	5,6%	6,6%	11,0%	7,4%		
14 *Boletina nasuta*	23,1%	22,8%	20,9%	21,9%	21,2%	22,4%	22,4%	23,1%	21,2%	22,2%	20,0%	22,6%	21,0%	
15 *Gnoriste bilineata*	17,7%	18,5%	18,2%	18,2%	17,7%	19,7%	18,8%	25,4%	18,8%	18,0%	17,4%	18,6%	17,9%	19,1%

cytB	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 *D. dentata* sp. n.														
2 *D. diutina*	8,3%													
3 *D. flavicoxa*	11,0%	14,5%												
4 *D. fumosa*	19,3%	22,0%	21,0%											
5 *D. fuscipes*	10,9%	12,5%	14,9%	24,1%										
6 *D. gilvipes*	19,6%	20,6%	19,9%	19,7%	21,9%									
7 *D. landrocki*	10,1%	9,7%	14,3%	23,6%	12,2%	19,9%								
8 *D. lastovkai*	15,5%	16,4%	15,8%	**26,0%**	18,7%	21,0%	15,4%							
9 *D. montana*	9,4%	12,8%	17,1%	22,9%	13,1%	22,3%	13,5%	21,9%						
10 *D. moravica*	10,0%	11,6%	12,0%	17,8%	14,0%	19,5%	12,0%	16,1%	14,5%					
11 *D. muranica*	7,8%	12,6%	13,6%	21,6%	10,4%	19,4%	12,9%	16,2%	13,1%	13,9%				
12 *D. sciarina*	7,8%	11,0%	10,8%	21,7%	11,4%	19,9%	10,1%	16,1%	11,6%	10,5%	10,7%			
13 *D. setosa*	**6,6%**	10,3%	10,0%	21,5%	11,0%	16,7%	9,4%	15,7%	10,8%	10,3%	10,2%	7,4%		
14 *Boletina nasuta*	17,4%	18,8%	19,0%	21,9%	22,2%	18,9%	22,3%	20,8%	25,0%	17,9%	23,9%	18,5%	19,9%	
15 *Gnoriste bilineata*	16,0%	18,8%	19,0%	18,9%	20,6%	20,4%	20,3%	21,1%	21,2%	16,0%	20,2%	18,9%	18,4%	17,1%

ITS2	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	*D. dentata* sp. n.													
2	*D. diutina*	1,8%												
3	*D. flavicoxa*	2,6%	3,4%											
4	*D. fumosa*	9,6%	9,2%	10,4%										
5	*D. fuscipes*	0,8%	2,3%	3,5%	8,7%									
6	*D. gilvipes*	7,2%	6,9%	9,1%	11,3%	7,2%								
7	*D. landrocki*	2,0%	1,3%	3,7%	9,2%	2,9%	6,0%							
8	*D. lastovkai*	4,3%	5,2%	5,8%	**12,7%**	4,7%	7,9%	5,2%						
9	*D. montana*	2,0%	3,4%	3,2%	9,6%	2,1%	8,7%	3,7%	6,4%					
10	*D. moravica*	1,3%	3,2%	1,8%	9,2%	1,9%	8,3%	3,5%	4,4%	2,6%				
11	*D. muranica*	**0,3%**	2,1%	2,9%	9,6%	0,5%	6,9%	2,3%	4,1%	2,3%	1,3%			
12	*D. sciarina*	1,3%	2,1%	3,4%	9,4%	2,1%	7,9%	2,3%	5,8%	2,1%	2,6%	1,5%		
13	*D. setosa*	1,3%	2,1%	2,3%	9,0%	2,1%	8,2%	2,3%	5,8%	1,8%	2,4%	1,5%	1,0%	
14	*Boletina nasuta*	23,7%	23,3%	23,6%	22,0%	23,4%	21,2%	23,3%	25,1%	23,2%	23,1%	23,3%	21,7%	21,7%
15	*Gnoriste bilineata*	20,5%	20,5%	20,3%	19,3%	20,2%	20,1%	20,5%	21,1%	19,6%	19,7%	20,1%	19,0%	18,5%	12,8%
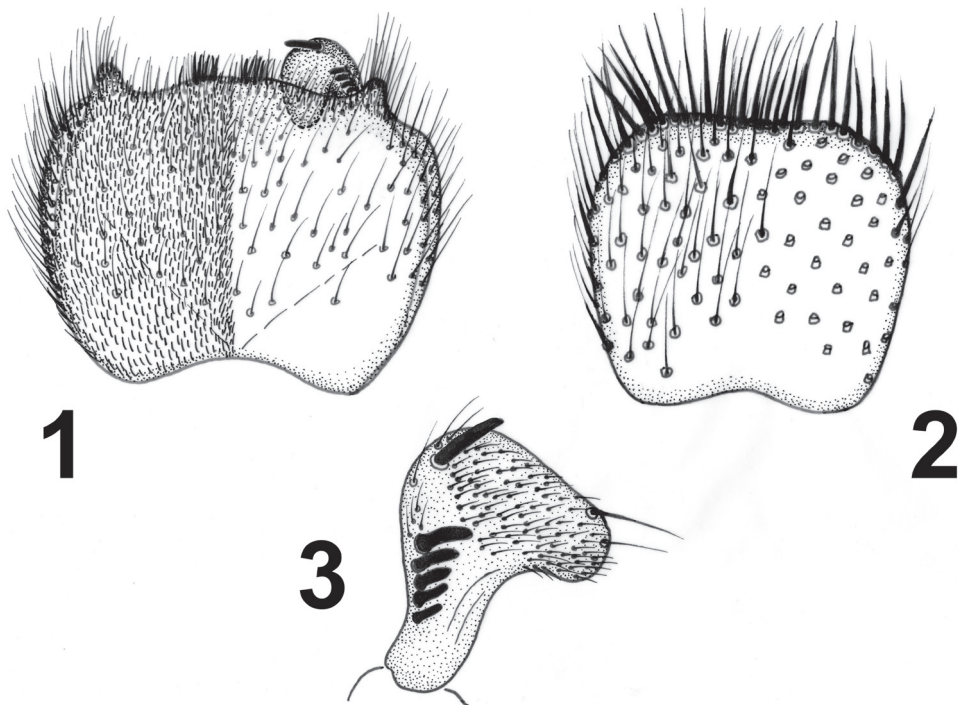
Figures 1–3. *Docosia dentata* sp. n. (holotype), male terminalia; **1** ventral view **2** tergite 9 in dorsal view **3** right gonostylus in dorsal view. Scale bar = 0.1 mm.

Antepronotum and proepisternum with pale bristles and short dark setae. Upper part of antepronotum with a strong pale bristle reaching to the ocellus. Laterotergite and other pleural parts bare. Haltere pale yellow.

Legs. All coxae entirely yellow. Femora yellow with hind femur brownish only around its tip. All trochanters blackish brown. Tibiae and tarsi yellow, tarsal segments seemingly brownish because of dense setulae. Fore tibia apicomedially with a semicircular tibial organ (anteroapical depressed area), without strong setae, only densely covered with fine setulae. Mid tibia with 5 anterior, 4 dorsal, 3 anteroventral and 5–6 posterior setae. Hind tibia with 16 anterior, 12 dorsal, 5 anteroventral and 6 posterior setae.

Wings hyaline, unmarked. Radial veins and r-m brown, other veins paler while m-stem and the base of M_1 are faint, almost not traceable. Sc, Rs and basal third of cu-stem asetose, the other veins setose. Costa reaches to 0.45 of the distance between R_5 and M_1. Sc ends in R at the level of beginning of m-stem. Posterior fork begins before anterior fork, approximately at the level of the middle of r-m.

Abdomen all dark brown. Terminalia (Figs 1–3) dark brown except lighter gonostyli. Tergite 9 in the shape of a rounded square, about as long as broad (Fig. 2). Posteroventral margin of gonocoxites with lateral projections and with two patches of short setae medially (Fig. 1). Gonostylus subtriangular with a row of black megasetae along its ventral margin (Fig. 3).

Female. Unknown.

Biology. Unknown.

Etymology. The species name refers to the structure of gonostylus.

Molecular data

The genetic distances among the 13 species of *Docosia* and two outgroup species for particular gene markers are presented in Tab. 2. The interspecific differences among *Docosia* species ranged from 0.3% (in ITS2 between *D. dentata* and *D. muranica*) to 26.0% (in CytB between *D. fumosa* and *D. lastovkai*), with the mean interspecific distances for particular genes: 12.8% (COI), 10.3% (COII), 14.9% (CytB) and 4.5% (ITS2). The genetic distances for the nuclear ITS2 marker were remarkably lower than for the mitochondrial markers. Fig. 5 shows that the distribution of K2P distances for cytB is rather broad (6.6–28%), while the distributions for COI, COII and ITS2 are relatively narrow.

The phylogenetic tree for the concatenated dataset is presented in Fig. 4. The genus *Docosia* was found to be monophyletic with maximum bootstrap support value (BV = 100). Surprisingly, *D. fumosa* branched basally as a sister group to all the other *Docosia* species included in this analysis, followed by *D. gilvipes*. All the other *Docosia* species grouped together as a monophyletic group with maximum support (BV = 100). Within this group, only *D. diutina* and *D. landrocki* were found to be closely related (BV = 100) while the other relationships between any two species are less supported. Also the monophyly of the group comprising eight terminal species (see Fig. 4) is highly supported (BV = 100). A sister taxon to this group is *D. fuscipes*, while *D. muranica* is sister taxon to the entire latter group. Finally, *D. lastovkai* is sister taxon to the all *Docosia* species in this dataset, except *D. fumosa* and *D. gilvipes*.

Discussion

Affiliation of the new species

According to the key by Laštovka and Ševčík (2006), the new species runs to couplet 10 (*D. montana* Laštovka & Ševčík, 2006), because of bare laterotergites, yellow coxae and basal flagellomeres relatively long. The structure of the male terminalia is, however, quite different from this species and also from two other species described later (*D. chandleri* Ševčík & Laštovka, 2008 and *D. matilei* Ševčík & Laštovka, 2008), which would run to couplet 10 too. It is thus difficult to find the closest relative of *D. dentata* according to morphological characters.

Considering the genetic distance, the closest relative of *Docosia dentata* is *D. setosa*, based on COI (6.0 %), COII (5.1%) and CytB (6.6%) gene markers. In the phyloge-
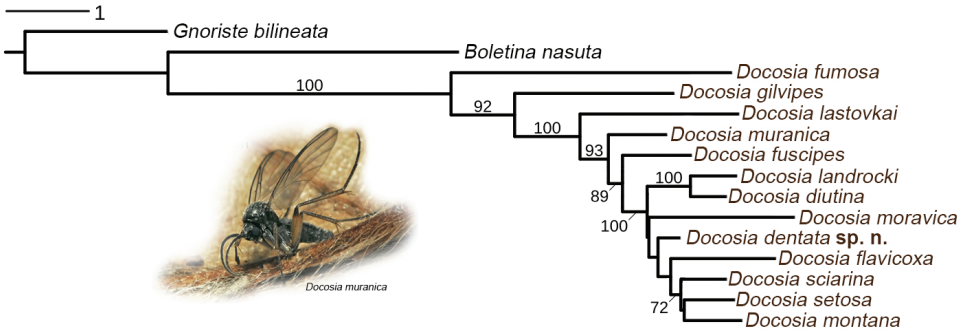
Figure 4. Maximum likelihood hypothesis for relationships among selected species of *Docosia* Winnertz based on DNA sequence data (COI, COII, CytB and ITS2), 2039 characters. Above node number = bootstrap support for ML.
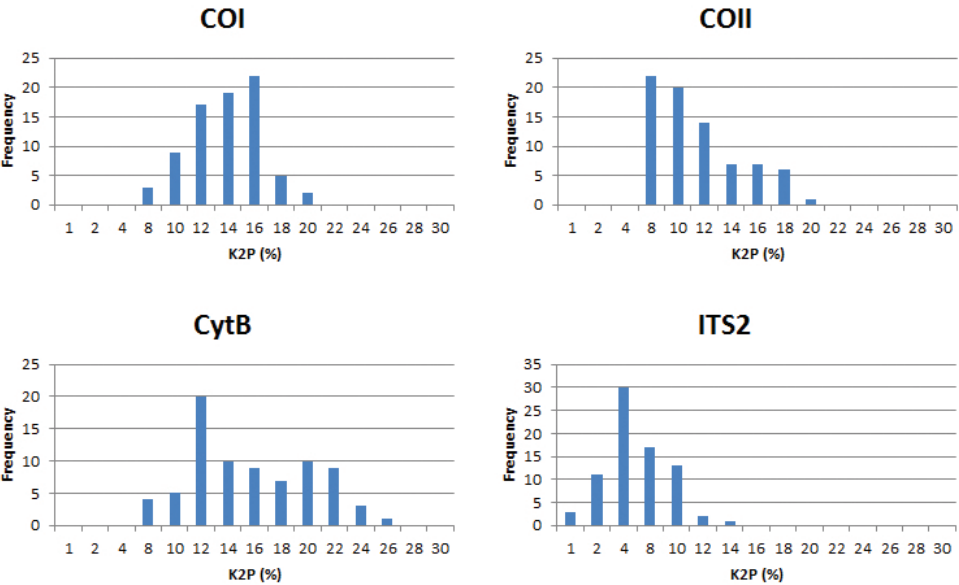
Figure 5. Frequency distributions of genetic distances (K2P) for particular gene markers.

netic tree based on all the four gene markers (Fig. 4), *D. dentata* forms a sister branch to a group of the following four species: *D. flavicoxa*, *D. sciarina*, *D. montana*, and *D. setosa*.

Comparison of the utility of COI, COII, CytB and ITS2 for barcoding of *Docosia*

The comparison of the four variable gene regions revealed that the genetic distances between *Docosia* species are quite high for CytB and COI, with the average values being 14.9% and 12.8%, respectively. From this point of view, CytB performs as the best barcoding marker for *Docosia* species, followed by the traditional animal barcoding

region (COI), COII and ITS2. The ITS2 sequences show remarkably high similarity in the genus *Docosia* and do not appear as a suitable barcode marker in this case. The high uniformity of ITS2 has been reported in several studies (e.g. Lv et al. 2014 or Navajas et al. 1988). At least within Mycetophilidae, the ITS2 marker may thus possibly be more suitable for intergeneric comparisons and higher phylogeny, similarly as the neighbouring ribosomal 28S region. In mycetophilids, ITS2 has already been successfully used for inferring phylogeny at generic or subgeneric level by Ševčík et al. (2013, 2014). This issue definitely deserves further study.

There are many studies comparing the utility of various gene markers for DNA barcoding and the identification of species (e.g. Bourke et al. 2013, Lv et al. 2014, Schwarzfeld and Sperling 2014). Concerning fungus gnats, comparisons between COI and ITS2 were recently provided by Jürgenstein et al. (2015) and Kurina et al. (2015). They both came to the conclusion that COI performed better.

The CytB region has mostly been used in the studies devoted to vertebrates but it was recently used also for barcoding of Calliphoridae (GilArriortua et al. 2013), tse-tse flies (Orji et al. 2015) or aphids (Chen et al. 2012).

Incongruence between molecular and morphological data

There has been no previous phylogenetical hypothesis for *Docosia* species published to date but if we take into account the characters used in most available keys, there is only little congruence between those morphological characters and the molecular results presented here. For example, *Docosia fumosa* does not appear as particularly separated from the other species by morphological characters. It belongs to the group of species with pubescent lateroterites, together with *D. flavicoxa*, *D. gilvipes*, *D. moravica*, *D. sciarina*, and several other species, not represented in our molecular dataset. These latter species do not constitute a monophyletic group in the molecular tree (Fig. 4) nor do the species with bare laterotergites. This means that this widely used character (pubescence of laterotergites) has most probably no or little value in reconstructing relationships within the genus.

The second widely used character in the keys is the coloration of legs, mainly the coxae, which also does not help much in defining any group congruent with the clades in the molecular tree presented here.

Further, it is difficult to find clear morphological synapomorphies for the highly supported clades in the tree (Fig. 4), e.g. for the sister relationship of *D. diutina* + *D. landrocki* (except for the overall resemblance of their male terminalia).

Interestingly, in two of the four trees based on one gene region only (in COI and ITS2, data not shown), *D. gilvipes* (not *D. fumosa*) branched basally as a sister group to the rest of *Docosia*, a result which would be expected on the basis of morphological and ecological data (*D. gilvipes* is the only species in the dataset with Sc setose and ending free, different structure of male terminalia, endomycophagous larvae etc.).

Nevertheless, the number of species included in this analysis is rather limited to reach any final conclusion. A more comprehensive phylogeny of the genus, as well as of other genera of fungus gnats, is thus needed.

Key to Central European species of Docosia

1	Laterotergite pubescent	**2**
–	Laterotergite bare	**9**
2 (1)	Sc setose and ending free	**3**
–	Sc bare and ending in R	**4**
3 (2)	Tergite 9 subrectangular, gonostylus with a patch of fine subapical setae .... ***D. gilvipes* (Walker, 1856)**
–	Tergite 9 distinctly broadened posteriorly, gonostylus without a patch of sub-apical setae (Kurina 2008: figs 10–15) .... ***D. pseudogilvipes* Kurina, 2008**
4 (2)	Hind femur completely black or dark brown	**5**
–	Hind femur at least partly yellow	**6**
5 (4)	All coxae and palpi black............................ ***D. carbonaria* Edwards, 1941**
–	Coxae yellowish brown, wings slightly smoked ...***D. fumosa* Edwards, 1925**
6 (4)	Coxae largely dark (at least basal ½), laterotergal setae short ....***D. sciarina* (Meigen, 1830)**
–	Coxae at most parts yellow, laterotergal setae long as usua	**7**
7 (6)	Mid tibia dorsally with longitudinal black band... ....***D. tibialis* Laštovka & Ševčík, 2006**
–	Mid tibia dorsally yellowish	**8**
8 (7)	Hind coxa basally brown, apical 1/5 and proximoventral part of hind femur darkened..***D. moravica* Landrock, 1916**
–	Hind coxa at most with basal margin darkened, hind femur dark only at tip, its ventral surface yellow ....***D. flavicoxa* Strobl, 1910**
9 (1)	All coxae dark brown, hind femur largely dark	**10**
–	Coxae with at least apical half pale	**11**
10 (9)	Haltere yellowish, male gonocoxites broadly rounded posteriorly (Laštovka and Ševčík 2006: Fig. 7) ....***D. fuscipes* (von Roser, 1840)**
–	Haltere with a dark knob, male gonocoxites with a deep median incision (Chandler and Blasco-Zumeta 2001: figs 42–47)....***D. morionella* Mik, 1884**
11 (9)	All coxae yellow, hind coxa dark at most on basal 1/6	**12**
–	Hind coxa blackish brown at least on the basal third	**17**
12 (11)	Antenna with long basal segments, flagellomere 1 to 4 about twice as long as wide, lateral ocelli distant from eyes	**13**
–	Antennal segments shorter, flagellomere 1 to 4 about 1.5 as long as wide, ocelli touching eyes	**16**
13 (12)	Pedicel yellow ....***D. chandleri* Ševčík & Laštovka, 2008**
–	Pedicel dark brown	**14**

14 (13) Posteroventral margin of gonocoxites almost straight, with posterolateral projections, gonostylus short, subtriangular (Figs 1, 3) ....***D. dentata* sp. n.**
– Posteroventral margin of gonocoxites medially with a distinct rounded projection, gonostylus elongated **15**
15 (14) Gonostylus with several unusually thick black megasetae along its ventral margin (Ševčík and Laštovka 2008: fig. 2) ....***D. matilei* Ševčík & Laštovka, 2008**
– Gonostylus with black megasetae only apically (Laštovka and Ševčík 2006: fig. 10)...***D. montana* Laštovka & Ševčík, 2006**
16 (12) Costa extends to ½ distance from R_5 to M_1 or slightly more, apical 1/5 of hind femur dark...***D. lastovkai* Chandler, 1994**
– Costa extends only to 2/5 distance from R_5 to M_1, only tip of hind femur dark ....***D. landrocki* Laštovka & Ševčík, 2006**
17 (11) Hind coxa dark only on basal third, haltere entirely yellowish...................**18**
– Basal half or slightly more of hind coxa blackish brown **19**
18 (17) Lateral ocelli distant from eyes (about a diameter of ocellus), mid coxa dark on basal third, pedicel dark, male tergite 9 subtrapezoidal (Laštovka and Ševčík 2006: fig. 15) .... ***D. setosa* Landrock, 1916**
– Lateral ocelli touching eyes, mid coxa dark on basal fourth or less, pedicel usually pale, male tergite 9 subcircular (Laštovka and Ševčík 2006: fig. 4).....
.... ***D. expectata* Laštovka & Ševčík, 2006**
19 (17) Costa extends about 2/5 from R_5 to M_1, palpi yellow, haltere darkened ....
.... ***D. nigra* Landrock, 1928**
– Costa extends only about 2/7 from R_5 to M_1, palpi darkened, haltere yellow...**20**
20 (19) Male terminalia with tergite 9 short, as long as broad, trapezoid, posterior margin of gonocoxites without distinct medioventral process (Kurina and Ševčík 2011: fig. 2) ....***D. muranica* Kurina & Ševčík, 2011**
– Male terminalia with tergite 9 long, about twice as long as broad, posterior margin of gonocoxites with distinct medioventral process, hind tibia with a dark patch of modified setae **20**
21 (20) Male terminalia with lateral lobes of gonocoxites in ventral view distinctly longer than medioventral process of gonocoxites (Laštovka and Ševčík 2006: fig. 3) ....***D. diutina* Plassmann, 1996**
– Male terminalia with lateral lobes of gonocoxites shorter, at most as long as medioventral process of gonocoxites **21**
22 (21) Tergite 9 pear-shaped, distinctly broader in posterior half (Laštovka and Ševčík 2006: fig. 13) .... ***D. pannonica* Laštovka & Ševčík, 2006**
– Tergite 9 subrectangular, not distinctly broader in posterior half (Ševčík 2006: fig. 3).. ***D. rohaceki* Ševčík, 2006**

Acknowledgements

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Description of a new species of the genus *Laelaspis* Berlese (Acari, Mesostigmata, Laelapidae) from Iran

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Abstract

A new species of the genus *Laelaspis* Berlese, *L. elongatus* **sp. n.** is described based on adult female and male specimens collected in association with *Pheidole pallidula* (Nylander) (Hym., Formicidae) in Ahwaz, Khuzestan Province, southwestern Iran, and also *Acinopus* (*Acinopus*) *picipes* (Olivier) (Col., Carabidae) in Bam, Kerman Province, southeastern Iran.

Keywords

Parasitiformes, Dermanyssoidea, taxonomy, myrmecophilus mites

Introduction

Laelaspis (Mesostigmata: Laelapidae) was originally established by Berlese (1903) as a subgenus of *Laelaps* Koch, 1939, with the type species *Laelaps astronomicus* Koch, 1839, and was later elevated to genus by Berlese (1920, 1924). Although Vitzthum (1943) considered *Laelaspis* as a subgenus of *Hypoaspis* Canestrini, 1885 sensu lato, and this idea was followed by some subsequent authors (e.g. Evans and Till 1966, Hunter and Glover 1968, Van Aswegen and Loots 1970, Lapina 1976, Bregetova 1977), Berlese's (1920, 1924) classification is followed by more authors (e.g. Hunter

1961, 1964, Hunter and Davis 1962, Bai and Gu 1993, Joharchi et al. 2011, 2012a, b, Babaeian et al. 2013, Ramroodi et al. 2014, Kazemi 2015).

The original description of *Laelaspis* was very poor. Although Hunter (1961) reviewed the genus and some authors tried to clarify its boundaries since Hunter's (1961) work (Evans and Till 1966, 1979, Bregetova 1977, Joharchi et al. 2011), the genus diagnosis was not clear. Recently, Kazemi (2015) reviewed the concept of *Laelaspis*, presented its generic diagnosis and detailed diagnosis, and considered the genus to include 40 described species of usually myrmecophilous mites, although some species occur in different habitats such as free-living in soil, litter and moss, or associated with beetles, and mammals or their nests (Berlese 1903, 1904, 1920, Evans and Till 1966, Lapina 1976, Hunter 1961, 1962, 1964, Hunter and Davis 1962, Hunter and Glover 1968, Joharchi et al. 2012a).

Until now 13 species of *Laelaspis* have been reported from Iran, including seven new species found mostly in association with ants, but also rarely in soil and litter (Faraji et al. 2008, Joharchi et al. 2012a, b, Babaeian et al. 2013, Kazemi and Rajaei 2013, Ramroodi et al. 2014, Kazemi 2015). Herein, we follow Kazemi's (2015) diagnosis of the genus and describe a new species of *Laelaspis* from Iran.

Material and methods

Mite specimens of the new species were removed from under elytra of a beetle host, *Acinopus* (*Acinopus*) *picipes* (Olivier, 1795) (Col., Carabidae) in Bam County, Kerman Province, southeastern Iran, and also associated with an ant host, *Pheidole pallidula* (Nylander) (Hymenoptera, Formicidae) in Ahwaz County, Khuzestan Province, southwestern Iran. Mite specimens were cleared in Nesbitt's fluid and then mounted in Hoyer's medium on microscope slides before examination.

Morphological observations, measurements and illustrations were made using compound microscopes (Olympus BX51) equipped with differential interference contrast and phase contrast optical systems, and a drawing tube. Figures were prepared using Microsoft Office Powerpoint 2003 based on scanned line drawings. Measurements were made in micrometers (μm). Dorsal shield length and width were respectively taken from the anterior to posterior shield margins along the midline, and from the lateral margins at the broadest level between setae *j6-J1*. The length of sternal shield was measured from the anterior to posterior margins of the shield along the midline, and its width at the lateral margins at the levels of setae *st2* and *st3*. The length of genitiventral shield was taken from the anterior margin of the hyaline extension to the posterior margin of the shield along the midline and also from the level of setae *st5* to the posterior tip of the shield; shield widths were taken at the level of *st5* and also at the broadest points. The anal shield length and width were measured along its midline from the anterior to posterior margins, including the cribrum, and at the broadest point, respectively. The leg lengths were taken dorsomedially from the base of the coxa to the apex of the tarsus, excluding the ambulacrum (stalk, claws and pulvillus). The

length of the second cheliceral segment was measured from the base to the apex of the fixed digit, and its width at the broadest point. The length of the fixed cheliceral digit was taken from the dorsal poroid to the apex, and that of the movable digit from the base to apex. The notation for idiosomal setae follows that of Lindquist and Evans (1965) adapted by Evans and Till (1965, 1966) and Lindquist (1994), and that for leg and palp setae follows Evans (1963a, 1963b). The notation for idiosomal pore-like structures as gland pores and poroids follows mostly Athias-Henriot (1971, 1975), adapted by Kazemi et al. (2014).

Kazemi (2015) indicated in the diagnosis of the genus *Laelaspis* that the genitiventral shield bears at least two pairs of setae on its lateral margins, always including *st5* and *JV1*. Herein, based on Evans and Till (1965) and also Lindquist (1994), we consider that *st5* and *ZV1*, not *JV1*, are the two 'core' setae always inserted on the genitiventral shield of *Laelaspis* species, and that the arrangement of opisthogastric setae in members of the genus is similar to that of the new species illustrated herein.

Taxonomy

Genus *Laelaspis* Berlese, 1903

**Type species.** *Laelaps astronomicus* Koch, 1839
Diagnosis. The genus diagnosis of Kazemi (2015) was followed.

Laelaspis elongatus sp. n.
http://zoobank.org/FC07A0CF-4110-4DEC-A180-F5A9C1B781C8
Figures 1–14

Diagnosis (adult male and female). Dorsal shield relatively elongate, ratio of length/ width of shield≈1.7, with 39 pairs of setae, including *Px2–3*, and three unpaired setae *Jx*, setae mostly subequal in length and relatively short, usually not reaching to following seta base, *j1* and *z1* shortest, subequal and lanceolate, situated subventrally, *J5* and *Z5* short, ratio of *J5/Z5* length≈1.5. Sternal shield of female with lineate-reticulate ornamentation on anterior and lateral surface, ratio of shield length/width (at *st3* level) ≈ 0.9; subequal sternal setae shorter than distance to following seta base. Genitiventral shield of female longer than wide, ratio of length/width (at broadest level) ≈ 1.9, shield bearing two pairs of smooth setae, *st5* and *ZV1*. Anal shield almost as long as wide (slightly wider than long in specimen removed from beetle host); circumanal setae smooth, postanal seta slightly shorter than para-anals. Opisthosomal membrane in female with 17 pairs of setae, 13 pairs in male. Peritrematal shields well developed, hind edge of shield not reaching to posterior edge of subtriangular parapodals. Peritremes long, reaching to anterior level of coxae I. Epistome with smooth and subtriangular anterior margin. Subcapitular setae *h3>h1>cs>h2*. Movable and fixed cheliceral digits
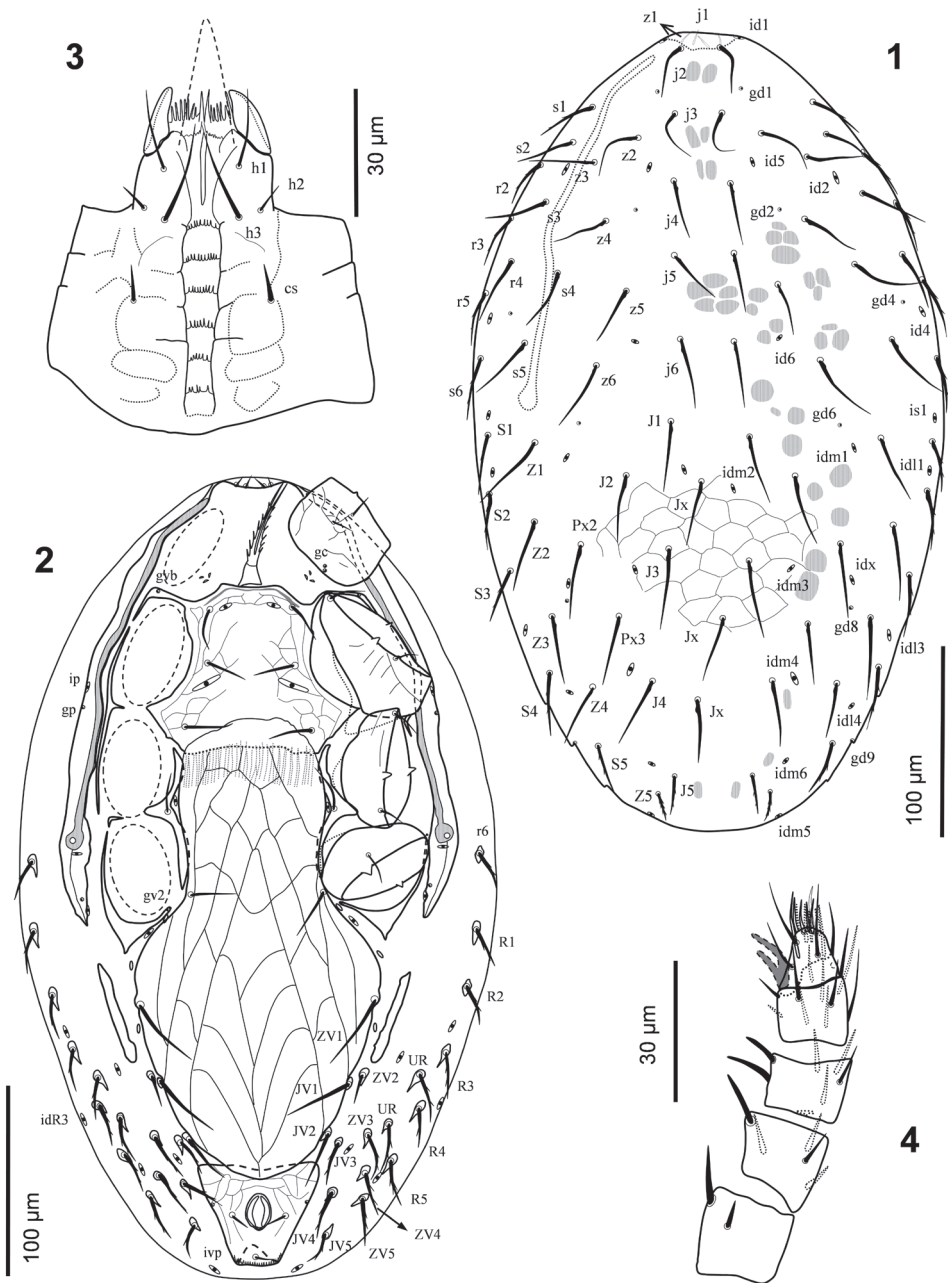
Figures 1–4. *Laelaspis elongatus* sp. n. Female: **1** dorsal idiosoma **2** ventral idiosoma **3** subcapitulum **4** palp.

in female bidentate; fixed and movable digits of male chelicera each with an acuminate weakly sclerotised apical projections, fixed digit with a prominent tooth (apical hook), movable digit thickened, unidentate, spermadactyle finger-like, slightly shorter than
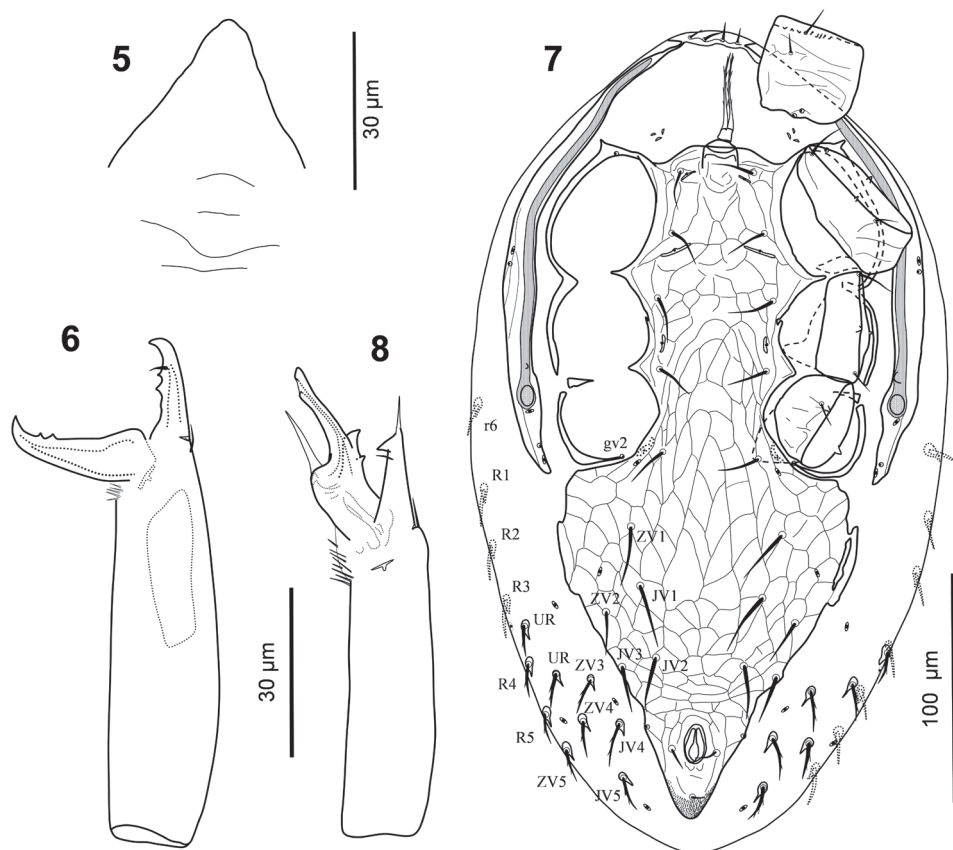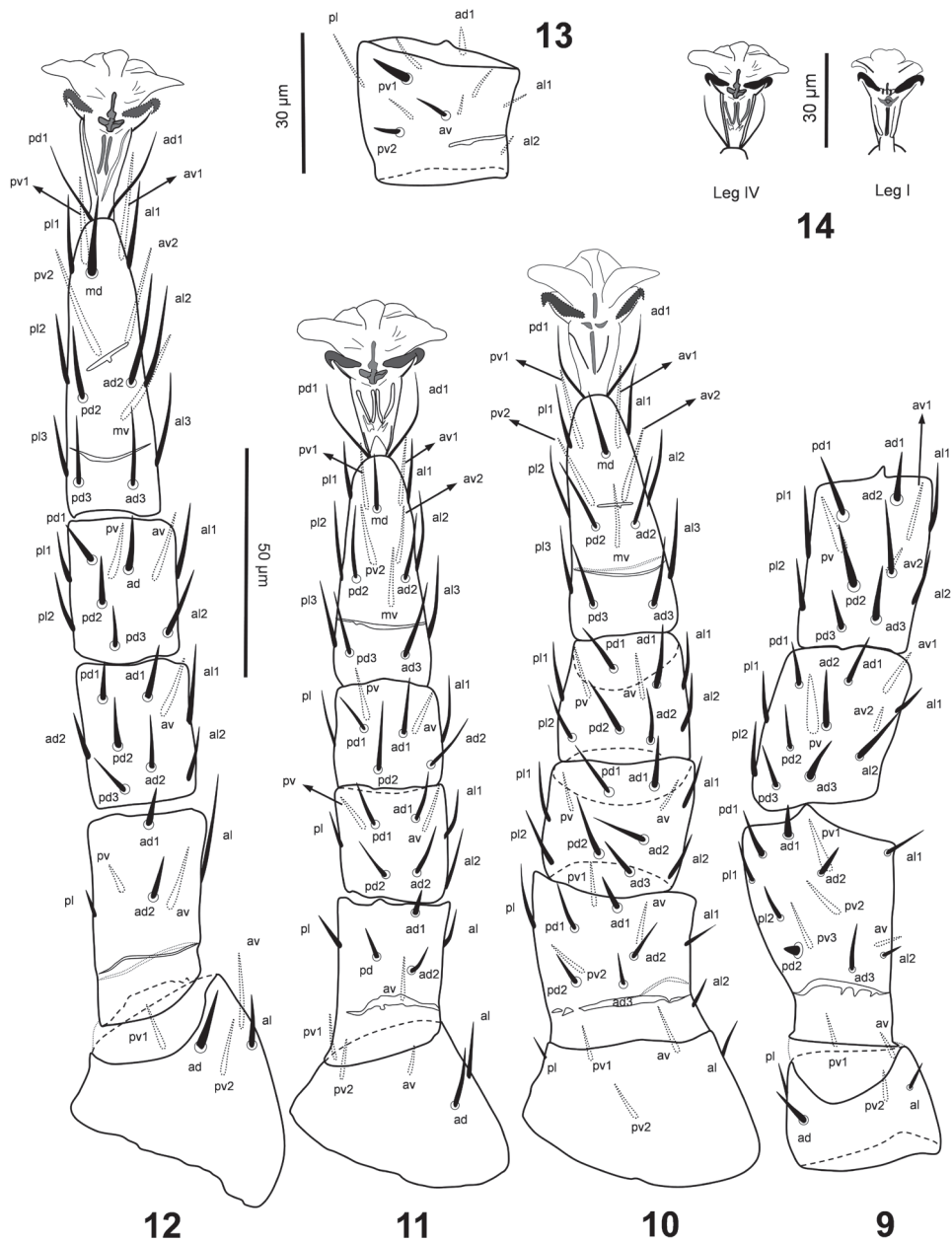
Figures 5–8. *Laelaspis elongatus* sp. n. **5–6** Female: **5** epistome **6** chelicera; **7–8** Male: **7** ventral idiosoma **8** chelicera.

movable digit, parallel with an acuminate protrusion inserted below it. Leg chaetotaxy normal for genus, including nine setae on genua IV and 10 setae on tibiae IV, setae mostly simple and slender or slightly thickened, except following setae: *pv1* on femur I, *pv* on genu I, *pv* and *pd2* on tibia I thickened; *pd2* on femur I short and spine-like. Seta *pv1* in femura II of male thicker than those in female.

Description. *Female* (n = 3). *Dorsal idiosoma* (Fig. 1). Dorsal shield 414–423 long, 243–248 wide, covered dorsal idiosoma completely, with lineate-reticulate ornamentation throughout, bearing 39 pairs of setae and three unpaired setae *Jx* between *J1* and *J5*, *j1* and *z1* subequal, lance-like, shortest (9–10), situated subventrally, *J5* (23–24) and *Z5* (17–18) shorter than the rest of setae, *J5* sparsely barbed, *Z5* pilose, other dorsal setae subequal, 25–43 long, usually with a small enlargement near base, setae *s1*, *s6*, *S1–5*, *r2–5*, with few sparse barbs. Dorsal shield with 16 pairs of poroids (oval-shaped symbols) and six pairs of gland pores, *gd1–2*, *gd4*, *gd6*, *gd8–9* (circular symbols).

Figures 9–14. *Laelaspis elongatus* sp. n. Female: **9–12** legs I-IV, dorsal view; **13** Male: femur II, ventral view **14** Female, ambulacra I and IV.

Ventral idiosoma (Fig. 2). Tritosternum with a short columnar base, 7–8 long, 10 wide at base, 5–6 wide at apex, and two pilose laciniae, free for 43–46 µm, fused 7

µm. Soft integument behind coxae I with three pairs of gland openings flanked by two minute valves. Sternal shield 84–87 long, 62–66 wide at *st2* level, 88–98 at *st3* level, distinctly reticulate on anterior and lateral surface; anterior margin of shield bilobed, posterior margin slightly concave; anterolateral corners narrowly fused to endopodal platelets between coxae I-II, bearing gland pores *gvb*, and fused to exopodals behind coxae II; shield with three pairs of smooth setae, *st1–3* (22–27) and two pairs of slit-like poroids, *iv1* between setae *st1*, and *iv2* enlarged, behind setae *st2*. Metasternal setae (25–26) on free endopodal platelets between coxae II-III, poroids *iv3* on soft cuticle. Genitiventral shield elongate, 226–238 long from anterior to posterior margins, 139–153 long from *st5* level to posterior edge, 71–75 wide at *st5* level, 119–128 wide at broadest point anteriad to *ZV1* level; anterior hyaline margin irregularly convex, covering part of posterior smooth area of sternal shield reaching to *st3* level, shield gradually narrowed from widest point, posteriorly convex, occasionally slightly bluntly tapered, and covered anterior margin of anal shield, inner Λ-shaped lines flanked nine cells; setae *st5* (25–27) and *ZV1* (42–44) inserted on lateral margins of shield. Anal shield subtriangular, anterior margin of shield slightly concave, 59–61 long, 59–66 wide, lineate-reticulate on anterior and lateral surface; circumanal setae smooth, fine, para-anal setae (13–14) slightly longer than postanal seta (10–11); cribrum developed posteriorly; para-anal gland pores *gv3* on lateral shield margins at level of anterior edge of anal opening. Peritrematal shields well developed along peritremes, anteriorly narrowed and fused to dorsal shield behind setae *z1*, bearing two pairs of pore-like structures near external margin of shield, a pair of gland pores at level of anterior edge of coxae III and one pair of poroids at level of posterior edge of coxae II; poststigmatic area with a longitudinal line from stigmata to shields hind edge, and with two pairs of poroids and one pair of gland pores. Peritremes long (205–208), reaching anterior margin of coxae I. Exopodal platelet between coxae II-III narrowly developed, exopodal between coxae III-IV small, parapodals developed and subtriangular posteriorly, bearing *gv2*. Opisthogastric soft integument bearing a pair of primary metapodal platelets narrowly elongate, laterad of genitiventral shield, 51–54 long, 6–7 wide; two pairs of paragenital minute platelets between primary metapodals and genitiventral shield and one pair between parapodal and ginitiventral shields; seven pairs of poroids including *iv5*, *ivp* and *idR3*, and 17 pairs of setae, *JV1* (35–41), *JV2* (30–33), *ZV2* (19–22) smooth, others barbed, 18–28 long.

Gnathosoma (Figs. 3–4, 5–6). Anterior margin of epistome subtriangular, smooth (Fig. 5). Corniculi horn-like, 45–47 long. Salivary stylets narrow and apically pointed, aligned beneath corniculi. Internal malae fringed, with a pair of smooth adjacent median projections, flanked by shorter and thinner lateral projections. Labrum acuminate, pilose, considerably longer than internal malae and corniculi. Hypostomal and capitular setae smooth, *h3* (21–23)>*h1* (17–18)>*cs* (9–10)>*h2* (7–8). Deutosternal groove with six rows of denticles, three basal rows narrower, with 3–7 denticles, rest anterior rows slightly wider, with 5–11 denticles (Fig. 3). Second segment of chelicera 86–88 long, 18–19 wide; fixed digit of chelicera 17–18 long, movable digit 23–25 long, both digits bidentate; dorsal seta short and setiform (Fig. 6). Palp 70–73 long;

palp chaetotaxy normal for Laelapidae with 2, 5, 6, 14, 15 setae on trochanter, femur, genu, tibia and tarsus, respectively , all setae smooth, *al1* and *al2* on palpgenu and *al* on palpfemur slightly thickened and subspatulate, *v1* on palptrochanter slightly thickened, somewhat spine-like; palptarsus apotele two-tined, basal tine shorter (Fig. 4).

Legs (Figs. 9–12, 14). Leg chaetotaxy normal for Laelapidae (sensu Evans and Till 1965). Ambulacra of legs I-IV subequal, 32–35 long, claws and pulvilli developed, ambulacral stalk broad. Lengths of legs I-IV 267–278, 190–192, 180–183 and 207–212, respectively. Lengths of femora I 70–73, II 32–33, III 31–34, IV 43–46; genua I 33–36, II 28–31, III 19–22, IV 28–31; tibiae I 38–39, II 25–26, III 21–24, IV 28–31; tarsi I 82–83, II 50–54, III 48–52, IV 65–68. Leg setae mostly narrow, needle-like and moderately short, as diagnosis of species. Coxa I bearing two gland pores (*gc*) (Fig. 2).

Male (n = 1). *Dorsal idiosoma*. Idiosoma 345 long, 205 wide. Dorsal shield 326 long, 195 wide, covering most of dorsal idiosoma but leaving a narrow exposed band of soft cuticle laterally and posteriorly; length of setae: *j1* 8, *z1* 7, *J5* 20, *Z5* 15, others 23–34; other dorsal characters similar to those in female.

Ventral idiosoma (Fig. 7). Tritosternal base 8 long, 7 wide at base, 4 wide at apex, with two pilose laciniae, free for 26 μm, fused basally for 5 μm. Holoventral shield 291 long from anterior to posterior margins of shield, 59 wide at level of *st2*, 66 at *st3* level and 132 at broadest point (*ZV1* level), anterolateral edges of shield narrowly fused to endopodals between coxae I-II, including gland pores *gvb*, then fused to exopodals behind coxae II-III; shield surface lineate-reticulate throughout, with five pairs of subequal smooth sternal setae, *st1–5* (19–22), and five pairs of smooth ventral setae, *ZV1*, *JV1–2* (24–28), *ZV2*, *JV3* (20–21), plus three smooth circumanal setae, para-anals (11) longer than postanal seta (8), with five pairs of poroids, *iv1–3* slit-like, *iv2* enlarged, and with a pair of gland pores *gv3* on lateral margins of shield at anterior level of anal opening; cribrum developed; metapodal platelets narrow, completely or partly fused to shield. Soft integument with 13 pairs of subequal and barbed setae (14–18), inserted on small platelets, and five pairs of poroids, including *idR3*. Peritremes relatively narrow and long (172), reaching to anterior margin of coxae I. Peritrematal shields similar to those in female, poststigmatic region slightly longer, reaching to posterior level of parapodals.

Gnathosoma (Fig. 8). Epistome, subcapitulum and palp characters similar to those in female. Hypostomal and capitular setae smooth, *h3* (18)>*h1* (14)>*cs* (9)>*h2* (6). Corniculi 9 long. Second segment of chelicera 76 long, 15 wide; fixed digit 22 long, unidentate (apical hook), with an apical fine projection, pilus dentilis short and setiform; movable digit thick, 21 long, with one small tooth, spermatodactyl almost straight, slightly shorter (18) than movable digit, parallel to and longer than a narrow and apically fine projection below it (Fig. 8).

Legs (Fig. 13). Leg chaetotaxy and characters similar to those in female, except *pv1* in femura II thicker than same setae in female. Lengths of legs I-IV 234, 166, 154, 187, respectively. Lengths of femora I 37, II 29, III 26, IV 29; genua I 29, II 22, III 18, IV 23; tibiae I 29, II 18, III 18, IV 25; tarsi I 68, II 42, III 43, IV 46; ambulacra I-IV 28–32.

Material examined. Holotype: female, southeastern Iran, Kerman Province, Bam County, under elytra of *Acinopus* (*Acinopus*) *picipes* (Olivier, 1795) (Col., Carabidae)

(29°06'096"N; 58°18'866"E), 1107 m above sea level, 31 August 2011, coll. N. Mehrzad, deposited in Acarological Collection, Institute of Science and High Technology and Environmental Sciences, Graduate University of Advanced Technology, Kerman, Iran (ACISTE). Paratypes: two females and one male, southwestern Iran, Khuzestan Province, Ahwaz County, associated with *Pheidole pallidula* (Nylander, 1849) (Hym., Formicidae), 18 Nov. 2013, deposited in ACISTE.

Etymology. The species epithet "*elongatus*" was chosen based on the elongated dorsal and genitiventral shields of the female.

Remarks. The new species, *L. elongatus* sp. n., can be easily distinguished from other members of the genus by combination of three unique characters: (1) postanal seta slender and slightly shorter than para-anal setae (thicker and longer than para-anals in other described species, except *L. kamalii* Joharchi et al. 2012 with subequal in length circumanal setae which can be easily distinguished from the new species by several characters such as: edentate movable digit in *L. kamalii* [bidentate in *L. elongatus* sp. n.], setae *J5* and *Z5* similar in length in *L. kamalii* [ratio of *J5/Z5* length≈1.5 in *L. elongatus* sp. n.], posterior edge of peritrematal shields well past hind edge of parapodal shields in *L. kamalii* [posterior edge of peritrematal shields shorter than hind edge of parapodal shields in *L. elongatus* sp. n.], genitiventral shield in *L. kamalii* wide and almost trapezoidal [the shield narrower and posteriorly convex in *L. elongatus* sp. n.]); (2) length/width ratio of the genitiventral shield in the new species almost 1.9 (the ratio less than 1.6 in other described species); (3) male chelicera with pointed and fine projections on the fixed and movable cheliceral digits, as those in figure 8 (without these projections in other described species).

Discussion

The genitiventral shield in *Laelaspis* species is often longer than wide, and the length/width ratio at the broadest level of the shield is usually between 1–1.5 (in *L. aviator* Berlese, 1920 and *L. volgini* Shereef and Afifi, 1980 wider than long), but in *L. elongatus* sp. n. this ratio is almost 1.9. On the other hand, in some keys (Joharchi et al. 2012a, Ramroodi et al. 2014) *L. secedens* Berlese, 1920 has been separated from related species by its elongated genitiventral shield. We studied the photographs taken from slide 201/22 (the holotype of *L. secedens*) in the Berlese's collection in Florence, Italy, and also the measurements of the species: the body size length 432, width 288; the genitiventral shield length 211 and its width 141 in the broadest point (pers. comm. of R. Nanelli with senior author), giving a ratio of the length/width of the genitiventral shield in *L. secedens*≈1.5, a usual ratio within the genus. On the other hand, *L. elongatus* sp. n. can be easily distinguished from *L. secedens* by some more features like postanal seta in *L. elongatus* sp. n. fine and shorter than para-anals, but serrate, considerably thicker and longer than para-anals in the latter species, length ratio of *Z5/J5* in the new species ≈ 0.75, but *Z5/J5* ≈ 2 in *L. secedens*, *JV5* almost as half-length of *JV1* in *L. elongatus* sp. n., but *JV5* almost as long as *JV1* in *L. secedens*.

So far only two species of the genus have been reported in association with beetles, *L. aviator* and *L. secedens*. In this research, two female and one male specimens were found in association with an ant, *P. pallidula*, in Ahwaz County (southwestern Iran), but one specimen of the new species was also found under the elytra of a carabid beetle in Bam County (southeastern Iran). This is the third report of a *Laelaspis* species from a beetle.

Acknowledgment

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